

Project documents



Ministry of Commerce
Science & Technology
Government of Jamaica

Renewable energies potential in Jamaica

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Prepared in collaboration with the Ministry of
Commerce, Science and Technology of Jamaica

June 2005



UNITED NATIONS



Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ)

This document has been prepared by the United Nation's Economic Commission for Latin America and the Caribbean (ECLAC) as part of a joint project with the German Agency for Technical Cooperation (GTZ) entitled: "Promotion of Economic Development by the Integration of Environmental and Social Policy Approaches in Latin America and the Caribbean", (GER/02/070).

The report has been prepared by the international energy specialist and UN consultant, Mr. Detlef Loy, and Mr. Manlio F. Coviello, Economic Affairs Officer, ECLAC, who also acted as activity supervisor.

The entire work has been carried out in direct and strict coordination with the Permanent Secretary of the Ministry of Commerce, Science and Technology of Jamaica (MCST) –that acted as the official counterpart for ECLAC– in cooperation with other governmental entities. In this regard, special mention has to be made to the Group Managing Director of the Petroleum Corporation of Jamaica (PCJ), who strongly supported the development of both field and conceptual work.

The text was reviewed by the project coordinator Mr. José Javier Gómez, Economic Affairs Officer, ECLAC, and by the entities of the government of Jamaica involved in the study, including the Ministry of Land and Environment, the Scientific Research Council, the Planning Institute of Jamaica/Ministry of Finance and Planning, and the Water Resources Authority.

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United Nations Publication

LC/W.18

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Printed in United Nations, Santiago of Chile

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Abbreviations

ACP	African, Caribbean, Pacific (states)
BTU	British Thermal Unit
CAF	Corporación Andina de Fomento
CARICOM	Caribbean Common Market
CBI	Caribbean Basin Initiative
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
GCT	General Consumption Tax
CREDP	Caribbean Renewable Energy Development Programme
DFP	Demonstration Fuelwood Project
DNA	Designated National Authority
DOE	Designated Operational Entity
DSM	Demand Side Management
EAU	European Allowance Unit
EIA	Environmental Impact Assessment
ETBE	Ethyl-Tertiary-Butyl-Ether
EU	European Union
EU-ETS	European Union – Emission Trading System
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GTZ	Gesellschaft für Technische Zusammenarbeit
GWP	Global Warming Potential
IEC	International Electrotechnical Commission
IPP	Independent Power Producer
JEP	Jamaica Energy Partners
JPPC	Jamaica Private Power Company
JPSCo	Jamaica Public Service Company Limited
LAC	Latin America and Caribbean
LCEP	Least Cost Expansion Plan
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
MTBE	Methyl-Tertiary-Butyl-Ether
NAP	National Allocation Plan
NEPA	National Environment and Planning Agency
NSWMA	National Solid Waste Management Act
OTEC	Ocean Thermal Energy Conversion
OUR	Office of Utilities Regulation
PCJ	Petroleum Corporation of Jamaica
PDD	Project Design Document
PCF	Prototype Carbon Fund
PV	Photovoltaic
REP	Rural Electrification Programme Ltd.
RFS	Renewable Fuels Standard
SCJ	Sugar Company of Jamaica
SRC	Scientific Research Council

SSC	Small Scale CDM
SWH	Solar Water Heater
TCD	Tonnes of Cane per Day
TES	Total Energy Supply
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies

Average exchange rate in 2004: 60 \$J for 1 US\$

Abstract

Jamaica has abundant renewable energy sources (RES), which have hardly been tapped in the past and could provide for large shares of the future energy requirements. In 2005, around 5% of the expected 4,020 GWh of electricity produced will be based on RES (wind and hydropower). With the new planned target of a share of 15% RES electricity by 2012, a combined renewable capacity of about 175 MW would need to be installed in that year.

There is further wind potential on Jamaica, even if no exact figures can be given on the magnitude of the exploitable wind potential. Nonetheless, it seems realistic that within the next years three more wind farms of about 20 MW each could be erected.

Several hydropower sites have been examined in the past with all but one being of minor scale. New hydropower plants can be economical under current conditions if generation costs do not exceed about 6 US-cents per kWh.

One of the largest renewable energy potentials for electricity generation is to be found in the sugar processing industry. With the installation of new high-pressure boilers and improvements in the energy efficiency of the sugar plants, more than 220 GWh/year of excess electricity could be supplied to the public grid.

Up to 10% of gasoline can be substituted by bioethanol or its derivate ETBE without modifications to the vehicle engines. Most favourable for bioethanol production in the case of Jamaica is the use of sugar cane.

Currently solar water heaters cover only about 1% of the domestic market (private houses). An estimated 75 to 100 GWh of electricity could be saved annually, if only the 45,000 residential homes with the highest electricity demand would use solar water heaters.

In order to achieve the long-term RES goals, the existing potentials will need to be better identified and located, using on-site assessments and long-term measurements if appropriate. Such pre-feasibility studies will require the involvement of private investors at an early stage.

To smooth administrative procedures and attract foreign investment, the establishment of a one-stop agency as central contact point is proposed. Financial and fiscal incentives (GCT waiver or reduced duty taxes) can lower the threshold for investments with high up-front costs.

Background

In the context of the Latin America and Caribbean Initiative for Sustainable Development, Jamaica has made a commitment to raise the level of use of renewable energy to 10% of total energy, by 2010.

The Ministry of Commerce, Science and Technology of Jamaica is aware of the changing investment patterns that have made the pursuit of renewable energy markets a national priority, along with studying associated technologies and their economic characteristics. The decision to approach renewable energy from a market or end-use perspective has been taken in order to catalyze commercial dissemination.

Furthermore, energy policies and planning have a major influence on market growth and sustainability, and Jamaica's National Energy Policy (1995), which is currently under review, expresses the government's commitment to continuing to foster, facilitate and encourage the development of all new and renewable energy sources where feasible. In Jamaica, the total cost of imported energy has increased from US\$ 316.4 million in 1998, to US\$ 640.7 million by 2002, an increase of over 100% in four years. In 2003, Jamaica spent approximately US\$ 800 million on imported energy. It is the second largest user of foreign exchange after debt servicing. This places a significant burden on the natural resource base to generate the needed foreign exchange.

With petroleum hitting an all-time high in early 2005, the need to diversify Jamaica's energy base has become even more urgent.

Protection of the environment is a primary objective of Jamaica's National Energy Policy, and one of the best options for reducing pressure on natural resources is to utilize the abundant indigenous renewable energy resources. In addition to reducing the demand for foreign exchange, the utilization of renewable energy resources would provide significant local employment beyond what is currently provided by fossil-based systems.

In order to improve the capacity to deal with vulnerability, the Jamaican and Caribbean region needs to invest in renewable energy and energy-efficiency improvements as a priority. Reducing the need for importing energy resources will significantly reduce vulnerability to global climate change, as well as to the global economy. Already vulnerable for food security, the region cannot continue to be also highly energy dependent, which leaves it even more vulnerable.

Jamaica has recognized that development in the field of renewable energy is critical to the progress of the country.

* * *

With this in mind, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) carried out a focus mission to Jamaica in July 2004, in order to identify concrete areas for cooperation and governmental support in the field of renewable energy sources. GTZ/CRDEP¹ supported ECLAC during the mission, because of the high level of regional synergy that those institutions are currently pursuing.

As a result of the discussion with different key-governmental stakeholders involved in the study (Ministry of Commerce, Science and Technology, Petroleum Corporation of Jamaica, Ministry of Land and Environment, Scientific Research Council, Planning Institute of Jamaica/Ministry of Finance and Planning, Water Resources Authority among others) –and in view of the very positive context for enhanced cooperation between ECLAC, the Government of Jamaica and GTZ– a final commitment was made by ECLAC to providing assistance to Jamaica in the development of its renewable energy sources, while promoting the integration of economic, social and environmental processes.

A study of the *"Renewable Energies Potential in Jamaica"* was identified by all stakeholders as a first, concrete step which could consolidate this cooperation process. Terms of reference were then jointly prepared for the work, which would be carried out by an international specialist before the end of 2004. The consultancy was then financed under the ongoing ECLAC/GTZ joint project: *"Promotion of Economic Development by Integration of Environmental and Social Policy Approaches in Latin America and the Caribbean"*.

The selected consultant (Dipl. Ing. Detlef Loy) started his activities in Jamaica in October 2004 maintaining close coordination with the various national stakeholders in the renewable energies sector, in order to: i) obtain all the data needed to organize and centralize information on the various renewable resources in the country; ii) carry out an updated analysis of the potential of such resources; iii) identify the barriers to the full development of the related technologies; iv) identify the most promising technologies; v) propose actions and policies to promote such technologies.

The Government of Jamaica (mainly through the project's local counterpart, i.e. the Ministry of Commerce, Science and Technology, solidly supported by the Petroleum Company of Jamaica) granted the consultant full assistance in gathering all available information, also providing *ad-hoc* personnel and logistic support for field visits and official meetings.

The concrete findings and result of the work are contained in the present Report.

¹ Caribbean Renewable Energy Development Project (CREDP) of the German Agency for Technical Cooperation (GTZ).

Introduction

Jamaica has abundant renewable energy sources (mainly wind, biomass and solar energy), which have hardly been tapped in the past and could provide for large shares of the future energy requirements. An estimated 8% of the total energy supply of Jamaica (2004) is currently based on alternative and indigenous energy sources, like wood, bagasse and hydropower. The by far most important alternative energy sources next to bagasse are fuel wood and charcoal, partially not considered to be renewable resources due to imbalanced extraction and reforestation.

More than 90% of Jamaica's energy needs are covered by imported crude oil and petroleum products. This amounted to a spending of an estimated US\$ 1.2 billion in 2004 for importation of more than 25 million barrels of raw and refined petroleum. The value is equivalent to more than 15% of the gross domestic product. The public electricity sector is almost totally dependent on imported petroleum (with a minor contribution from hydropower and wind), resulting in fuel costs of around US\$ 200 million in 2003. Those costs were expected to increase to US\$ 280 million in 2004, due to the sharp rise of world market prices for petroleum. This fuel price hike led to a cost increase of US-cents 2.0 per generated kWh.

The available capacity of the public electricity sector is reported to be around 780 MW (June 2004), including the new 20 MW wind farm commissioned in May 2004. 80% of this capacity is provided by the utility JPSCo, with the rest distributed among four IPPs. The actual installed capacity (name plate) is somewhat higher, but some plants are out of operation or cannot provide the full output. Peak demand in the public electricity system was 614 MW in 2004. Line losses and unaccounted electricity summed up to more than 700 GWh in 2004 (close to 19% of net production and well above the target level for the electricity price cap), thus exceeding the production of renewable energy electricity by far.

The new Least Cost Expansion Plan of November 2004 (with addendum of March 2005) for the public electricity sector is based on the assumption of an average growth rate of 4.57% per annum over the next 23 years (until 2027). This would mean that electricity generation would reach about 5,480 GWh by 2012 (against 3,700 GWh in 2003), while the installed capacity in this year would be 1,170 MW. In 2005, around 5% of the expected 4,020 GWh of (public) electricity produced will be based on renewable energy sources, with wind energy contributing about 60

GWh and hydropower about 140 GWh. Those figures do not contain the electricity produced in the sugar industry from bagasse for self-supply.

According to the draft of the new electricity policy, suppliers (currently only JPSCo) will be mandated to provide a certain percentage of renewable energy electricity annually, either through own generation or purchase from external providers. Non-compliance is thought to be fined. With the new planned target of a share of 15% renewable energy electricity with respect to the total installed capacity by 2012, a combined renewable capacity of about 175 MW would need to be installed in that year. If the achievable goal is related to electricity generation, the expected growth rates would result in about 820 GWh coming from renewable energy in 2012. This means that at least an additional 130 MW based on renewable energy resources needs to be installed within the next seven years.

The average generation costs of the public electricity supply are estimated to be in the range of 7 US-cents per kWh in 2005, with 3 cents originating from operation and maintenance and 4 cents from fuel costs. The two independent power producers, JPPC and JEP, will supply electricity in 2005 at an expected cost of 11.5 US-cents/kWh and 11.0 US-cents/kWh. A new plant to be commissioned by JEP at the end of 2005 is expected to supply electricity under the same unfavourable (while expensive) pricing terms.² Even under optimistic fuel price conditions, average generation costs will not significantly decrease in the coming years, taking into account the installation of a new combined cycle plant based on liquefied natural gas (LNG) with preferential energy supply prices and of further plants based on oil. The high generation costs of the current inefficient plant stock (which needs to stay in operation) will prevail.

According to preliminary assessments there is further wind potential on Jamaica. Limits are mainly set by the availability of land (unless off-shore sites can be accessed), the topographic conditions as well as road and grid access. Currently no exact figures can be given on the magnitude of the exploitable wind potential. But it seems realistic that within the next years three more wind farms of about 20 MW each could be erected. Pre-selected sites with favourable framework conditions will need long-term wind measurements to secure high energy yields and determine the exact location of the turbines and the total wind farm size.

Several hydropower sites have been examined in the past with all but one being of minor scale. New hydropower plants can be economical under current conditions if generation costs do not exceed about 6 US-cents per kWh. If firm capacity can be secured during most time of the year, hydropower would be capable of displacing high-priced fossil electricity. All calculations need to take into account that generation costs for fossil plants tend to increase in the future. A major additional contribution from hydropower is not to be expected within the next decade due to limited resources and competing water uses, which tend to reduce the river flows. All new hydropower investment would have to come from independent producers, since JPSCo shows now interest in operating any small-scale plants beyond the existing facilities.

One of the largest renewable energy potentials for electricity generation is to be found in the sugar processing industry. Currently the bagasse output of approximately 600,000 tonnes per annum (2003) is burnt in inefficient boilers with cogeneration, covering only own heat and electricity needs of the sugar factories. With the installation of new high-pressure boilers and improvements in the energy efficiency of the sugar plants more than 220 GWh per annum of excess electricity could be supplied to the public grid, based on current cane production. At least 300 GWh would be available, if the cane plantation is extended to former volumes for the (additional) production of bioethanol from sugar.

² At least until cheaper LNG is made available.

Recent field tests have demonstrated that dedicated fuelwood plantations could provide more than 90 tonnes of wood per hectare and year, based on a five year crop cycle. Such fuelwood could be used to operate the sugar plant boilers during off-harvest periods, in order to secure firm capacity throughout the year (with subsequent higher sales prices for electricity supply). Other options could be to use pelleted and stored bagasse or fossil fuels as supplementary feedstock.

The required modernisation of the sugar plants and operation of the cogeneration systems as well as the capital input needed should preferably be managed by external service companies on the basis of contracting agreements with the private or state-owned mills. The specific investment requirements for boilers and cogeneration facility are highly dependent on technical parameters, such as steam pressure and temperature.

Up to 10% of gasoline can be substituted by bioethanol or its derivate ETBE without modifications to the vehicle engines. Most favourable for bioethanol production in the case of Jamaica is the use of sugar cane. Gasoline consumption in the jamaican transport sector amounted to an estimated 4.5 million barrels in 2004. With growth rates of 4% per year, the annual demand for ethanol could reach 0.57 million barrels in 2010. With fermentation of the whole sugar cane plant the farming of an additional 19,000 hectare would be required to cover this demand. The blending of gasoline with bioethanol would have the additional advantage that the octane enhancer MTBE for unleaded fuel, which is currently imported, could be gradually displaced. Mandatory goals for the introduction of bioethanol would ease the transient increase of blended gasoline in the market.

Reference sources show costs for ethanol plants with output of 76 million litres per year to be in the range of US\$ 32 million, for 38 million litres of about US\$ 19 million. Off-factory prices are then in the range of 41 to 44 US-cents per litre. Any bioethanol production would have to be competitive with current gasoline prices (sold at about 70 US-cents/litre at the petrol station). In addition to setting up an own bioethanol production, thoughts could be given to import ethanol from Brazil on preferential bilateral price conditions. First cars using so-called “flexible fuel” technology are now on the market in Brazil. Those cars can either run on alcohol alone or use any mixture with blended gasoline.

The 680,000 tonnes of waste collected by the regional waste managements in Jamaica contain a large proportion of organic matter (65%). Under anaerobic conditions as on landfill sites, this biodegradable material will produce more than 180 m³ methane per tonne of waste over a time span of 50 to 100 years. About 50 to 80% of this gas can be captured by wells and drains and used in cogeneration facilities for heat and electricity production. Landfill gas extraction and use is one of the cheapest measures to tap renewable energy sources and offers good opportunities for additional financing within the flexible mechanisms of the Kyoto protocol (Clean Development Mechanism). Further investigation will be needed to analyse the current and future landfill gas potential and to assess viable and profitable solutions for the capturing of the methane.

Biogas from animal manure and sewage sludge will only provide limited contributions to the overall energy consumption, but can have a significant impact in individual cases, like in the food processing industry in connection with organic waste treatment. Sewage treatment plants can be operated on a stand-alone basis if biogas is used for oxygen supply and electricity needs.

Jamaica has a high medium solar radiation of about 4.8 kWh/m² per day. Currently solar water heaters cover only about 1% of the domestic market (private houses). The total number of solar water heaters is estimated to be in the range of 7,000, mainly in the form of small-scale passive thermosyphon systems with integrated water tanks. Higher oil prices and subsequent electricity price increases offer new opportunities for solar water heaters mainly in the domestic

sector as well as for hotels, restaurants and hospitals. Primarily new housing schemes could cost-efficiently be equipped with solar heaters. In order to stimulate the market, mandatory requirements as well as tax incentives should be taken into consideration.

The wide-spread application of solar water heaters could certainly contribute to lowering significantly the current peak demand of electricity at evening hours and levelling out the load curve, thus avoiding high-cost electricity generation. An estimated 75 to 100 GWh of electricity could be saved annually, if only the 45,000 residential homes with the highest electricity demand would replace their electrical systems by solar water heaters.

Existing photovoltaic applications for rural electrification show rather negative results due to a lack of continued monitoring and maintenance as well as the absence of funding for spare parts and rehabilitation. New solar electric installations for remote houses will need to be established within an improved long-term financing and operation scheme. It is estimated that about 6,000 houses will not fulfil the minimum conditions for grid extension by JPSCo and would therefore be targets for stand-alone generation systems.

Financing through the sale of emission certificates within the Clean Development Mechanism can facilitate the implementation of renewable energy projects. Such sale will under current pricing conditions “earn” 0.4 US-cents/kWh and more. Of particular interest for Jamaica could be small-scale projects of up to 15 MW capacity, which are subject to a fast-track procedure with reduced application requirements and lower transaction costs. As to avoid a number of unsolicited proposals, the Government should set priority development goals and draw the attention of potential investors to respective opportunities.

In order to achieve the long-term renewable energy goals, the existing potentials will need to be better identified and located, using on-site assessments and long-term measurements if appropriate. Such pre-feasibility studies will require the involvement of private investors at an early stage.

To smooth administrative procedures and attract foreign investment, the establishment of a one-stop agency as central contact point is proposed, that acts as a node between the investor and the Government, coordinate actions with all public entities involved and promote the integration of sustainable energy approaches into the main economic policies.

Tendering procedures for renewable energy projects in the electricity sector make only sense if they are related to specific sites and technologies. A competition among different technologies and across various external conditions will hardly deliver the expected results and could even be counter-productive.

Financial and fiscal incentives like income tax rebates, GCT waiver or reduced duty taxes can lower the threshold for investments with high up-front costs, as in the case of renewable energy technologies. For larger projects the accessibility of low-interest long-term credits and an adequate risk management is an essential. State guarantees can support and facilitate bank lending. An additional financing source could be the proposed Energy Efficiency Fund with an extension for renewable energy projects.

For renewable electricity supplied to the public grid a non-discriminatory access to transmission lines as well as secure long-term rates based on prospected effectively avoided costs (including external social and environmental benefits) are pre-requisites for any investment. Small-scale power generation units should be enabled to work with uniform net-metering and interconnection standards.

The achievement of the renewable energy goals will not only depend on external factors, but also on a strong and competent administrative structure with clear responsibilities and sufficient and well informed personal capacity.

I. Current energy situation in Jamaica

1. Energy balance

Jamaica's total energy supply (TES) amounted to about 27.1 million barrels of oil equivalent in 2003 and is almost completely dependent on non-indigenous fossil fuels. More than 90% of the TES consists of petroleum imports (crude oil and derivatives) from Mexico and Venezuela, less than 2% is covered by imported coal.

More than 7% is supplied from alternative energy, mainly on the basis of renewable resources (table 1). Part of the consumed fuelwood is considered to be non-renewable, i.e. the extraction of wood and reforestation is not balanced. The by far most important renewable energy sources are bagasse (for cogeneration in the sugar industry) and wood (for domestic cooking and frying), while hydropower and wind energy (not yet included in the 2003 statistics) play only a minor role.

TABLE 1
TOTAL ENERGY SUPPLY 2003

Jamaica 2003 – Total energy supply			
Oil	91.10%		
Coal	1.70%		
Renewable/Alternative	7.14%	Hydro	0.7%
		Charcoal	0.8%
		Fuelwood	2.4%
		Bagasse	3.3%
	100.00%		

Source: MCST, Feb. 2004.

Growth rates for the TES varied in recent years between -0.1% (2000/2001) and 3.8% (2001/2002).

Total spending for the import of petroleum products and crude oil was close to US\$ 800 million in 2003, with average prices for raw oil of US\$ 28.4 and for refined products of US\$ 30.0

per barrel. With world oil market prices skyrocketing in the course of 2004, import spending for petroleum was above US\$ 1.2 billion for this year.³

Most of the petroleum is consumed in the bauxite/alumina industry (for the self-supply of electricity, table 2). Second major consumer is the public electricity sector (with close to 6.5 million barrels in 2003), followed by road transport (almost 5.9 million barrels).

TABLE 2
PETROLEUM CONSUMPTION BY ACTIVITY 1999-2003
(in barrels)

Activity	1999	2000	2001	2002	2003 ^(p)
Road & rail transportation	5 950 265	5 691 514	5 714 767	5 883 380	5 866 667
Shipping	204 441	156 024	356 187	360 968	391 008
Aviation	1 519 714	1 640 492	1 452 198	1 616 873	1 589 139
Cement manufacture	400 768	183 190	132 759	84 941	51 124
Electricity generation	5 267 036	5 889 825	6 031 323	6 136 061	6 471 480
Bauxite/alumina processing	8 739 108	8 763 373	8 595 428	9 167 593	9 548 474
Sugar manufacturing	151 091	186 159	144 500	152 178	114 086
Cooking & lighting	893 559	889 818	873 776	906 919	905 551
Petroleum refinery		288 555	285 787	296 526	259 405
Other manufacturing	81 795	81 450	55 516	73 066	142 276
Other	215 188	112 141	364 349	375 499	252 743
Total	23 422 965	23 882 541	24 006 590	25 054 004	25 591 953

Source: PCJ 2004.

^(p) preliminary.

2. Public electricity sector

The electricity market continues to be dominated by the utility JPSCo despite an opening of the generation sector for independent power producers (IPPs) in the 1990s.⁴ The formerly state-owned JPSCo was privatized and sold in 2001 and operates now under a 20 year-licence, granting it the right to act as single buyer for electricity delivered by external producers and maintaining the sole ownership on transmission and distribution lines. Since 1 April 2004 competition has formally started in the generation sector, requiring public tenders for most of the future capacity additions.

Regulation of the electricity sector is exercised by the Office of Utilities Regulation (OUR), which was established in 1995.

2.1 Capacity, production and costs

As of June 1, 2004 the total installed capacity for public electricity generation was 821 MW, but a number of facilities were out of operation. The available capacity accounted for about 780 MW, including the 20 MW from the Wigton wind farm. Of this 621 MW was provided by JPSCo, the rest by four independent power producers under long-term (20 years) contractual agreements.

³ Oil prices averaged about US\$ 48 per barrel in 2004.

⁴ The first IPP contracts were signed in 1994.

JPSCo's steam plants were commissioned between 1968 and 1976 and need to be gradually replaced by modern facilities. In 2002 and 2003 a total of 120 MW combined cycle capacity was put into operation.

In 2003 JPSCo's power plants contributed with 72.3% to the total electricity output, with the remaining delivered by IPPs (see table 3). More than 45% of the electricity was generated in the relatively old and inefficient thermal (steam) plants.

TABLE 3
CAPACITY AND GENERATED ELECTRICITY IN 2003

	Generating capacity		Electricity generated	
	<i>MW</i>	<i>GWh</i>	<i>Percentage</i>	
Total (JPSCo + IPP)	785.6	3 696.0	100.0	
JPSCo:				
Steam	332.0	1 685.0	45.6	
Hydro	21.5	146.3	4.0	
Slow speed diesel	36.0	200.3	5.4	
Gas turbine	237.5	641.9	17.4	
JPSCo. total	627.0	2 673.6	72.3	
Independent producers:				
Jamaica energy partners (JEP)	74.2			
Jamaico ⁵	11.0			
Jamaica private power company (JPPC)	61.3			
Jamaica broilers ⁶	12.1			
IPP total	158.6	1 022.4	27.7	

Source: JPSCo.

Growth rates in the electricity sector have been varying significantly in recent years, between 1.7% in 2002 and 11.8% in 2000 (against previous years).

The public electricity system has produced about 3,700 GWh in 2003 and sold close to 3,000 GWh with the difference accounting mainly for line losses, unmetered consumption and theft.⁷ All losses combined amounted to 18.6% of net generation. With full operation of the Wigton wind farm in 2005, renewable electricity (hydro and wind) will account for about 5% of the expected total output of 4,020 GWh.

In 2003, about 37% of the sold electricity was consumed by residential and small-scale customers, with the remaining delivered to the commercial and service sector, industry and agricultural facilities (table 4). The average price per kilowatt-hour was approaching 19 US-cents for households, including taxes and fuel costs.

⁵ It is expected that not more than 5 MW of the contracted capacity will be available in 2005.

⁶ Contract was cancelled at the end of 2003.

⁷ Sales demand for 2004 was estimated to be 3,075 GWh.

TABLE 4
JPSCO ELECTRICITY SALES AND REVENUES IN 2003 (PRELIMINARY)

	Sold		Revenue	Average revenue per unit
	GWh	Percentage	\$J	US\$/kWh ⁸
Residential rate	1 106.7	36.9	11 748 604	19.3
General service rate 20	652.4	21.8	5 974 248	16.6
Power service rate 40	625.7	20.9	4 495 123	13.0
Large power rate 50	540.6	18.0	3 534 253	11.9
Street lighting rate 60	59.9	2.0	638 414	19.4
Other ^(a)	13.1	0.4	157 512	21.8
Total	2 998.3	100.0	26 548 153	16.1
Company use	12.4			
Line losses & other unaccounted for net generation	685.3			
Total electricity produced	3 696.0			

Source: JPSCo.

^(a)Includes other generating and other operating revenues.

With the exception of some hydropower contribution (and more recently wind energy) the electricity system is completely reliant on imported oil. JPSCo consumed within its plants a total of 5.2 million barrels in 2003 of fuel oil and diesel, the (then four) IPPs another 1.3 million barrels.

Generation costs for 2005 are estimated to be between 6 and 7 US-cents/kWh for JPSCo's steam plants, 5 US-cents/kWh for diesel generation and 6 US-cents/kWh for combined cycle generation. For purchased electricity from JPPC and JEP a high 11.5 respectively 11.0 US-cents/kWh have to be paid.⁹

2.2 Tariff system

Electricity tariffs are regulated for all customer groups by OUR after proposals from JPSCo, based on expected expenses and a requested return of investment. The different factors which determine the end-user tariffs represent a price-cap-scheme, allowing JPSCo to benefit from improvements (e.g. by reducing the heat-rate below the target levels) and accept financial disadvantages if the performance objectives and standards are not met.

Tariffs contain a basic connection and electricity charge (non-fuel base rate), and a variable fuel and IPP charge. The fuel charge is adjusted monthly according to international fuel price changes, inflation and exchange rate of the jamaican Dollar. Fuel price variations are therefore directly transferred on to the consumers. The IPP charge is also monthly adjusted and reflects variations of the non-fuel costs of IPPs.

⁸ Based on an exchange rate of 50 \$J for one US\$ (reference value).

⁹ In June 2004 the monthly capacity payment for JPPC was 41.7, for JEP 23.0 US\$/kW. The energy payment was 51.6 resp. 60.1 US\$/MWh.

Due to fuel price increases and the devaluation of the Jamaican dollar, generation costs and tariffs have moved upward considerably in recent years. A new 5-year tariff scheme came into effect in June 2004 with the average non-fuel revenue to be recovered from customers by JPSCo set at \$J 5.627 per kWh. System losses are capped at 15.8%, heat rates at 11,200 kJ/kWh for the whole five year period.¹⁰

The tariff scheme now provides for five main rate schedules and special rates for stand-by power. The last applies for customers with a minimum demand of 25 kVA, who own and operate power production equipment or other source of power to meet their own electricity requirement and in addition contract to take supply from JPSCo on a firm or non-firm basis.

2.3 Least cost expansion plan

In November 2004 the new Least Cost Expansion Plan (LCEP) submitted by JPSCo was approved by the Regulator OUR. The LCEP sets a timeline until 2017 for the addition and retirement of generation capacity in the public electricity grid. It is based on the assumption that the prospective growth rate of electricity generation and peak load will be on average 4.57%/year in this period and that a reserve margin of at least 25% is required (table 5).

In March 2005, the OUR approved an addendum to the LCEP extending the forecast period until 2027, thus covering the whole time-span of the envisaged LNG import from Trinidad and Tobago (see next chapter).

TABLE 5
FORECAST FOR ELECTRICITY DEMAND

Year	Peak	Growth rate (percentage)	Electricity generated (gwh)	Growth rate (percentage)
2004 ^(e)	614.0	4.1	3 848.3	4.1
2005	641.9	4.5	4 023.1	4.5
2006	670.8	4.5	4 205.0	4.5
2007	700.8	4.5	4 393.9	4.5
2008	732.1	4.5	4 591.6	4.5
2009	764.8	4.5	4 798.6	4.5
2010	798.9	4.5	5 014.5	4.5
2011	834.6	4.5	5 241.3	4.5
2012	871.9	4.5	5 478.6	4.5
2013	911.1	4.5	5 728.1	4.6
2014	952.1	4.5	5 989.9	4.6
2015	995.3	4.5	6 265.6	4.6
2016	1 040.5	4.5	6 555.0	4.6
2017	1 088.1	4.6	6 860.3	4.7

Source: LCEP, Nov. 2004.

^(e) Estimated.

¹⁰ The heat rate in 2003 was 11,554 kJ/kWh.

3. Supply of liquefied natural gas (LNG)

In November 2004 the Governments of Jamaica and Trinidad and Tobago signed a Memorandum of Understanding on the annual supply of 1.15 million tonnes of LNG under preferential pricing terms over a 20-year period.

The delivery is envisaged to start in 2008 and would mainly contribute to the supply of two new combined cycle power plants, the growing energy demand of the bauxite and alumina industry, the subsequent replacement of oil in other power plants (in first place those units operated by JEP and Jamalco) and the requirements of other industrial, commercial and residential final consumers.

Now private investors are sought to participate in the setting up of the infrastructure needed to unload, store, regasify and distribute LNG. The purchase price is expected to be below 3.90 US\$/million BTU (2004)¹¹ and will equal prices paid by large-scale customers in Trinidad and Tobago, when the world market price was in the range of 4.30 US\$/million BTU.

4. Rural electrification

Jamaica has a high grid-connection rate of about 95%, based on the basic requirement that at least 20 houses need to be located within one mile of a distribution line. In 2002 a 100% electrification target was set to be achieved within a 5-year-period.

In 1995 the state-owned company Rural Electrification Programme Ltd. was established as a non-profit company to carry out grid-extensions and connection of rural households. Since beginning, about 68.000 households were electrified with an estimated 350.000 people being affected. More than 3.000 miles of a single-phase line were constructed at state costs (with support of international donors like the Caribbean Development Fund and KfW) and later handed over to JPSCo.

Connection to the grid and in-house wiring (two plugs and lighting) has to be done at full costs of about \$J15,000 to be charged from the customer. \$J1,500 have to be paid up-front; the rest is repaid on a loan-basis with zero interest over a 4 years period (\$J280 /month). This repayment is going into a revolving fund. Since privatisation of JPSCo in 2001 the transfer of the assets and its value is in discussion.

It is estimated that about 20,000 houses remain for electrification, of which roughly 6,000 do not meet the required density standards for grid extension. The later ones are therefore prime targets for individual solutions based on solar electricity, small windpower systems or other options, which could include the use of renewable energy sources. Surveys deem necessary to get a more precise picture of the current energy use in rural areas and the expectations and financial capabilities of rural households.

¹¹ The Least Cost Expansion Plan (October 2004) refers to a price of 3.50 US\$/million BTU.

II. Renewable energy policy

1. Energy sector policy and strategy of 1995

In 1995, the Government of Jamaica approved and published an Energy Sector Policy and Strategy paper, which will be revised in the course of 2005.¹² This paper was essentially a description of the status-quo-situation and focussed as well on the potentials from indigenous energy supplies and energy efficiency measures. The paper defined as main objectives of the Energy Sector Policy to:

- Diversify the energy base;
- Encourage the development of indigenous energy resources (where economically viable and technically feasible);
- Ensure the security of energy supplies;
- Minimize the adverse effects of pollution caused by the production, storage, transport and use of energy, and minimize environmental degradation as a result of the use of fossil fuel.

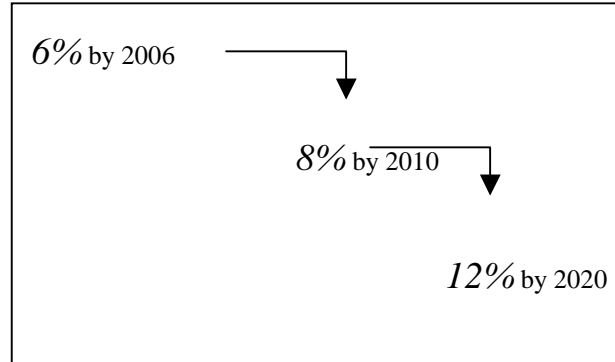
In order to achieve this objective the principle aim was to establish an appropriate regulatory framework to protect consumers, investors and the environment.

As one of the central pillars of the energy policy it was stated, that the use of cogeneration would continue to be pursued and principles under which the electricity company (JPSCo) purchases electricity from co-generators would be clearly established (see below).

Institutional and political support was thought to come from a central “Energy Conservation and Renewable Energy Unit” within the Ministry responsible for energy which would act as a facilitator for all new and renewable energy projects.

In 2000 the Government of Jamaica considered to produce 12% of all its electricity requirements from renewable energy sources by 2020 and established the following interim targets:

¹² A draft for the new policy of the Electricity Sector has already been released in June 2004.



2. Co-generation policy 1995 - 1998

As part of the official Jamaican Energy Policy, the then fully state-owned utility JPSCo established its co-generation policy in 1995. The company expressed its willingness to enter into multi-year contracts for the purchase of electricity from small-scale independent power producers operating plants of 2 MW or less electrical capacity (so-called “qualifying facilities”). Standard conditions for such facilities were designed to allow for fast-track agreement procedures, without the need of individual contractual arrangements. JPSCo agreed to take over the produced electricity into its grid up to a combined total of 20 MW and for contracts signed before the end of 1998.

At that time, JPSCo also expressed its interest in purchasing power from plants exceeding the size of 2 MW; but in such cases an individual contract was to be negotiated with JPSCo; and such plants would only be accepted if they were consistent with the current Least Cost Expansion Plan. Such plants were to be selected by a system of competitive procurement, as well as examination of the supplier's ability to integrate the operation of his system with the utility.

As pre-conditions for the purchase of any power from third-party operated co-generation plants, JPSCo defined that:

- a. The aggregate power available from these sources serves to postpone or avoid the need for new generating plant, or to improve the reliability of the system;
- b. The cost of the purchase of electric power through a long-term contract is no greater than the cost the utility would otherwise incur, except for a premium paid to users of renewable energy sources (see below);
- c. The combined efficiency (electrical and thermal) would be greater than that of the most efficient plant operated by JPSCo.
- d. The facility demonstrates that a minimum of 20% of the heat is used in some external application;
- e. That the operation of the project, as designed, produces a net foreign exchange benefit for the country; and
- f. The small producers comply with all applicable environmental regulations.

Standard purchase rates for a period of 5-10 years were established for qualifying facilities, incorporating both capacity and energy components, applicable depending on the provision of firm capacity at certain times of the day. The pricing scheme was based on JPSCo's avoided cost principle (cost no greater than it would have incurred in providing a similar amount

of power itself), allowing renewable energy co-generators to benefit from an additional premium of up to 15% above the “regular” level.

JPSCo declared to make supplementary, standby and maintenance power available to small-scale cogeneration operators, at rates, which reflected the cost of providing these services. Those special tariffs did not apply to co-generators or renewable energy producers whose own needs would otherwise be provided for under Rate 10 (Residential) or Rate 20 (General Service).

It was further determined that each Qualifying Facility shall be obliged to pay interconnection costs on a non-discriminatory basis with respect to other customers with similar load characteristics, including the cost of the provision of the transformer if necessary.

Despite such relatively favourable conditions for small-scale co-generators, this promotional scheme did not prove successful with only one smaller unit at a hotel being connected to the grid during the envisaged time period.¹³ Main reasons for the low grade of acceptance were the low power purchase rates, the comparatively short contractual period, the inexperience of potential co-generators (like hotel-owners and industries), the high up-front costs without sufficient bank crediting and the lack of technical capability to combine renewable energy resources with co-generation facilities (as e.g. in the case of biogas co-generation from organic residues in the food processing industry).

In contrast to this negative result for Qualifying Facilities, JPSCo contracted several independent large-scale producers on the basis of individual long-term purchase agreements for the supply of electricity to the public grid, using fuel oil.

3. Redesigning the jamaican energy policy

Ten years after the above-mentioned analysis, the need for the tapping of renewable energy sources is more compelling than ever before. The demand for all types of energy has increased substantially within the last decade, oil prices have soared up to the highest all-time level, consuming an ever larger percentage of GDP and foreign exchange income, and many natural resources still remain untapped or inefficiently used.

Beyond this, national and international private investors and financial institutions are more inclined to support renewable energy projects, while risks could be minimized and new financial resources were made available. A number of technical applications, which were judged as being economically unattractive 10 years ago, are now competitive or nearing equal opportunity on a commercial scale. Taking further into account the environmental and social benefits connected with a number of those alternative options, the advantage of many projects, which pursue the tapping of indigenous renewable energy sources, is evident.

The Government of Jamaica is therefore in the process of redesigning its energy policy. As a first step, a consultation paper on Electricity Sector Policy has been released in June 2004 by the Minister for Commerce, Science and Technology, opening the forum for further discussion. Other energy sectors will be targeted in a separate draft, elaborated under guidance of the Prime Minister’s office and due to be published in spring 2005.

¹³ The 2 MW project was commissioned at Braco Resorts, a Hotel complex located in Trelawny, in 1997. Excess electricity was delivered to the public grid. The diesel generators had to be dismantled due to a number of technical problems.

3.1 Draft for the electricity sector policy (2004)

In this paper, the Government reconfirms its commitment to reduce the dependence on imported energy through continued exploration for and development of indigenous energy resources. This includes renewable energy sources as well as fossil energy (like natural gas) extracted within the national borders of Jamaica. Special emphasis is given to the involvement of the private sector.

Of major importance is the point that all new generation capacity to come on stream in the future shall be subject of a competitive and transparent bidding process. This has to be seen in the light that the overall framework of the electricity sector has changed, since JPSCo has been privatized in 2001 and the electricity market was opened for competition in the generation sector in April 2004.¹⁴

A separate tendering is thought to take place for renewable energy projects whose overall target is set for 15% of the total installed capacity of the public electricity system in 2012. A simplified procurement process is provided for renewable and cogen capacity addition of 15 MW and less. Such facilities will qualify for a premium of 15% above the avoided costs of JPSCo's least cost facility.

The electricity sector policy maintains the term of Qualifying Facilities, as originally used in JPSCo's co-generation policy of 1995 (see above), but extends the definition to all small-scale power generators below 2 MW, with cogeneration or not. Such facilities will not be part of the Least Cost Expansion Plan (LCEP) and operators can refer to standardized power purchase agreements (7-10 years) without having to negotiate individual contracts or will get the option of net-metering, as in the case of grid-connected photovoltaic systems.¹⁵ A cogeneration plant will be required to demonstrate that its combined efficiency is greater than that of the most efficient thermal plant operated by JPSCo.

By the end of 2004 about 6% of the installed capacity of the public electricity system of 737 MW was based on renewable energy sources. Based on the Least Cost Expansion Plan 2004-2017 with average annual growth rates of 4.57 %, as approved in November 2004 (and further revised and extended in March 2005), in order to achieve the target of 15% renewable energy contribution of the total system capacity, more than 130 MW of additional RE capacity would need to be installed between 2005 and 2012 (see table 6).

TABLE 6
RENEWABLE ELECTRICITY EXPANSION UNTIL 2012
BASED ON THE CURRENT LCEP (MARCH 2005)

Year	Total system capacity ¹⁶ (mw)	Renewable energy target (percentage)	Renewable energy share based on capacity (mw)	Renewable energy share based on generation (gwh)
2004	737	6.0	44.0	
2006	861	8.0	69.0	210
2010	1 055	10.0	105.5	500
2012	1 170	15.0	175.5	820

Source: LCEP Addendum No. 1, March 2005; own calculation.

¹⁴ JPSCo. will keep the monopoly for transmission and distribution and continue to act as a single buyer until the end of its licence period in 2021.

¹⁵ Models for such standardized power purchase and net-metering agreements still have to be designed.

¹⁶ Excluding the renewable energy capacity.

An important role for the further promotion of renewable energy projects is assigned to the state-owned PCJ. To bring about new projects, PCJ or its subsidiaries may joint venture with the private sector as a minority equity partner. But the main role of PCJ shall be to develop renewable power generation projects and to seek for expression of interests from private investors to build, own and operate such facilities.

An important aspect for the future development of renewable electricity could also be the provision to enable non-discriminatory access to the transmission grid, so that self-generators of electricity could transport (wheel) electricity for own use from the generation to the (remote) consumption site at transparent rates, defined and approved by the regulating entity OUR.¹⁷ No legal barrier shall prevent an end-user to self-generate and use electricity for its own purposes.

The basic terms for rural electrification have been defined in the All-Island Electricity Licence for JPSCo in 2001. The utility and the state-owned Rural Electrification Programme Ltd. (REP) were instructed to periodically agree on the development plans proposed by REP. This includes as well off-grid electrification based on renewable energies.

The new energy policy provides that REP acts as a non-grid electricity supplier for rural regions outside of JPSCo's licensed area. REP will therefore fall under the regulatory supervision of OUR.

3.2 Model electricity bill (draft of July 2004)

Parallel to the formulation of a revised Electricity Policy, new electricity legislation has been designed on the background of a liberalized power market with new players entering the scene. This new legislation will replace several out-dated laws related to electricity sector regulation, in particular the Electricity Lighting Act of 1890 and its amendments.¹⁸

The model electricity bill, which has still not been approved by the parliament, refers to renewable energies as follows:

“59. (1) The Minister may, on the recommendation of the Office¹⁹ following consultation with the suppliers concerned, by order require each licensed supplier, before a day specified in the order, to make (in so far as he has not already done so) and produce evidence to the Office showing that he has made such arrangements as will secure the result mentioned in subsection (2).

(2) The result referred to in subsection (1) is that, for a period specified in the order, there will be available to the licensed supplier

(a) From renewable or indigenous generating stations; or

(b) If the order so provides, from generating stations of any particular description, an aggregate amount of generating capacity which is not less than that specified in relation to him in the order; and an order under subsection (1) may make different provision for different suppliers.

(3) Prior to setting targets in terms of (2), the Minister shall consult with the Office as to the measures to be taken or planned, at national level, and shall authorise the Office to take such measures as the Office reasonably considers most likely to achieve such national indicative

¹⁷ No transmission rates for electricity transport had been disclosed by OUR by the end of 2004.

¹⁸ The proposed law is based on examples from the UK Electricity Act 1989, the Hong Kong Electricity Ordinance 1999 and the India Electricity Act 2003.

¹⁹ This means the regulator OUR.

targets at minimum economic cost taking into account the duties of the Minister and of the Office in 4(1).

(4) The Minister may require the Office to publish, for the first time not later than the first anniversary of the setting of targets in terms of (1) and thereafter every two years, a report which includes an analysis of success in meeting the national indicative targets taking account, in particular, of climatic factors likely to affect the achievement of those targets and which indicates to what extent the measures taken are consistent with the national climate change commitment.”

With this paragraph, the Government would therefore be capable of setting defined targets for renewable energy power plants with respect to the total generating capacity, which the electricity suppliers would be obliged to accomplish. But the act further rules that in making such a direction the effect of the additional cost of such purchases on customers' bills must be taken into account. Periodical reports about the achievements of the targets will prepare the basis for the Government to reconsider its objectives and policy instruments.

For hydropower projects, the draft of the Electricity Bill stipulates, that the OUR “*may require through licence conditions any licensed generator who owns, operates or plans to operate a hydro-electric generation to operate such station in such manner as will reasonably protect the interests of users of water downstream of the generation station in respect of such water.*” (Paragraph 65)

The draft of the Electricity Bill further contains a model Power Purchase Agreement, which is likely to form the basic principle of future tendering processes for larger generation capacities, including those based on renewable energy resources.

III. Wind energy

Jamaica, like many of the Caribbean islands, has a reasonable wind potential which has scarcely been tapped up to date. First experiences with modern turbines could be collected since 1995, when the Danish company Vestas donated a 225 kW machine to the Munro College.

Since 1995, the PCJ has been studying the feasibility of a wind farm project. Wind speed assessments have been conducted at various sites across the island, including:

1. The *Palisadoes Strip* near Norman Manley Airport
2. *Green Castle* on the north coast, near Robins Bay and west of Annotto Bay
3. *Spur Tree* on the Manchester Plateau
4. *Blenhiem* on the Manchester Plateau
5. *Wigton* on the Manchester Plateau.

The site near Wigton in the parish of Manchester proved to be the location with the highest medium wind speed. The first wind farm in Jamaica was actually located at this site and commissioned in May 2004, adding to the very few plants already in operation in the Caribbean.²⁰ The project has been developed jointly by PCJ and the British developer Renewable Energy Systems Ltd (see Box 2 in the Annexes section for project details).

The wind measurements taken at Blenhiem between June 1997 and October 1998 showed average speeds of 6.3 m/s at a height of 40 m. Most of the wind measurements were not continuous or were not conducted over a sufficiently long period of time.

The preliminary results have proven however, that Jamaica has sufficient wind potential for energetic purposes, mainly along the southern coast. Beyond the existence of an adequate wind regime during most of the year, criteria for the use of wind energy at specific sites are mainly:

- The accessibility by road or other transport means for the supply of the turbines

²⁰ 12 MW are operating in Curaçao, 35 MW in Costa Rica, about 15 MW on Guadeloupe, and 19.5 MW on the Caribbean Coast of Colombia.

- Land ownership and sufficient land space for wind farms
- Proximity to the high voltage transmission grid
- The topography at the site and in the vicinity
- The required distance from dwellings
- Suitability of soil conditions for the foundations.

PCJ estimates that at least another three wind farms at various other sites could be developed with about 20 MW each. It cannot be verified at this stage, if this assumption is realistic. Further long-term wind measurements would be required for those sites, which match the general preconditions, listed above. From the electrical point of view, a wind capacity of up to about 15% of the total maximum load would not interfere with requirements for allowed voltage and frequency fluctuation.

While currently the first pilot turbines of 5 MW capacity have been installed in Germany, the manageable size in Jamaica will be limited for the time being to a maximum of 1 to 1.5 MW due to transport conditions and crane availability for mounting of the turbine. In some time in the future and after further experience with wind use on land, investigation could also be started on installing turbines off the coast of Jamaica in shallow waters.

Prices for wind turbines and transport range at about US\$ 1 million per MW of rated capacity, excluding costs for roads and other civil works, grid connection, planning and financing, which make up about one fifth of the total investment. Since the turbines have to be completely imported, duty tax exemptions can be decisive for the commercial success of future wind power projects. For operation and maintenance as well as spare parts an annual percentage of 3 to 5% of the investment costs needs to be taken into account.

Since JPSCo has declared explicitly that it will not invest in wind energy, further wind farm projects will depend on third-party engagement by private developers and operators, possibly in joint-venture with the state-owned PCJ. As long as no model power purchase agreements and clear rules exist for the remuneration of electricity supplied to the public grid, such contracts will have to be negotiated with JPSCo on a project-to-project basis.

Wind energy applications are generally well suited projects for CDM financing. Due to their higher generation costs compared with fossil fuel-based plants, the application of wind turbines is in accordance with the additionality criteria required for CDM projects.

The utility of Medellín²¹ in Colombia has successfully placed its wind farm at Jepirachi on the Caribbean coast within the Prototype Carbon Fund (PCF) of the World Bank in 2004.^{22,23} The average net generation costs in this case have been calculated at US\$ 38.35/MWh and were higher than comparable production with fossil plants.

Baseline emissions are reflecting reality best if calculated based on the projected growth scenario for electricity demand and the anticipated dispatch system for the plants in the system

²¹ Empresas Públicas de Medellín. All relevant documents for this project can be accessed on the website of the Prototype Carbon Fund (<http://prototypecarbonfund.org/>).

²² A minimum CO₂ reduction of 1.168 million tonnes over a 21 year period has been projected, displacing fossil fuel thermal power as the most expensive dispatchable electricity. The output of the wind farm is estimated to be 68.3 GWh per year. Note that in size and wind regime this project is very similar to the Wigton Wind Farm in Jamaica.

²³ Several other wind projects in the region have also submitted applications to the Prototype Carbon Fund, namely the projects Chorotega and Vara Blanca in Costa Rica and the Cruz Azul wind farm in Oaxaca, Mexico.

and those that are envisioned to be added. A sound long-term capacity expansion plan (as has been recently established by Jamaica) and accepted CO₂ emission data (in the case of fossil plants) are a fundamental prerequisite for such calculations. It can generally be assumed that wind power, as non-dispatchable electricity, will displace always the most expensive units at the margin.

Of course it is in the nature of this topic, that emission reductions over time periods of up to 21 years can only be projected by narrowing simulations and will never be fully in line with future actual outcomes.

For wind energy (as well as a number of other renewable energy) projects like the Wigton Wind Farm, the CDM Executive Board has approved and published in September 2004 a new “Consolidated baseline methodology for grid-connected electricity generation from renewable sources”. This methodology has been developed by combining the techniques of different individual CDM proposals, of which the Wigton Wind Farm was one.

IV. Hydropower

Due to its topography and climate Jamaica has various rivers suitable for the exploitation of hydropower. Electricity generation by using run-of-river plants has been a common operation on the island for the last 100 years.

Currently there are 8 plants in operation, all owned and maintained by JPSCo and providing base load capacity for the public grid during the rainy seasons (see table 7). All hydropower plants combined contributed with only 4% to the public electricity generation in 2003. Frequent droughts limit the supply of firm capacity during some periods of the year. Most of the systems are fairly old, with the youngest ones being more than 15 years in place.

**TABLE 7
INSTALLED HYDROPOWER CAPACITY IN JAMAICA**

Location	Year of commission	Capacity (mw)
Upper White River	1945	3.8
Lower White River	1952	4.9
Roaring River	1949	3.8
Rio Bueno A	1949	2.5
Maggotty Falls	1966	6.3
Constant Spring	1989	0.8
Rams Horn	1989	0.6
Rio Bueno	1989	1.1
Total		23.8

Source: own elaboration.

In February 2003 JPS completed a comprehensive rehabilitation of its hydroelectric units, which contribute currently a total of 21.4 MW to the grid. The rehabilitation project, which started prior to privatization, was implemented in partnership with the German Government (through its development bank KfW) at a cost of US\$ 27 million.

A number of studies mandated by PCJ have shown that the hydroelectrical potential could be further exploited by constructing a number of small-scale plants. The total technical potential is estimated to be in the range of more than 80 MW, including one large-scale facility at Back Rio Grande (see table 8).

TABLE 8
PROPOSED HYDROPOWER PROJECTS

Location	Capacity (mw)	Annual generation (gwh)	Investment (US\$)	Status
Back Rio Grande	50.0			Hydroelectric development feasibility study 1986-1991; environmental barriers seen by the water resources authority
Great River	8.0			Feasibility study 1985
Laughlands Great River	1.3	8.44	2 million	Re-analysis in 2001; re-assessment with flow measurements in 2004/2005 (gtz/credp)
Rio Cobre	1.0	4.1 4.45 (alternative)	3.5 million (1995) 2.9 million (alternative)	Feasibility study 1985; pricing updated in 1989; updated feasibility study in 1995
Spanish River	2.5		4.7 million for 2.2 MW (review: 5.5 million)	Project status report 1996; feasibility study review 1996; part of the equipment (30%) has been delivered by Italy several years ago, but was not put in place due to economic reservations; Chinese developer has shown interest in using the parts and set up a plant, possibly at a different location
Negro River	1.0			
Yallahs River	2.6			
Wild Cane River	2.5			
Morgan's River	2.3			
Green River	1.4			
Rio Grande	3.6			
Dry River	0.8			
Martha Brae River	4.8			
<i>Total</i>	<i>81.7</i>			

Source: own elaboration.

While the technical feasibility has been proven in most cases, the economic assessment resulted in negative decisions in the past, with high specific investment costs involved and low comparative electricity costs from conventional plants. This picture may change nowadays on the background of boosting oil prices and subsequently increasing electricity generation costs. Some of the previously selected sites are therefore re-evaluated as in the case of the Laughlands Great River Hydropower Project.²⁴ Some of the potentials could be downscaled due to reduced flow data as a result of changing precipitation²⁵ and competing up-stream water uses for irrigation and fresh-water supply.

²⁴ A feasibility study has been mandated at the end of 2004 in the framework of the GTZ Caribbean Renewable Energy Development Project. The study includes long-term measurements and will not be completed before the end of 2005.

²⁵ The Water Resources Authority reports that no change in average precipitation has occurred in recent years, as well as no change in the total water flow. But the occurrence of more peaks and bottoms is noticeable, due to soil degradation as consequence of deforestation and extended agricultural use.

Realization of the largest hydropower plant at the Back Rio Grande, which has been assessed in great detail, is rather doubtful, due to restrictions from the environmental and touristic side. This project has received considerable attention in the past, since it has a high potential for firm capacity (45.6 MW), while all other schemes combined are estimated to have a firm capacity of not more than 6 MW.

One of the more recent hydropower studies (1995) concerns with the feasibility of a run-of-river plant at the Rio Cobre Plant. This plant with two submersible turbine-generator units was estimated to cost about US\$ 2.9 million, the total avoided cost was calculated at 7.5 US-cents/kWh.

Beyond the listed projects a systematic new assessment of the existing potentials may identify further sites to be applicable for housing hydropower plants. According to the Water Resources Authority, daily stream flow data are available for all about 100 streams (an equal number of gages is installed), so that there is only limited need for additional measurements. In particular very small hydro plants for remote settlements or industrial and agricultural facilities could find new applications.

Legislation requires a license for all types of water uses, issued by the Water Resources Authority. The license is granted for a period of 5 years, but can be extended thereafter. In competing situations preference is given to fresh-water use over any energetic purposes. All environmental aspects have to be solved with the National Environment Protection Agency (NEPA).

All proposed projects would have to be realized with private capital, since JPSCo has signalled no interest in operating further small-scale hydropower stations.

V. Biomass energy

1. Sugar industry in Jamaica

The production of the Jamaican sugar industry has been in a state of decline and uncertainty for the past three decades. The levels of production, productivity and contribution to the macro-economy have experienced significant setbacks.

During the crop season 2002/2003 production of 96-degree sugar was down to a historic low of 152,000 tonnes from seven factories (5 state owned, 2 private), compared to 176,000 tonnes in the previous season and more than 250,000 tonnes in the calendar year 1980.²⁶ In the harvest period 2003/2004 the situation improved somewhat with a production of approximately 195,000 tonnes of sugar from 2.1 million tonnes of cane, supported by a better quality of sugar cane supplied to the mills.²⁷

TABLE 9
PRODUCTION STATISTICS: SUGAR CANE AND DERIVATES, 1999-2003

	Unit	1999	2000	2001	2002	2003
Cane Milled	'000 tonnes					
Total		2 313.0	2 025.0	2 231.0	1 965.5	1 775.7
Farmers		1 127.0	920.0	949.0	852.0	748.5
Estates		1 186.0	1 105.0	1 282.0	1 114.0	1 027.3
Sugar Production	'000 tonnes					
Calendar Year		207.0	203.0	199.0	170.0	124.6
Crop Year (Dec. previous year – April)		204.0	216.0	204.0	174.6	152.5
Acreage Reaped (Industry)	'000 hectares	37.6	39.4	36.0	34.2	30.6
Tonnes Cane per Hectare	'000 tonnes	60.8	51.8	52.2	57.4	58.5
Tonnes Cane per 96 Sugar		11.3	9.4	10.9	11.3	11.6
Tonnes Sugar per Hectare		5.4	5.5	5.7	5.1	5.0
Molasses Production	'000 tonnes	86.1	76.3	85.9	79.8	68.5

Source: Based on data supplied by the Commodity Boards, the Ministry of Agriculture and the Sugar Industry Authority.

²⁶ Sugar production peaked in 1965 with an output of 506,000 tonnes of sugar. By 1977, sugar production had declined to 296,000 tonnes.

²⁷ Close to 1.5 million tonnes of cane were processed in the state-owned factories alone.

Of the 2002/03 crop about 129,000 tonnes of sugar were exported, while about 100,000 tonnes were imported, mainly in the form of refined sugar for the national food industry (in first place carbonated beverages).²⁸ It is still the second largest export commodity in terms of earnings, exceeded only by bauxite, and remains the largest employer of labour with 41,000 workers in the crop season (accounting for 16 to 18% of agricultural employment). The by-product molasses is completely used within the jamaican rum industry.²⁹

The sugar industry depends almost completely on protected and guaranteed markets through Preferential Agreements with the European Union. The price received for its raw sugar is more than twice that prevailing on the world market. Not surprisingly, the current cost of production is far from being competitive on the world market and even among Jamaica's direct co-producers from other ACP countries.

Current estimates show that there are approximately 46,000 hectares designated sugar lands.³⁰ The average yield of about 60 tonnes of cane per hectare is well below other countries (compared to 70 tonnes in Kenya and Mexico and 84 tonnes in Columbia).³¹ The ratio of cane milled to raw sugar production is about 10.8, higher than in comparative countries.

A fixed amount of 126,000 tonnes of sugar is being exported to the European Union at beneficial prices under an agreement (Sugar Protocol) with ACP countries. Another 18,600 tonnes can be exported to EU countries under the Special Preferential Sugar (SPS), an addendum to the Protocol. The rest of the production is consumed internally.

Due to the low-cost production of sugar in the new EU member states it is assumed that the price paid by the EU³² will be reduced after 2006 by an initial 10 to 15% and the SPS agreement will cease by 2008.³³ This will put additional pressure on the industry to reduce production costs and diversify its market.

The objectives of the Government of Jamaica and its sugar industry, established in a sectoral policy in 1999, to improve this sector significantly within a period of 5 years, have been almost completely missed. The policy document called for the production of 311,000 tonnes of 96-degree sugar from 3,155,000 tonnes of sugar cane at a ratio of 10.14. Acreage harvested and average yield were established in the policy at 42,000 hectares and 75 tonnes per hectare. All those targets could not be achieved.

Depending on different scenarios, projections of 2003 for the total future sugar demand until 2008 show a high of 273,000 tonnes³⁴ and a low of 179,000 tonnes (about the existing level).

²⁸ An absurd situation, but the price achieved from sugar exports is higher than the price for sugar imports. Sugar refining was discontinued in Jamaica in 1997.

²⁹ In 2003 about 100,000 tonnes of molasses were produced within the sugar process and used for the rum industry, another 10,000 tonnes had to be imported. Molasses is produced from 4% of cane conversion at the current level of efficiency in Jamaica. This rate could be lowered with improved technical processes.

³⁰ About 36,000 hectares are under cultivation for the state-owned sugar mills alone. In 1975, well over 55,000 hectares of land was under sugar cane farming.

³¹ Sugar cane yields can vary significantly from year to year depending on precipitation, if fields are not irrigated artificially.

³² The price has remained the same since 1984 at 523.70 Euros per tonne, well above world market price.

³³ The EU Commission has proposed a 37% price cut, gradually applied over three years, starting in July 2005. This would transfer into a loss of about US\$ 37 million in export earnings per year for Jamaica.

³⁴ Includes coverage of currently imported refined sugar.

Jamaica's sugar factories are not very efficient in terms of productivity and energy consumption. They all operate far below their potentials. The following table shows the rated capacity to be achieved after upgrading the sugar factories.

TABLE 10
CAPACITY OF JAMAICA'S SUGAR FACTORIES³⁵

	Rated Capacity <i>(tonnes of sugar)</i>	Rated Capacity <i>(tonnes of cane)</i>	Tonnes of Cane per day (TCD)
Frome	90 000	1 080 000	6 000
Monymusk	65 000	780 000	4 333
Bernard Lodge	50 000	600 000	3 333
Trelawny	30 000	360 000	2 000
St. Thomas	25 000	300 000	1 667
Appleton ^(p)	50 000	600 000	3 333
Worthy Park ^(p)	26 000	312 000	1 733
Total	336 000	4 032 000	22 400

Source: The Sugar Company of Jamaica; own calculation.

^(p) private.

By far the largest sugar mill is Frome (see Box 1 in the Annexes section for details) with a possible production capacity after rehabilitation of 90,000 tonnes of raw sugar per annum (or more than 1 million tonnes of cane). Currently this factory alone is milling about 650,000 tonnes of cane annually (equivalent to one third of the national cane harvest).³⁶

2. Cogeneration from bagasse

2.1 Facts and figures on bagasse co-generation

The residues of the sugar production contain significant amounts of energy. It is state of the art to use at least the fibrous material that is left after juice extraction (bagasse) for process heat and power generation, while the leafy parts are in most cases left on the fields.

Each tonne of sugar cane yields between 250 and more than 300 kg of bagasse, depending on the fibre content of the cane which normally ranges from 12 to 19%.

³⁵ Slightly lower total figures are given in the inception report of the Sugar Ethanol Study by J.P. Mukherji & Associates (Dec. 2004). Especially for the two private factories the rated capacity is estimated to be significantly lower.

³⁶ Output in the harvest season 2002/2003 was 56,000 tonnes of sugar.

TABLE 11
1 TONNE OF SUGAR CANE CONTAINS:³⁷

	Weight (kg)	Energy content (MJ)	
Sugar	153	2 546	Ethanol
Bagasse (50% moisture)	276	2 504	Fuel for co-generation
Straw (15% moisture)	165	2 144	Fuel for co-generation
1 barrel of oil		7 194	
		5 803	

Source: own elaboration.

→ 1 tonne of sugar cane is equivalent to about 1.2 barrels of oil

The net calorific value of bagasse with a moisture content of 50% is 7,620 kJ/kg. One tonne of fresh bagasse is therefore equivalent to about 1.6 barrels of oil. The moisture content is the most crucial parameter in that, the lower the moisture content the higher the calorific value. Bagasse with 45% moisture content can be obtained from sugar factories with good milling processes. Poor milling performance results in bagasse with 52% moisture.

The amount of energy that can be extracted from bagasse is largely dependent on the technology used for energy production. Bagasse with a moisture content of 50% and burnt in a boiler of 50% efficiency will result in about 1,050 kWh of energy per tonne.

Basically, the available energy from bagasse combustion is by far exceeding the demand for the processing of cane and the sugar production. Therefore, in most sugar producing countries excess bagasse is being treated as waste and incinerated in low-efficient boilers, largely as a process of disposal.³⁸ Process steam and power are in this case treated as a by-process of the disposal exercise. Conventional cogeneration deploys a low-pressure boiler (20-25 bar) in conjunction with an extraction-condensing and/or back-pressure steam turbine coupled to an electrical generator. The resultant system efficiencies are less than 10%.

A number of sugar factories, e.g. in Brazil, already use high pressure/high temperature boilers, which provide much higher electricity outputs than the technologies currently used, as in the case of Jamaica. System efficiencies of up to 25% can be achieved for steam pressures of 45-66 bar, permitting electricity exports of up to 100 kWh per tonne of cane.

TABLE 12
COMPARISON OF BOILERS

	Low temperature and pressure	High temperature and pressure
Power generation (kWh/tonne of cane)	20-30	90-160
Net power from bagasse (kWh/tonne of bagasse)	60	370-510
Heat rate, processing (kcal/kWh)	21 000	6 000 – 8 000

Source: Gollakota & Sobhanbabu (2002).³⁹

³⁷ Actual figures can vary depending on type of sugar cane and ripeness.

³⁸ There is a limited option of using bagasse as animal feedstock and in the paper and pulp industry.

³⁹ Gollakota, S.V. & Sobhanbabu, P.R.K. (2002). Accomplishments of the USAID-India's GEP-ABC Component. Proceedings of the 3rd International CHP and Decentralized Energy Symposium & USAID.

Plant performances of 110 kWh and more surplus electricity per tonne of cane, based on high-pressure boilers with steam of 82 bar and 525°C are operational in Réunion, India, Mauritius and Brazil.⁴⁰ The only two factories in Réunion are equipped with two 30-35 MW power plants each and crush about 900,000 tonnes of cane annually per facility. The plant of Belle Vue in Mauritius, commissioned in 1999, has been able to increase the amount of electricity exported to the grid from crushing 850,000 tonnes of sugar cane from almost nothing to 110 GWh. The installed capacity is 70 MW. The electrical energy produced is 150 kWh per tonne of sugar cane, of which 130 kWh are exported.

In order to maximise the amount of electricity sold to the grid, it is also important to minimise the process use of steam and power through the use of energy conservation techniques and management as well as energy efficient equipment.⁴¹ Such policies can include the conversion of mills from steam-driven to electricity-driven, use of steam-saving equipment in boiler houses and the installation of energy-efficient pumps and motors.

Another challenge that needs to be addressed is the supply of electricity in the off-harvest season, which lasts from May to November in the case of Jamaica. The sales price of electricity can generally be improved, if electricity can be supplied year-round on the basis of a high availability of firm capacity. On Mauritius a first plant using coal for the same furnace as bagasse out of the crop season was put into operation as early as in 1982. In Nicaragua a sugar mill cogeneration plant using eucalyptus during the off-harvest season has been commissioned in 2000. The 15 MW plant requires 60,000 tonnes of woodchips per season, for which 590 hectares of trees have to be cut annually

Enhanced electricity generation could become possible if the current research on gasification technologies in conjunction with a combined cycle power plant (BIG/CC – Biomass Integrated Gasifier / Combined Cycle) proves successful. The available capacity and electric energy could at least double in comparison with modern high-pressure boilers.

A number of policy measures have led to the uptake of several advanced bagasse cogeneration projects in Mauritius during the last two decades. They included:

- Performance linked rebates on export duty payable by millers for efficiency in energy conservation to generate surplus bagasse and in energy generation, preferably firm power;
- Income tax exemption on revenue derived from sale of power, and capital allowances in such investment;
- Raising of tax-free debentures;
- Centralisation of cane-milling activities spelling out the guidelines for mills;
- Bagasse energy pricing.

Advanced bagasse cogeneration can be subject to CDM financing, since the basic criteria of additionality and sufficient CO₂-mitigation are easy to fulfil. One of the best documented and already validated projects is at the Vale do Rosário sugar mill in the state of Sao Paulo (Brazil), where an additional 35 MW electrical capacity could be provided through the installation of a new high-pressure boiler.

⁴⁰ Jeremy Woods (Imperial College London) is giving the following figures for surplus electricity:
 - 20 kWh/tonne of cane for cogeneration with 20 bar and 350 °C.
 - 92 kWh/tonne of cane for cogeneration with 45 bar and 440 °C
 - 143 kWh/tonne of cane for cogeneration with 82 bar and 525 °C.

⁴¹ The electricity demand alone ranges between 15 and 34.5 kWh per tonne of cane crushed.

2.2 Improved use of bagasse for cogeneration in Jamaica

Total bagasse output is currently at the order of 600,000 tonnes per annum (2003), equivalent to about 940,000 barrels of oil with a value of US\$ 37.5 million.⁴²

All jamaican sugar mills are equipped with cogeneration units of low efficiency⁴³ for self-supply of heat and power by burning bagasse, while at certain times even additional oil and electricity has to be purchased from outside or electricity is produced in own diesel plants. Typically, the boilers were designed to have an efficiency of less than 50%, as to maximize the amount of bagasse being fired. Excess bagasse was not desired when the plants were built and selling electricity to the grid was not an option.

As was shown above, the production process and electricity generation could be improved to such an extent, that at least 110 kWh excess electricity per tonne of cane crushed would be available for delivery to the public grid. If extended to all factories and the complete harvest, this would accumulate more than 220 GWh during the harvest season. Basic requirement is that the energy consumption for all processes within the sugar production is reduced to the lowest level possible.

Based on the assumption that the sugar cane production would need to be extended for the supply of bioethanol (see next subchapter) to about 2.7 million tonnes of cane,⁴⁴ a rough estimation shows that excess electricity at the order of at least 300 GWh per year would be available with bagasse combustion alone, resulting in about 68 MW of available capacity.^{45,46}

Due to the harvest period of only about 185 days per year and in order to secure firm capacity at the highest availability possible, additional fuelwood and/or coal or other biomass resources need to be fed into the furnaces during the rest of the year.⁴⁷ The necessary feedstock for most of the demand could come from dedicated energy plantations.

The study “Cogeneration in the jamaican Sugar Industry” (Sept. 2002, by David Barret) had shown that it is possible to harvest about 90 tonnes of (green) wood per hectare and annum, based on a five year crop cycle. The state company (Sugar Company of Jamaica – SCJ) and private farmers could supply wood to the factories, using species of fast growing trees, such as Cassia, Acacia, Leucaena and others. The study indicated that the fuelwood could be produced for US\$ 8.90 per tonne and sold to the cogeneration plants for US\$ 15.00 per tonne. If all state-owned factories had similar cogeneration facilities like the one proposed for the Frome sugar mill, fuelwood would be a \$J 390 million per year business with an annual profit of \$J 173 million.

⁴² In the harvest season 2003/2004 the bagasse output was up to 695,000 tonnes due to a better sugar cane harvest.

⁴³ System efficiencies of less than 10%.

⁴⁴ This figure does not take into account the substitution of imported refined sugar by national products with about 1 million tonnes of sugar cane required.

⁴⁵ Note that for ethanol production and subsequent effluent treatment the electricity consumption is somewhat higher than for sugar production alone. The capacity calculation is based on a crop period of 185 days.

⁴⁶ This estimation is well in line with figures given in the inception report of the Sugar Ethanol Study by J.P. Mukherji & Associates: Based on 3.36 million tonnes of cane, a supplemental biomass feedstock and for a boiler with 63 bar and 510°C they estimate the available power export at 375 MWh/a with a total installed capacity of 84 MW and an export capacity of 47.4 MW.

⁴⁷ If pelletizing at least part of the bagasse for consumption during the off-harvest period or for sale, as proposed by some experts, is a viable option needs to be analyzed.

In case of 2.7 million tonnes of sugar cane per annum, the boilers would need a supplemental annual feedstock of about 226,000 tonnes of fuelwood that could be harvested from a plantation area of about 12,600 hectares.

According to Gibson Energy Ltd., the SCJ mills alone could provide up to 85-95 MW of new capacity. More than 266 GWh of electricity per year could be supplied to the grid from burning bagasse.⁴⁸ Out of the harvest season, an additional over 280 GWh could be supplied from burning fuel wood and over 140 GWh from coal.⁴⁹ The annual CO₂ emissions would be reduced by about 500 million lbs.

The installation of about 94 MW of new capacity would cost an estimated US\$ 142 million (only the five state-owned factories). The sale of electricity would bring in an estimated US\$ 44.7 million in annual revenue (with sales price of 6.5 US-cents/kWh). Net profit from cogeneration would be US\$ 20.5 million per year.

The efficient burning of bagasse in all five state-owned sugar factories would reduce the consumption of oil by about 22.3 million imp. gallons per year. The use of alternative fuels (wood) and supplementary coal would reduce the national oil consumption further by an additional 35.3 million imp. gallons.

Further renewable energy potentials in the sugar industry could be exploited with the use of the other residues of the sugar cane (leaves) and with the application of the gasification technology which could double the amount of electricity with regard to the current best technologies.

Essential for the improved use of bagasse for cogeneration and supply of export electricity is a long-term power purchase agreement with reasonable rates and the unrestricted access to the public grid. Fundamental is also that the future sugar production (or other derivatives of sugar) and therefore the flow of sufficient biomass is secured. A limiting and cost-increasing factor could be the relatively small size of some of the sugar factories.

If the investment and operation of the new co-generation plants is being done by the mill owners or external service companies is not a decisive issue, but the involvement of additional capital and expertise could speed up the implementation process.

3. Bioethanol perspectives

3.1 Perspectives and requirements of bioethanol production

There have been increasing initiatives to formalise ethanol fuel programmes in countries in the region. Most clearly in Costa Rica and Guatemala, several countries – at the government level and in coordination with the sugar sector – are implementing proposals for the mandatory adoption of gasoline/ethanol blends. The basic goal for the business community is to improve the flexibility and scale of production of its agro-industry whereas the governments are focusing on advantages in regard to the environment, reducing imports, creating jobs and energizing the economy.

There are clear advantages for the bioethanol production (see Box 3 in the Annexes section for details) and its use in the jamaican transport sector:

⁴⁸ Note that this is more than the figure above, calculated on the basis of other reference information.

⁴⁹ SCJ gives preference to such cogeneration solutions which are based 100% on renewable energy and do not require the use of additional coal.

- It could help stabilise the agricultural sector and the sugar market and make it independent from sugar price volatility and export demand
- Sustainable jobs would be created on the island⁵⁰
- The dependence on oil imports and the need of foreign exchange would be reduced (US\$ 22.8 million in 2010 at market prices of US\$ 40 per barrel)
- The production costs could be kept low due to established technology and an existing sugar cane market
- An indigenous and renewable resource would contribute to the fuel mix
- Air pollution as well as greenhouse gas emissions would be lowered, thus offering opportunities for CDM financing⁵¹
- Ethanol can act as octane enhancer and oxygenate and substitute imported MTBE directly or in the form of ETBE (see below).
- No car engine modifications are necessary for blends of up to 10% ethanol
- The mileage performance of “low-share” ethanol/gasoline blends (E-10) is essentially the same as for pure gasoline.

The main disadvantages are:

- The sugar cane yield is depending on the climate and other variables and can differ from year to year as do the world market prices for sugar. This affects the willingness of the sugar industry to either prefer the production of sugar or ethanol.
- The establishment of a new ethanol production and distribution infrastructure is capital intensive and will certainly need private sector investments
- In the initial phase, the introduction of ethanol might need fiscal incentives in the form of tax allowances for production facilities, reduced tax rates for ethanol purchase and subsidies for the purchase of ethanol cars (with modified engines for higher blends or neat ethanol fuel).
- The success of the introduction of ethanol will depend on the development of the world oil market price.

It needs to be seen if bioethanol under jamaican conditions can compete with gasoline that is currently sold for about 40 \$J per litre (US\$ 0.70) to the customer at the petrol station.

⁵⁰ In Brazil some 720,000 direct jobs and 200,000 indirect jobs in rural areas have been created.

⁵¹ Actually under Brazilian typical production and demand conditions bioethanol avoids the emission of 2.6 tonnes of CO₂-equivalent per m³ for the anhydrous grade while for the hydrous grade the value is 1.7 tonnes of CO₂-equivalent per m³. For further information see: Government of the State of São Paulo, Assessment of greenhouse gas emissions in the production and use of fuel ethanol in Brazil, April 2004. The US-based Argonne National Laboratory estimates that a 2% reduction in greenhouse gas emissions per vehicle mile travelled is achieved when corn-based ethanol is used in gasohol (E-10), and that a 24 to 26% reduction is achieved when it is used in E-85. As a reference see also: PEW Center: Reducing Greenhouse Gas Emissions from U.S. Transportation, May 2003.

Fiscal incentives could provide reduced tax rates on the bioethanol content of the mix fuel and/or tax credits for investments in ethanol production facilities.⁵²

The proximity to the US as well as to Brazil and their car and fuel markets will probably facilitate the introduction of low-blend gasohol (E-10) and a later extension of fuel ethanol for cars operating with high-blend petrol (e.g. E-85) or with “flexible fuel” engines. In this context, options should be assessed if the import of low-cost bioethanol from Brazil could help to stimulate the introduction on the Jamaican fuel market.⁵³

A long-term strategy would require the introduction of a Renewable Fuels Standard (RFS) setting targets for the share of transport fuel based on domestic renewable resources.⁵⁴ Creating an RFS would provide a positive roadmap for reducing consumer fuel prices in the long-term, increasing energy security, giving planning security for farmers and fuel producers, saving foreign exchange and stimulating rural economy.

The European Union has set such goals with its directive 2003/30/EC in 2003.⁵⁵ The indicative target to be achieved by all member states is a contribution from all types of biofuels in the transport sector of 2% (with regard to energy value) by the end of 2005 and 5.75% by 2010. All member states are obliged to establish within this framework own national objectives. Many of them have already introduced favourable tax regimes for biofuels based on the EU directive 2003/96/EC.^{56,57}

For a detailed review of ethanol programmes around the world, see Box 4, in the Annexes section.

3.2 Jamaica’s experience in the ethanol business

Jamaica has some experience with ethanol, even though this is limited to the dehydration of imported wine ethanol from the EU, and more recently cane ethanol from Brazil. On a regular basis the EU Commission is intervening in the European wine production and distilling and storing surplus amounts as wine alcohol. The 150,000 to 250,000 m³ of alcohol annually are normally sold in public tenders far below costs. An important (intermediate) market with specific rules has been in the Caribbean. Since the cessation of the EU wine ethanol export to the

⁵² For an overview on the various types of incentives view the following publication: California Energy Commission, Ethanol Fuel Incentives Applied in the U.S., January 2004. The U.S. is currently providing an excise tax reduction for ethanol fuel on the federal level: The regular tax on gasoline is 18.3 ¢/gal, and is paid at the terminal by refiners and marketers. If the fuel is blended with 10% ethanol, the tax is reduced to 13.2 ¢/gal. As an alternative, the law allows refiners to claim an income tax credit of 51 ¢/gal of ethanol used to produce ethanol-blended gasoline (equates to 5.1 ¢/gal for a gallon of gasoline blended with 10% ethanol).

⁵³ Proposals already exist to import hydrous ethanol from Brazil so that Jamaica would act as a „hub“ for the US market by dehydrating those quantities in replacement of the current wine alcohol from the EU. A direct import from Brazil would not be compatible against U.S. produced ethanol with import taxes standing at US\$ 0.54 per US gallon, while the upper limit of 7% of the U.S. ethanol consumption for CBI imports is by far not reached with current supplies.

⁵⁴ A first initiative to introduce such Renewable Fuels Standard in the U.S. as part of the Energy Bill failed in 2002.

⁵⁵ Directive 2003/30/EC of May 8, 2003 on “Promotion of the use of biofuels and other renewable fuels for transport”

⁵⁶ For member states reports (2004) on the implementation of the EU directive 2003/30/EC view the website http://europa.eu.int/comm/energy/res/legislation/biofuels_members_states_en.htm.

⁵⁷ Directive 2003/96/EC of October 27, 2003 on “Restructuring the Community framework for the taxation of energy products and electricity”

Caribbean countries in mid 2004 due to the development of a bio-fuels market in the EU, the Jamaican dehydration plants have turned to Brazil for a new source of ethanol feedstock supply.

Several countries in the region including Jamaica built dehydration facilities⁵⁸ to produce anhydrous ethanol in order to benefit from the 1983 Caribbean Basin Initiative (CBI) trade protocol, which permitted exports of alcohol to the US, processed or dehydrated in the Caribbean.⁵⁹ Although the Caribbean countries that qualify for this duty exemption have approximately 300 million gallons per year of indigenous ethanol production, the duty waiver can also be used for ethanol from other origins (as in the case of European wine alcohol or Brazilian ethanol), as long as a treatment is performed in the Caribbean countries that qualifies for a change in origin. The requirement is fulfilled if a processing step is performed that adds at least 35% to the appraised value of the product at the time it is entered into the Caribbean Basin Country.

PCJ has been operating two ethanol dehydration facilities since 1986 until the late 1990's: a 42 million US-gallon/year plant (Petrojam Ethanol Ltd.), in disuse since 1997, and the 10 million US-gallon/year Petronol ethanol plant at the sugar factory Bernard Lodge (originally designed to produce indigenous alcohol from sugar cane and sorghum). Both plants have been mothballed.

Petrojam maintained its stake in the ethanol dehydration business through a fobbing and tolling arrangement with ED&F Man, a leading European commodity trader. The two operating ethanol dehydration plants at Rockfort in Kingston are owned by ED&F Man and up to the latter part of 2003 when EU wine ethanol was available the plants would process feedstock traded by both ED&F Man and Petrojam Ethanol Ltd. The plants with a joint capacity of 72 million US-gallons per year operate under the names of Jamaica Ethanol Processing Co. Ltd. (JEPCO) and Caribbean Pacific Alcohol Co. (CPAC).

The tolling agreement between Petrojam Ethanol Ltd. and ED&F Man expired in late 2003 and Petrojam Ethanol Ltd is since 2004 in the process of rehabilitating its 42 million US-gallon per year dehydration facility through a joint venture arrangement with a Brazilian company. The dehydration plant will initially process feedstock from Brazil for export to the U.S. fuel market under the CBI agreement and will eventually later incorporate indigenous feedstock for both the local and export fuel markets. The plant is planned to start operation with hydrous ethanol from Brazil in May 2005.

3.3 Future ethanol use in the Jamaican fuel market

With the intention of diversifying and revitalizing the Jamaican sugar sector (see above) it is now discussed to extend the planting of sugar cane and use this as a feedstock for an indigenous ethanol production, mainly for the fuel supply to the national transport sector.

Jamaica had a gasoline consumption in 2004 of about 4.5 million barrels (equal to 675 million litres or about 150 million imp. gallons). Up to 10% of this gasoline can be substituted by ethanol without modifications to the vehicle engines, so that the current market potential for ethanol is about 0.45 million barrels (equal to 68 million litres or 16.3 million imperial gallons).

With growth rates of 4% per year, the annual demand for ethanol could reach 0.57 million barrels (91 million litres) in 2010. As octane enhancer and oxygenate, ethanol would

⁵⁸ A total of six plants exist in Jamaica, Costa Rica and El Salvador with a combined output of 450,000 m³.

⁵⁹ Since 1989 the total annual CBI-import is limited to 7% of the U.S. ethanol fuel market. On the background of a strong increase in the demand for ethanol this limit is by far not reached.

replace the current use of MTBE that is imported by Petrojam at a cost of about US\$ 20 million annually.

Typically, a dedicated sugarcane-to-ethanol plant would not separate and dewater the raw sugars and molasses, but ferment the crushed cane directly. In such an integrated operation, the unconverted biomass after fermentation (bagasse and – at a later stage – also the leafy trash) would be used to generate heat and power in a cogeneration plant.

In the case of Brazil, more than 80 litres of ethanol per tonne of sugar cane are being produced, if the whole plant (sugar content) is fermented. Based on the current yield of about 60 tonnes of sugar cane per hectare for Jamaica, the farming of an additional 19,000 ha (or more than 50% above the current level) would be required to cover future domestic ethanol demands based on a 10% blend.

Additional plantation of sugar cane would be needed, if “flex-fuel” vehicles using higher ethanol percentages are introduced into the jamaican market or ethanol would also be produced for export, e.g. for the U.S. market under the CBI agreement or to other CARICOM member states.

A recent assessment for Hawaii⁶⁰ estimates the cost for a 10 million US gallon (38 million litres) per year ethanol plant to be in the range of US\$ 19 million. A larger plant would have lower specific capital costs: US\$ 32 million for 76 million litres per year. The off-factory prices for ethanol from sugar cane are calculated at US\$ 1.68 per US gallon (US\$ 0.44 per litre) for the smaller plant and US\$ 1.57 per US gallon (US\$ 0.41 per litre) for the larger plant. With such costs the production and use of ethanol should be economic in the case of Jamaica at current gasoline prices, even if additional costs are added for storing, blending and distribution.⁶¹

The same study estimates power consumption for the plant at 0.65 kWh per US gallon of ethanol. The larger 76 million litres plant could provide as much as 45 GWh of export power for the public grid (or 54 GWh for the assumed production of 91 million litres ethanol per year).

The production of ethanol might be eligible for financing within the CDM scheme, if the main criteria of additionality and reduction of greenhouse gas emissions compared to an adequate baseline scenario can be met. A first approach for CDM financing has been started by the Khon Kaen ethanol project in Thailand, which submitted a project design document to the UNFCCC in late 2004.⁶²

Before deciding on any indigenous bioethanol production it would be advisable to execute a full-scale analysis of the social and economic implications and examine which alternatives exist for the sugar industry and if other biomass options might be more beneficial for the agro-business and the jamaican economy.

3.4 The future of bioethanol applications

For the future it is expected that anhydrous ethanol will also be mixed with diesel fuel. Up to now, several tests with a maximum proportion of 10% alcohol were performed successfully. Dedini SA, a Brazilian ethanol-engineering firm, announced in June 2003 that it had developed such technologies to extract ethanol from sugarcane leaves in addition to cane juice. It estimates that this technology could double the amount of ethanol produced per hectare of sugar cane.

⁶⁰ Stillwater Associates, Hawaii Ethanol Alternatives, October 2003

⁶¹ This point needs to be further addressed in detail. Currently only in Brazil the production of bioethanol is competitive against gasoline.

⁶² Can be accessed on the website of CDM/UNFCCC.

Ethanol can also be used as domestic fuel for stoves, thus replacing the use of fuel wood and charcoal in households. For easier handling, it can be converted into a gel. First field tests with this type of fuel have been undertaken in rural areas of Africa by the Dutch research team Biomass Technology Group BV at the University of Twente.

In July 2004, the California based company Intelligent Energy Inc. announced the successful completion of trials with an ethanol supplied fuel cell for stationary power generation. Intelligent Energy is engaged in a partner programme in Argentina, Brazil and Mexico, which is focused on providing rural and urban electricity solutions for Latin America.

4. Fuelwood

It is estimated that currently approximately 37,000 t of charcoal are produced annually and mainly consumed in the domestic sector.⁶³ In addition to households, there is a demand for fuelwood in industry such as sugar factories, if the combustion of bagasse would be supplemented by wood energy in the out-of-harvest period.

The island of Jamaica has a total surface area of roughly 10,900 km². About 30% of Jamaica (equal to 325,000 hectares) is covered by forests,⁶⁴ with only 9,000 hectares being forest plantations with pine trees, fast growing eucalyptus, mahogany, teak, cedar and some other tropical species. To what extent the forest is threatened by uncontrolled extraction of firewood and trees used for other purposes, like construction and furniture, is not documented.⁶⁵ According to the Forestry Department there is currently no major forest depletion, i.e. the extraction of trees and natural replanting is more or less balanced.

In 1995, PCJ started a 5-year fuelwood project on 4 hectares in Font Hill in the parish of St. Elizabeth (Demonstration Fuelwood Project - DFP). Five fast-growing fuelwood species (Acacia, Leucaena, Casuarina, Cassia and Prosopis) were selected and 20,000 trees planted. The highest wood yields achieved were in the range of 108 to 118 tonnes per hectare, with Leucaena showing the best overall result. The calorific values have been measured as between 14,500 and 16,200 kJ/kg.

A feasibility assessment for a 200 hectare plot found out that an initial investment of \$J 6 million with subsequent investments of \$J 26 million over 5 years would generate income of \$J 12 million per annum after the fifth year. After 7 years, the initial capital would be recovered.

Based on the findings of the DFP it was judged at that time (2000) that it may not be economically feasible to establish commercial fuelwood plantations. However, these fast growing trees could be beneficially used in reforestation efforts in watershed areas as well as for the rehabilitation of bauxite mined-out lands. A different economic assessment could result nowadays on the background of increased oil prices and based on considerations to use fuelwood in an industrial format.

⁶³ An estimated 41% of Jamaican households mainly in rural areas are thought to depend completely or partially on fuelwood and charcoal for cooking and frying.

⁶⁴ Based on FAO estimations for the year 2000. According to other information sources, about 335,900 ha are classified as forests. While there are varying estimates of the deforestation rate, a moderate estimation would be about 3.3% /a (equal to 11,085 ha of forest lost every year). The Forest Management Plan gives the following explanation: "Estimation of deforestation rates in Jamaica has been confounded by inconsistent land classification systems and questionable extrapolation of unlimited data. Consequently, the extent of deforestation in the island is still unknown".

⁶⁵ It is reported that illegal cutting of trees without replanting is common practice in Jamaica.

The Forestry Department estimates that in the future approximately 50,000 hectares of forests will be needed to meet and sustain the total demand for (fresh) fuelwood and charcoal.⁶⁶ As part of its reforestation plans, the Department aims at planting an additional 6,400 hectares of hardwood by 2005.⁶⁷ About 32% of these trees would have to be planted on private land.

It can be assumed that the extended use of wood as energy resource in co-generation plants of the sugar industry would not threaten the sustainability of the existing forest, if the demand would be covered by dedicated energy plantations with a rotating crop cycle on currently unused farmland. It could generate additional income to farmers and contribute to rural stability and wealth by securing long-term employment.

On the other hand, the demand for fuelwood and charcoal could be minimized by improving the efficiency of domestic stoves, stimulating the switching to other fuels (like bottled LPG) and applying an improved forest management and control system.

If fuelwood and wood residues could be used for other energy purposes using efficient technologies (e.g. for thermal needs at drying of crops or fruits, in biomass co-generation plants or for ethanol production) and possibly in conjunction with other biomass feedstock, needs to be further investigated. This will require a closer assessment of the existing resources and of the options of harvesting wood within a sustainable forest management by maintaining a balanced biodiversity and avoiding any deforestation.

5. Energy from organic waste

5.1 Generation, collection and energetic use of landfill gas

Through anaerobic decomposition of the organic matter in the waste, methane gas is being produced which is a far more potent greenhouse gas than carbon dioxide.⁶⁸ Landfill gas is composed of about 50% CH₄ with the remainder being mostly CO₂. The gas mixture is explosive and relatively easy to inflame and forms an odorous problem for the environment.

Landfill gas production will start when the conditions for anaerobic degradation are favourable (factors of importance are e.g. organic content, amount of waste, moisture content, temperature). The gas can then be extracted during most of the operation period of the site and for some time after the closure with decreasing annual amounts (normally a total of much more than 20 years).⁶⁹

The capturing of landfill gas and its energetic use is common practice in most European countries and North America. The flaring of landfill methane or the combustion for energy purposes is even mandatory in the European Union. In the U.S. the “Landfill Methane Outreach Program” is promoting the landfill-gas-to-energy transformation.

Notwithstanding the trend in Latin America and the Caribbean toward improved landfills, only a few cities in Chile and Mexico actively collect the landfill gas and utilize its inherent

⁶⁶ The Forestry Department was charged by the Forest Act of 1996 with the responsibility of preparing a National Forest Management and Conservation Plan.

⁶⁷ Trees for Tomorrow Project.

⁶⁸ Ratio of 23:1 based on a 100-year period.

⁶⁹ Landfill gas production will continue for 50 to 100 years.

energy value, or are planning to do so.⁷⁰ At the end of 2004, several projects were in the pipeline, specifically in the framework of CDM activities in Brazil and Argentina.

Even though landfill gas is not a truly renewable energy source, most country policies regard it as such. In comparison with other renewable energies it is in most cases the cheapest alternative, at least in industrialized countries.⁷¹

In Jamaica, as in most developing countries, there is no legal requirement to flare or recover the landfill gas. It is estimated that for a content of organic matter of about 60%, the methane production is at the order of 180 m³ per tonne of waste.⁷² About 50 to 80% of this methane can be captured by vertical gas extraction wells and horizontal drains connected by a piping network. Typical pipeline grade natural gas has approximately double the heating value or fuel content of landfill gas (18 MJ/m³).

The captured methane can be flared directly or piped after filtering and de-watering and be used in boilers at the landfill site, e.g. for the evaporation of the wastewater (leachate),⁷³ for cogeneration of electricity and thermal heat with internal combustion engines or turbines, or fed into natural gas pipelines.⁷⁴ The electricity generation is continuous, but will vary from year to year depending mainly on the amount of “fresh” waste and the stage of degradation. Due to this nature of landfill gas production a flexible system with modular co-generation plants consisting of several independent engines should be given preference.

If electricity is produced, most of it will be supplied to external consumers or to the public grid. It will then displace electricity and the related CO₂ emissions from other fuel sources. For a project at three landfill sites in Durban/South Africa, the electricity generation cost is calculated at US\$ 0.0422/kWh. This creates revenue that can be used for the further improvement of the design and operation of landfill sites. For secure financial planning of landfill gas-to-energy projects, long-term agreements on the purchase price of electricity are a prerequisite.

Costs for landfill gas collection and use depend to a large extent on site-specific parameters and cannot be generalized. The costs to install a typical gas collection system that satisfies good practice and conforms to accepted guidelines can range from less than US\$ 25,000 to more than US\$ 50,000 per hectare, depending upon the specific site conditions and the scope of the overall design and services that may be required.

As a rule of thumb, it is reported that there would need to be projections of landfill gas generation at threshold levels of more than 750 m³/hr for a minimum of 10 years before active gas collection would be given any serious consideration. Typically a gas flow of greater than 1000 m³/hr for a period of 20 years or more is the threshold level required for consideration of a landfill gas-to-energy project if the energy value is worth at least US\$ 0.065/kWh (including payments for CER's).

Because of the composition of the landfill gas any form of avoiding its emission into the atmosphere is part of the strategy to curb greenhouse gases. Capture and use of landfill gas have even a twofold effect: it eliminates a significant source of greenhouse gases and it can help to

⁷⁰ A valuable source of information for landfill gas projects in the LAC region is the following publication: The World Bank/ESMAP, Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean, January 2004 (<http://www.bancomundial.org.ar/lfg/>).

⁷¹ Most projects offered in the tendering procedures of the Non-Fossil-Fuel-Obligation of the UK in the 1990s have been landfill gas-to-energy options.

⁷² With a moisture content of 20-25% of mass. One tonne of fully decomposable organic matter has a methane potential of about 400 m³. The gas release occurs of course over a very long time-span.

⁷³ As in the case of the Beijing landfill gas project.

⁷⁴ If mixed with natural gas the CO₂ content needs to be eliminated first.

avoid the emission of other energy sources. Landfill gas projects are therefore becoming common practice in the CDM project portfolio of many developing countries.⁷⁵

The Executive Board for CDM projects has recently published guidelines for the establishment of baseline and monitoring methodologies for landfill gas projects:

- Consolidated baseline and monitoring methodology for landfill gas project activities. (ACM001, 3 September 2004).

This consolidated methodology is based on elements from the following approved proposals for baseline and monitoring methodologies on the background of concrete project proposals:

- AM0002 (26 September 2003): Greenhouse Gas Emission Reductions through Landfill Gas Capture and Flaring where the Baseline is established by a Public Concession Contract.⁷⁶
- AM0003 (12 January 2004): Simplified financial analysis for landfill gas capture projects.⁷⁷
- AM0010 (13 July 2004): Landfill gas capture and electricity generation projects where landfill gas capture is not mandated by law.⁷⁸
- AM0011 (13 July 2004): Landfill gas recovery with electricity generation and no capture or destruction of methane in the baseline scenario.⁷⁹

It should be noted, that even the flaring of the landfill gas only can be a sufficient measure for greenhouse gas emission reduction to apply for CDM financing.⁸⁰ In this case methane with a high Global Warming Potential (GWP) is converted into CO₂ with a far lower GWP.

5.2 Perspectives for landfill gas extraction and use in Jamaica

It is estimated that approximately 950,000 tonnes of waste are generated annually from households, industries, the commercial sector and other entities across the island. Of this amount, 72% (or 680,000 tonnes) are collected by the regional waste managements (public service).⁸¹

The National Solid Waste Management Act of 2001 has led to the establishment of the National Solid Waste Management Authority (NSWMA), which took over the central responsibility for four regional waste management companies that serve the same number of so called wastesheds. The collected waste is currently disposed at 9 different disposal sites. It is proposed to close many of those sites as they are operated as dumps without sufficient protection against negative effects on the surrounding environment, specifically leakages into the

⁷⁵ Several Project Design Documents (PDD) can be accessed on the Internet: <http://cdm.unfccc.int/>

⁷⁶ Based on the landfill gas project in Salvador da Bahia – Brazil.

⁷⁷ Based on the NovaGerar landfill gas project in Brazil which was registered as the first CDM project at the end of 2004. The certified emission reductions will be purchased by the Netherlands CDM Facility.

⁷⁸ Based on the Durban landfill gas project in South Africa.

⁷⁹ Based on the Onyx landfill gas project in Trémembé, Brazil.

⁸⁰ This is the case in the Olavarría Landfill Gas Recovery Project in the Province of Buenos Aires, which is the first project under a carbon finance agreement in Argentina. Also the landfill gas project in Salvador da Bahia will only flare the gas for the moment, as the generation of electricity is only considered economic for self-utilisation at the site for which there is a very low demand.

⁸¹ The remaining amount is collected by private service companies. All figures in this section are estimations and not based on verifiable countings.

groundwater. As a consequence, only one central landfill site with regular controlled disposal would remain in every region.

The wasteland with the by far largest amount of waste is Riverton⁸² with the capital Kingston and an estimated 380,000 tonnes of waste collected.⁸³ Most of this waste is disposed at the landfill site of the same name, which is the largest in the country.

Analysis of the composition of the municipal solid waste in Kingston show a high share of organic material with about 65%.⁸⁴ Alone 40% of the waste stream is composed of yard waste, the rest mainly divided among food waste, paper and cardboard. This high percentage of biodegradable material has led to various proposals in the past to recover the methane gas produced within the anaerobic degradation process at the landfill sites for energetic purposes.

Information provided by NSWMA point to the fact that most disposal sites are not properly sealed and that the gas content might be lower than expected due to spontaneous fires in the past. In addition to those restrictions, the proper extraction of the gas through the construction of pipes across the landfills could get into conflicts with the common picking of recyclable waste on the sites.⁸⁵

Despite those barriers, several CDM proposals for landfill gas capturing have been submitted for comment and support to the Ministry of Land and Environment as the interim Designated National Authority for CDM projects.

Further investigation seems therefore necessary, if and how the existing and future organic material respectively the gas produced at the landfill sites could be energetically used. Another option for the future would be the controlled biodegradation of the organic components right after the collection and before disposing it on the landfills. In this context it would be advisable to introduce a separate collection system at least for such substances as yard waste, as the organic residues after biogas production could be used as valuable fertilizer.

Studies on the incineration of the waste (“Waste-to-Energy” plants) have not shown economically viable solutions in the past. Capital investments for such plants are generally high and require a constant flow of sufficient and in energetic terms “valuable” waste. The high moisture content of the existing waste stream that is favourable for the landfill gas generation could form a limiting barrier for the combustion process.

5.3 Biogas production from liquid waste treatment

Apart from solid waste, liquid remains (such as wastewater and effluents with a high organic content from human settlements, industrial facilities and farms) can also provide a basis for biogas production as part of the (anaerobic) treatment process of such wastes. Under tropical conditions as in Jamaica and with appropriate technologies, such biodigestion will always result in a surplus of energy, since the required temperature of the process does not have to be maintained by external heating.

⁸² Covering the parishes of Kingston, St. Andrew, Clarendon, St. Catherine and St. Thomas, i.e. the south-eastern part of the island.

⁸³ Estimations talk of 474,500 tonnes for 2004.

⁸⁴ For comparison, waste in western Europe has only an organic content of about 30%.

⁸⁵ Such informal collection of waste can be overcome by introducing an adequate waste management system, as described for the municipality of La Reina in Santiago de Chile (Inter-American Development Bank, Economic Instruments for Solid Waste Management: Global Review and Applications for Latin America and the Caribbean, December 2003). In this context it should also be taken into consideration that landfill gas is a toxic contaminant that can cause cancer and other health problems.

Wastewater and sewage being discharged into the sea or into rivers and the open soil is one of the primary environmental concerns in Jamaica. Currently only about 30% of the domestic wastewater is handled by the central sewage system, which provides hardly any treatment and disposes most of the sewage with high organic loads into the open sea or into the landscape. This is even truer for the remaining 70% of the non-collected sewage. About 150 private and public wastewater treatment facilities operate in the country. The majority of those central sewage treatment facilities has been constructed in the 1960s and is reported to be in a bad condition. It is estimated that less than half of those installations are in workable conditions.

Biogas plants utilising animal manure have been in use in Jamaica for over two decades, with over 150 such systems put into operation. Those plants have focused on providing energy for heating and cooking purposes of farms and households, but are only in exceptional cases attached to power generators for electricity production.

Since 1993, about 10 Biodigester Septic Tanks (BST) have been installed for on-site treatment of domestic sewage in single households and housing complexes, as well as an anaerobic demonstration pond for the treatment of wastewater at the Frome sugar factory and two up-flow Anaerobic Sludge Blanket reactors for the treatment of food processing wastewater. The biogas plants were realized within a German-funded technical cooperation project assisted by GTZ.⁸⁶

This cooperation project entered into a new phase in 1996, now under the title “Integrated Wastewater Management Project” and dealt with avoiding, recycling and treating domestic and industrial waste water from urban and touristic zones. The Scientific Research Council (SRC), which is the main driver of most of the wastewater treatment projects, sees further potential for anaerobic biodigesters mainly in the residential and commercial sector (hotels), in agro-industry and food processing and for distilleries.

In general, domestic BST provide only small amounts of gas if the input of black water from toilets is not supplemented by other organic material, such as food remains, yard waste and other.

One good example of a biodigester catering domestic waste and animal manure was established at “St. John Bosco Boys Home” in Hatfield, Manchester. The 100 m³ biodigester, which was implemented at a total cost of US-\$ 14,200, produces over 50 m³ of gas per day, equivalent to about 300 kWh. The school presently utilises the gas generated to operate cookers, stoves, water heaters and brooders.

The primary goal of the current activities of the SRC on wastewater management is to get rid of common septic tanks and soak-away pits, which currently are used by an estimated 36% of the Jamaican households, and substitute those by an anaerobic treatment within the residential communities or at central collection sites.

A brief assessment of a proposal by SRC to collect septage and sludge from private households and treat this waste under anaerobic conditions at (or near) the central disposal site in Kingston, has shown that 840 to 6,300 MWh of surplus electricity could be delivered to the grid, depending on the collection rate of such waste. It should be kept in mind, that energy production in this process is only a by-product of the principal objective to clean wastewater and avoid harmful effects on the environment. A central collection and treatment of such liquid waste would necessarily require a well organized transport system, which provides for a constant flow of input to the plant.

⁸⁶ “Dissemination of biogas technology in Jamaica and the Caribbean.”

As an alternative it has been suggested in the above mentioned assessment to concentrate efforts on existing or new central sewage treatment facilities operated by the National Water Commission and equip those plants with anaerobic technologies, as it is widely common in Europe and in the US.

Since basic data are not available, it cannot be determined within this study, to what extent liquid organic material could be used in the agro-industry (like pig and chicken farms) and in food-processing factories to combine the objectives of waste treatment and energy production. But it appears certain at a first glimpse –and derived from experiences in other countries– that there are a number of facilities in Jamaica producing sufficient quantities of liquid (and solid) organic waste, which allow for the installation of individual anaerobic digesters. A further detailed analysis of this sector could certainly provide valuable information.

VI. Solar energy and other renewable energy technologies

1. Solar radiation in Jamaica

Jamaica has a high average solar irradiation of about 5 kWh/m².day, i.e. about 1,800 kWh per annum. A first solar radiation map was published in 1994 with measurements taken at various locations (see table 13).⁸⁷ The average radiation in a month is between 4.1 and 5.6 kWh/m².day.

JAMAICA
DAILY GLOBAL RADIATION, FOR TWELVE MEASURING STATIONS
(mj/m²/day)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Alcan	14.6	15.1	18.0	18.9	N/A	19.6	20.4	N/A	N/A	16.7	15.6	15.1
Allsides	13.1	13.7	17.4	17.3	17.5	22.0	17.7	17.7	16.3	14.8	13.3	14.8
Black River	16.2	17.1	18.6	18.8	20.9	26.1	24.6	25.4	18.7	16.5	16.1	14.5
Bodles	15.2	16.8	19.5	21.5	21.2	19.7	20.8	20.4	19.0	18.0	16.2	15.5
Discovery Bay	12.9	14.9	19.6	21.3	21.0	21.1	21.6	18.6	18.7	16.0	14.1	12.9
Duckensfield	16.5	15.8	21.1	22.9	21.9	22.4	22.3	21.1	21.4	17.6	18.4	16.4
Manley Airport	15.9	18.0	20.3	20.7	20.0	19.5	19.9	21.4	19.0	17.3	15.8	15.4
Mona	14.4	17.0	19.5	19.5	20.0	20.5	19.5	18.7	17.8	15.4	15.7	15.2
Negril	15.8	17.5	18.4	19.7	18.4	19.9	18.7	17.8	18.6	16.1	15.2	14.7
Orange River	15.9	13.0	13.0	18.7	18.0	19.0	17.9	19.5	17.8	15.9	16.1	15.5
Sangster	14.5	15.5	19.0	20.9	20.6	20.0	20.5	19.3	16.8	15.9	14.9	13.8

Source: A. A. Chen (1994).

⁸⁷ Dr. A.A. Chen of the Physics Department of the University of the West Indies (UWI).

2. Solar water heating

There are an estimated 7,000 Solar Water Heaters (SWH) installed in Jamaica, mainly on private homes. Compared to the approximately 450,000 household on the island, the penetration rate of SWH is still rather low.

Almost all SWH appliances are small-scale passive thermosyphon systems with water storage tanks directly attached to and above the glazed flat-plate collector. Only a few large-scale applications are active systems using a collector circulation pump and a remote storage tank. Under Jamaican conditions solar water heaters will earn about 550 kWh per square meter of installed collector area annually. If properly designed, those systems can cover almost hundred percent of the hot water demand. All SWHs are imported models, mainly from Barbados and from Israel. Locally manufactured systems have not demonstrated to be competitive in the past.

Conventional water heating for sanitary purposes is in first place done by using electric heaters with storage tanks. Flow-through systems (as in Brazil) are not common in Jamaica. Prices for such electrical storage systems are reported to be about \$J 12,000 for a 10 gallon tank, \$J 25,000 for 20 gallon and \$J 35,000 for 40 gallon. SWH systems are normally fitted with a user controlled back-up electrical booster for use in periods of inclement weather.

It should be noted that warm water is not an essential requirement in Jamaica, with many households having no heating system at all. Yet, the growing numbers of electrical heating devices are contributing significantly to the daily evening load peaks in the public electricity system.

Hot water needs are calculated at between 15 and 20 gallons per person and day, at temperatures of 55 to 60°C. Typical sizes for collectors respectively storage tanks vary from 50 to 80 gallons.

The installation of several hundred SWHs was stimulated by activities under the Demand Side Management (DSM) demonstration project operated by JPSCo⁸⁸ in the period 1998 - 2001, by the introduction of a tax reduction for imported systems in the range of 5 to 30%⁸⁹ and the total exemption from CGT⁹⁰ payment for imported products since 1994.⁹¹ After abolishing the CGT waiving in April 2003, it was reinstated in June 2004.

The promotion activities within the DSM programme targeted the residential as well as the commercial and service sector. Both parts were financed by a grant and a revolving loan with assistance from the World Bank. More than 300 units have been installed in the residential sector after the SWH were selected on the basis of an international bidding. The 200 and 300 litre systems cost US\$ 730 and 1065 respectively, generating paybacks of 4 to 5 years. Measurements have shown that on average an annual 1,825 kWh of electricity could be saved in households.

The commercial part of the DSM programme combined energy audits and SWH installation on selected properties. SWH were integrated into the hot water supply of 10 hotels

⁸⁸ The DSM project was established in 1994 as a semi-autonomous unit under the Corporate Services Division of JPSCo. and closed in July 2001. Between 1994 and 1999 the project was financed primarily by the Global Environment Facility (GEF) of the World Bank and the Inter-American Development Bank, along with some funding from the Rockefeller Foundation and the Canadian Trust Fund as well as contributions of JPSCo.

⁸⁹ No duty taxes are applied for SWH from other CARICOM countries.

⁹⁰ A type of value-added tax.

⁹¹ Imports from other CARICOM member states are generally tax exempted. In practice the tax reduction or waiver was only applied to complete systems, not to local manufacturers importing only certain parts.

and two student residences at the University of the West Indies in Kingston. As a consequence of those activities the market got off the ground and more than 1,000 units were installed in 2000 alone.

Within the energy efficiency programme of PCJ, 485 SWH were imported in bulk from Israel in 2004 and installed (primarily by the housing developer New Era Homes in St. Catherine) at a system cost of approximately \$J 10,000 below regular market prices. Other collector systems have been mounted on a number of hospitals.

Prices for SWH range between \$J 900 and 1,250 per US gallon. A well sized SWH for a family of four (55 gallon) will cost up to \$J 100,000 (US\$ 1,640).⁹² An electric water heater with 60 imp. gallons costs about \$J 17,000 (uninstalled), while a SWH with equivalent capacity will cost at least \$J 55,000 (installed). Based on current electricity tariffs of about 20 US-cents/kWh for residential customers, it is estimated that the payback period for SWH is now between two and three years.⁹³

It is reported that the high initial investments are prohibitive for a wide-spread application of SWH. An additional incentive, like tax rebates as in Barbados or a low-interest credit system could improve the situation. In the past, PCJ (as JPSCo before) has already offered a loan and 2 year-repayment scheme for 200 SWH. Also the manufacturer Solar Dynamics allows its customers to make the purchase of SWH on rate terms.

Potentials for SWH exist in particular in medium- and high-income households and in the tourism sector. The hotel industry alone provides for about 14,000 rooms with 30,000 beds across the island and has an occupancy rate of well above 50%, indicating that there is a hot water need throughout most of the year. In this specific case solar water heating has to compete against LPG, since this is the common energy source for hot water generation in hotels. Other niche market potentials can be found in the industrial sector, mainly in food-processing, and for sporting facilities.

The company Solar Dynamics Ltd. has done some market research, showing that about 45,000 residential customers of JPSCo have an electricity demand of above 600 kWh/month. Most of those customers are expected to have an electric heater and spend about one third of their electricity bills for hot water generation. Therefore, about 75,000 to 100,000 MWh would be saved annually, if those customers would install collector systems with an area of 3 to 4 m² each to cover almost all their hot water needs.

PCJ estimates the potential for SWH conservatively at about 1,000 systems per year for the period 2003-2008. The figure is thought to increase significantly if driven by intense marketing. A model for Jamaica could be the island of Cyprus (with similar solar radiation characteristic), where almost all private houses and more than 50% of the hotels are equipped with technically simple and reliable solar installations. Solar thermal energy could also gain attraction in the future for cooling purposes (air-conditioning), using absorption chillers.

The current building code of 1994 refers briefly to the use of SWH but contains no obligation for the installation of such systems. The new energy policy provides only for the requirement to design buildings in such a way that they can take up solar collectors, without enforcing the use of such systems directly. In April 2001, the Government of Jamaica made it mandatory for public buildings requiring hot water to utilize solar energy for that purpose.

⁹² The average size of SWH systems on Barbados are reported to be 45 imp. gallons.

⁹³ In the case of Barbados with electricity prices of 17.5 US-cents/kWh payback periods were calculated at 3.2 years for a 50 gallon system and 2.5 years for an 80 gallon system (CARICOM/CREDP, Solar Water Heating Market).

The general knowledge about solar thermal applications is considered to be low. An urgent need is therefore seen in deploying awareness raising campaigns among the general public and in disseminating specific information for hotel managers and technical staff (hotel association).

3. Photovoltaics

Photovoltaic systems have in the past only captured niche markets in Jamaica for rural electrification, street lighting and several stand-alone applications.

Within the above mentioned DSM programme JPSCo launched a pilot PV project to demonstrate the performance of such applications for off-grid communities. A total of 50 panels with 120 W each and AC inverters were installed in two villages⁹⁴ in 1999 at a cost of about US\$ 1,700 per unit. Such systems are capable of supplying electricity for up to three fluorescent light bulbs, small TV sets and a radio at the same time.

Repayment was thought to be done through billing by JPSCo of \$J 500 per month and customer. After 5 years the systems showed significant failures, mainly due to water damages and a lack of maintenance and spare parts. Most PV panels were out of operation, the repayment scheme cancelled.

Despite this negative experience, there is a continuous need for PV electrification of remote settlements and individual houses as well as for electricity supply of off-grid appliances. A growing market is also expected for grid-connected PV systems of high-income households on the basis of net-metering and possibly purchase agreements with JPSCo for delivery of excess electricity to the public grid.

4. Other renewable energy technologies

Some other renewable energy technologies have not been covered in full scale within this study due their infancy status, which needs further development to demonstrate technical reliability and economical competitiveness.

Among those technologies, which could be suitable for Jamaica, some time in the future is *Ocean Thermal Energy Conversion (OTEC)*, which uses the year-round temperature gradient of about 22 °C between the sea surface water and the water some 1000 m deep. Such temperature differences should be available at close distance from the shore, as in the case of Jamaica, to allow for siting of land-based OTEC plants.

Currently only one 30 kW experimental plant is being operated in Japan by the Institute of Ocean Energy of the Saga University, showing the general technological viability.⁹⁵ No evidence exists yet for the successful operation of such a system at commercial scale, while a 1 MW capacity OTEC barge (floating plant) by the National Institute of Ocean Technology in India is under preparation. Further investigation is also needed on the environmental impact of such a system. Besides producing electricity, OTEC systems could also provide cold seawater for air conditioning of large buildings.

⁹⁴ Middle Bonnet in northern St. Catherine and Ballymony in St. Ann.

⁹⁵ In fact, the very first experimental open-cycle OTEC system producing 22 kW was built in Cuba as early as in 1930, but failed to supply net electricity. A 50-kW closed-cycle OTEC demonstration plant went up at the National Energy Laboratory in Hawaii in 1979, producing 15 kW net power. Based on those experiences a further 210 kW land-based experimental plant with an open cycle was installed in Hawaii and operated between 1993 and 1998, achieving a maximum net power of 103 kW.

Another renewable energy technology, which would deserve perspective attention, is *Solar Thermal Electricity (STE)* production. This technology, using parabolic troughs with heat pipes or central receptors, has proven viability at large scale for years now in California as well as in Spain. Currently large 50 MW solar thermal plants are on the verge of being set up in Spain (where favourable framework conditions have been established by the Government) as well as in India (with funding from Germany). With specific costs going further down –i.e. when components are manufactured at a larger scale– this technology could have a considerable impact for Jamaica, with a high solar irradiation existing.

Fuel Cells have also not been given a closer look within this study, since they are not regarded as a true renewable energy technology, but as a means to possibly convert energy carriers derived from renewable energy sources, such as hydrogen, into electricity and heat, either for mobile or stationary purposes. Apart from this, fuel cells are still far from being economically competitive despite their high efficiency, and have shown substantial failures with regard to long-term operation of some of their components.

VII. Carbon market perspectives for Jamaica

1. Clean development mechanism (CDM) under the Kyoto Protocol⁹⁶

The CDM is one of three flexible, market-based instruments as outlined in Article 12 of the Kyoto Protocol adopted in 1997. Besides giving stakeholders from Annex I (industrialized) countries opportunities to invest into cost-effective measures for the reduction of greenhouse gases in developing countries and creating an emission certificate trading system in this context, projects should also provide for the transfer of technologies and know-how and contribute to a sustainable development.

After Russia notified the ratification of the Kyoto Protocol in November 2004, this important multinational agreement on the reduction of greenhouse gases under the United Nations Framework Convention on Climate Change (UNFCCC) has entered into force on 16 February 2005. CDM projects could already be started prior to this date (since January 1, 2000).

The basic participation requirements for voluntary measures under the CDM scheme include that eligible reductions must be:

- certified by independent Designated Operational Entities (DOEs),⁹⁷
- approved by each party involved;
- involve real, measurable, and long-term climate change mitigation benefits; and

⁹⁶ For a more detailed description of the CDM procedures refer to one of the following documents: International Emissions Trading Association (IETA), IETA's Guidance note through the CDM Project Approval Process, 2004 (version 1.0); Department of Trade and Industry (UK) / The Climate Change Projects Office (CCPO), The Joint Implementation and Clean Development Mechanism explained, May 2004; Tiempo #53, Special Issue on the Clean Development Mechanism, October 2004; SouthSouthNord, Clean Development Mechanism Practitioners' Practical Toolkit, www.cdmguide.org (with several modules for download).

⁹⁷ By the end of 2004, four DOEs with different sector responsibilities had been accredited worldwide. For energy-related projects only Det Norske Veritas Certification Ltd. in Norway and TÜV Industrie Service GmbH in Germany are responsible.

- be additional to what would occur in the absence of the project activity.

A detailed analysis of CDM procedures and CDM project cycle is presented in Boxes 5 & 7 in the annexes section; for Small-Scale CDM (SSC) projects procedures, see Box 6.

Jamaica has ratified the Framework Convention on Climate Change on 6 January 1995 and the Kyoto-Protocol on 28 June 1999. It can therefore fully participate in CDM activities. The Ministry of Land and Environment was officially nominated by Cabinet to be the Interim Designated National Authority (DNA) in charge of CDM projects. Jamaica has so far signed only one bilateral Memorandum of Understanding for the co-operation on the Wigton Windfarm as a project under the CDM.

As of January 21, 2005 a total of 144 CDM projects⁹⁸ in 34 countries had claimed generating 450 million CERs, of which 276 million would be realized until 2012. Most projects pursued the tapping of renewable energy sources, followed in number by projects in the field of gas capture (mainly landfill gas) and gas destruction (HFC₂₃).⁹⁹ Only two projects (NovaGerar landfill project in Brazil and the Rio Blanco small hydropower project in Honduras)¹⁰⁰ had been registered by the CDM Executive Board. Another five projects had been validated and were seeking registration. By far the most projects intending to sell CERs are located in Brazil (28) and India (27).

Buyers from Annex I countries included among others the World Bank (mainly within its Prototype Carbon Fund), the Dutch CERUPT initiative and a number of Japanese private sector companies.

The Executive Board has so far approved 19 baseline and monitoring methodologies and is in the state of assessing many more through its methodology panel.

2. Emission trading system in the European Union

The EU Emissions Trading Scheme (EU-ETS)¹⁰¹ has started on 1st January 2005, establishing the world's largest market in greenhouse gas emissions. The EU-ETS is in principle an allowance scheme with specified emission caps. Within National Allocation Plans (NAPs) the member states have set limits for the allowed emissions of greenhouse gases (expressed in credits) for dedicated installations or sites,¹⁰² below the current level.

The first phase of the EU-ETS will run until 31 December 2007, a subsequent second phase until the end of 2012. The second phase therefore coincides with the first Kyoto Commitment Period. In the first phase the scheme is limited to CO₂ emissions, leaving aside other greenhouse gases.

There are three routes an installation can employ to ensure that the allowances it holds match its emissions:

⁹⁸ Includes only those projects for which a Project Design Document has been made available. All figures are taken from CDM Watch, www.cdmwatch.org

⁹⁹ Most project documents can be found on the UNFCCC website. Already validated energy projects or projects in validation can be found on the website of Det Norske Veritas (www.dnv.com) or of TÜV Industrie Service GmbH (www.tuev-sued.de).

¹⁰⁰ Being at the same time the first small-scale project registered.

¹⁰¹ Based on the Directive 2003/87/EC.

¹⁰² The scheme is mandatory for such installations or sites, which are active in energy production, iron and steel production, mineral industries and pulp and paper. A total of about 10,000 facilities are affected in the EU.

- reduce the installation's own annual emissions to the number of allowances allocated for that year;
- reduce annual emissions to below the cap and either sell the excess allowances to another company or "bank" them for future use;
- if the annual emissions are above the allowances allocated, the company owning the installation may buy allowances (or certificates, see below) from the market to cover the difference.

Allowances that can be used for compliance are called European Allowance Units (EAUs).¹⁰³ Their price depends mainly on the supply of, and demand for, carbon allowances within the Europe wide carbon trading market. At the end of January 2005, prices for EAUs were in the range of 7.10 Euros, down from a peak of 12 to 13 Euros per tonne CO₂ equivalent in February 2004, and seemed to stabilize at this level.¹⁰⁴ The two main reasons cited for this decrease are the fact that the NAPs were less stringent than anticipated¹⁰⁵ and that the linking directive (see next chapter) allows for the importation of CERs as early as 2005.

If an installation is not able to surrender sufficient allowances to cover its annual emissions by the reconciliation date, it will be financially penalised, and the amount of the deficit in allowances will be carried over to the following year. The fine for non-compliance in the first phase is 40 Euros/tonne CO₂, and rises to 100 Euros/tonne CO₂ for the second phase.

In addition to EAUs, carbon credits from international climate change projects (CERs from CDM projects and Emission Reduction Units from Joint Implementation projects) can be used, following the European Directive 2004/101/EC (EU "*Linking Directive*"), which forms a bridging, link between the EU-ETS and the other flexible mechanisms of the Kyoto-Protocol and entered into force on 13 November 2004. The member states were given a 12 months period for the transposition of this new directive into national regulation.

If CDM credits (CER) are acceptable under the Kyoto rules, they will also be allowable for the EU emission trading scheme and replace EAUs on a one-to-one basis, starting in 2005. Each member state of the EU can decide on its own on the limit for the use of CERs from project activities, taking into account that the use of the flexible mechanisms should only be supplemental to domestic actions. In addition to the Kyoto requirements, hydropower projects exceeding 20 MW have to comply with relevant international criteria and guidelines, including those established by the World Commission on Dams.

Credits from CDM projects are expected to be cheaper than EU allowances, so allowing them into the EU-ETS may make it less expensive for participating companies to meet their targets than it would otherwise have been. For Kyoto compliant carbon credits, the World Bank's Prototype Carbon Fund pays about US\$ 5 per tonne CO₂ equivalent. Somewhat more will be paid in a new scheme, where credits demonstrate a high level of community benefit as well.¹⁰⁶

Market trends are not easy to project, since an open trading system of CERs is not in place. It is generally expected that prices for CERs and EUA will converge in the future. Currently, CER prices are on average about 2 € lower than for EUA, mainly due to perceptions of high risks in CDM projects.

¹⁰³ One EU allowance equals 1 tonne CO₂ equivalent.

¹⁰⁴ Daily EUA prices can be observed on the website www.pointcarbon.com.

¹⁰⁵ It is expected that the NAPs will only generate a demand of 20 to 50 million tonnes CO₂ equivalent annually between 2005 and 2007 relative to business-as-usual.

¹⁰⁶ The World Bank's Community Development Carbon Fund was established in 2002.

It is anticipated that the Linking Directive will attract more direct or indirect (through bilateral¹⁰⁷ or multilateral funds) investment from owners of installations, which are subject to the EU allowance scheme, into cost-effective greenhouse gas reduction activities in developing countries.

3. Carbon market perspectives for Jamaica

CDM financing can contribute to facilitating the implementation of renewable energy projects, even though with current low CER prices the additional benefit may not be as decisive for individual projects.

Of specific interest could be the generation of CERs through small-scale projects in the hydropower, wind and landfill gas sector. CDM projects in general can be unilateral, i.e. they may be realized without the participation of stakeholders from Annex I countries, as for the purchasing of CERs.¹⁰⁸ Carbon credits could in this case be “banked” by the plant owner and sold on the carbon market, when prices are more attractive.

As previously demonstrated, all future *hydropower* plants will be far below the 15 MW threshold for SSC. A 5 MW hydropower facility operating with a capacity factor of 90% would reduce CO₂ emissions by about 30,000 tonnes annually and earn about 0.4 US-cents/kWh by selling CERs.¹⁰⁹

The 15 MW threshold is also well suited for *wind farms*, not taking into account the possibility that two or more separate wind farms of this size may be realized adjacent to each other. Such wind farm with an assumed capacity factor of 35% would avoid CO₂ emissions in the range of 34,500 tonnes annually and also earn roughly 0.4 US-cents/kWh through trading of CERs.

Since, specifically in the case of hydropower, the total “turnover” of CERs may not be attractive enough for large carbon investment funds, thought should be given to “bundle” several individual projects, if they can be realized at the same time and do combined not surpass the threshold of 15 MW or equivalent in order to fulfil the SCC criteria.

Landfill gas projects can be of particular interest for CDM financing, since they can generate emission credits both, for methane abatement and for displacing fossil fuel based electricity.

In the case of *ethanol* replacing gasoline the net emission reduction is in the range of 2.3 kg CO₂ per litre. With a conservative purchase price of US\$ 5 per tonne of CO₂ CDM financing would contribute 1.15 US-cents per litre to the generation of ethanol or a share of 3 % to the

¹⁰⁷ For example, the German Development Bank KfW acts in its own name as a trustee for the account of the participating companies and institutions and will enter into long-term Emission Reduction Purchase Agreements with suitable carbon sellers. KfW will only purchase certificates that are potentially convertible into EU Allowances under the European Emissions Trading Scheme. The minimum project size is a reduction of 100,000 tonnes CO₂ equivalent per annum. See www.kfw.de (KfW Carbon Fund) for more information.

¹⁰⁸ Note that the implementation of unilateral projects is still a controversial issue among the Parties of the UNFCCC. The following definition for unilateral projects has been proposed by GTZ: “A project which involves no foreign direct investment, which has only the approval of the host country before registration and which sells its CERs through a Direct Purchase Agreement (DPA) after certification and issuance or sells them not at all.” (GTZ, 2003)

¹⁰⁹ Based on a conservative emission factor of 750 g CO₂ per kWh for a fossil fuel mix and a low trading price for CERs of US\$ 5.0.

expected total production costs.¹¹⁰ The expected production and consumption of 91 million litres of ethanol by 2010, as outlined in chapter V, would contribute to avoiding an estimated 210,000 tonnes of CO₂ annually.

Based on the calculated minimum of 300 GWh excess electricity annually from bagasse *cogeneration* (see chapter V), avoided CO₂ emissions would be in the range of 225,000 tonnes, at a value of at least US\$ 1,125,000.¹¹¹

¹¹⁰ The figure was taken from the Khon Kaen fuel ethanol project in Thailand, which assumes a car efficiency of about 12.3 km/l. Please note that the simple baseline methodology may not be accepted in the validation process, since it omits to consider a life-cycle analysis taking into account CO₂ emissions which occur on the ethanol production side.

¹¹¹ As reference you may take a look at one of the following bagasse cogeneration projects in Brazil proposed for CDM financing: Vale do Rosário (73 MW), Jales Machado (33 MW), Catanduva (25 MW), Moema (74 MW), Barralcool (45 MW), Santa Elisa (88 MW), Santa Candida (32.6 MW).

VIII. Proposal for instruments & actions

Discussions with the main stakeholders and entities from the public and private sector have revealed a number of **barriers, which impede the expansion of the renewable** energy use in Jamaica.

Obstacles and **deficits exist mainly in the regulatory area** and with respect to financial issues. Inexistent or imprecise legal formulations and the lack of financial and fiscal incentives or the lack of economically sound contractual arrangements can jeopardize investor engagement and create incalculable risks. The **new long-term energy policy will need to tackle those problems** in order to achieve its ambitious goals.

An essential element is to better identify and **locate the existing potentials and create a favourable, enabling environment**, specifically for private investment from over-seas. This will require further on-site assessments, specifically in the case of wind, hydropower, landfill and bagasse co-generation. Despite the fact, that a number of feasibility studies have been elaborated in the past (mainly in the hydropower sector), it needs to be acknowledged that technology and in particular **economic framework conditions have changed considerably** and will lead to far different conclusions than in previous analyses.

For those renewable energy sources, which are highly site-specific, like hydropower and wind, long-term land use and water resource planning should assign those locations that are most suitable for such purposes. **This effort will need the cooperation of all relevant stakeholders** involved, like local authorities, Water Resource Management, transmission line operators and others. Sites should not only be selected by their natural energy potentials, but also by aspects of (road) accessibility, land ownership, competing interests, grid connection availability, and others.

Continuous long-term wind measurements of two or more years are an essential requirement for a precise calculation of energy yields and subsequently the economic viability of wind farms. Year-to-year variations of wind speeds can be significant, leading to an over- or under-estimation of electricity production if translated into the future.

As has been disclosed by various stakeholders, precipitation –possibly as consequence of climate change– show also strong variations between the years and in contrast to one or two decades ago, in addition to changing water flows due to other uses like irrigation and fresh water piping. This results in the need of doing careful new examinations and pre-estimating future changes at previously selected sites.

It certainly needs further consideration and smart solutions, **how private investors or project developers can be integrated into such pre-feasibility assessments** by taking over at least part of the financial burden. More so than in conventional energy projects, such pre-investment activities in the renewable energy field can absorb large shares of the overall project costs. One idea could be to **address specific “lots” to selected companies** (as in the oil and gas extraction business), which gain the right to explore the potentials if the investigations prove successful (or can sell on the rights to other companies). Such engagement could possibly be made attractive by linking it to **dedicated grants or soft-loans provided by international donor institutions**.¹¹²

A central issue with far-reaching consequences for all grid-connected renewable energy projects are the current high transmission, distribution and non-technical losses. Electricity generated with considerable technical efforts should not get lost on its way to the final consumers. Currently such **losses are by far exceeding the electricity produced by all renewable energy plants combined**. It is obvious that technical as well as non-technical losses have a direct effect on raising the prices above the “regular” level for those clients, who pay for their electricity consumption. An enforced and targeted endeavour will therefore be needed to improve at least the transmission and distribution system and curtail the losses to international standards.

Administrative procedures can absorb personnel and be time-consuming and lead as a result to significant up-front expenses. It is therefore advisable to give clear guidance for project developers and investors, which licences, permits, audits, stakeholder responses, clearances etc. are necessary for a certain project type. **A one-stop agency or contact point is fundamental to ease the contact** between the investor and the public entities involved. It should centrally communicate with all relevant institutions and request statements and permissions if required. Technology-specific guidelines should be established for such tasks as environmental impact assessments and construction permit requirements. In the case of medium-sized renewable energy projects, **all administrative procedures combined should be concluded within one year** or less.

The new Electricity Bill provides for targets/shares of renewable energy the suppliers of electricity have to provide. Such shares should be related to the electricity generated (instead of capacity) in response to the lower natural capacity factors of some renewable energy technologies. In secondary legislation it should be established what measures are taken by the Government or the regulator, if those objectives are not being met. One instrument could be the **setting up of a financial penalty acting as a compensation** that would flow into a public fund for the support of renewable energy projects. Such fines should of course not be turned over as expenditures to the tariff scheme for end-use customers.

Mandatory goals are also advisable for the use of bioethanol in the transport sector. The ultimate objective of achieving a 10% share of ethanol for all gasoline consumed should be achievable by 2012. **Intermediate targets could be fixed to allow for continuous expansion** of the production facilities, the required extension of the sugar plantations and the step-wise build-up of the necessary infrastructure.

Electricity generation is not the domain of the sugar industry. **Such business can best be performed by specialised operators (Energy Service Companies, ESCOs)**, which provide the required heat and electricity for the sugar processing and deliver power to the public grid on contractual terms with the single buyer. All cogeneration within the sugar industry based on bagasse and additional biomass feedstock could be outsourced, attracting investment capital as

¹¹² Like the so-called TERNA programme for wind energy assessments and other pre-feasibility activities of the German Agency for Technical Cooperation (GTZ).

well as planning, installation and operating know-how from third parties who have specific experience in those fields.

Tendering procedures for renewable energy projects in the electricity sector make only sense if they are related to specific sites and technologies. **A competition among different technologies and across various external conditions will hardly deliver the expected results** and could even be counter-productive. As the tapping of renewable energy sources requires significant pre-investment efforts, mainly carried out by the project developer or the investor itself, tendering of such projects will be simply impossible.

The new energy policy contains a requirement to provide for the up-take of solar water heaters (SWH) in buildings. More striking would be a mandatory requirement for solar water heaters to be installed on new buildings with hot water needs.¹¹³ Such request could be expressed and enforced in connection with building permits.

The high up-front costs of renewable energy technologies, in particular for the investment itself, form a significant impediment for all types of projects. **Subsidies and fiscal benefits can lower the threshold for investments** into such technologies, even if they contribute only a minor share to the overall costs. As one step in this context, the supply of major renewable energy equipment, which cannot be manufactured domestically, should be generally exempted from duty tax or imported at reduced tax rates.

For solar water heaters, income tax rebates or other fiscal and financial incentives beyond the existing duty tax reduction and CGT waiver can increase the willingness of building owners to invest into such renewable systems in replacement of conventional electrical appliances. Incentives should also apply for establishing a national production of SWH, thus lowering the costs of such systems and creating additional employment. Tax credits and other subsidies could be annually declining in order to stimulate a fast uptake of the SWH business and trigger a reduction of system prices.

Large RE projects are in first place interested in low-interest long-term credit financing (soft loans) and adequate risk management that gives banks or investors sufficient security for their capital. **State guarantees can support and facilitate bank lending**, while financing institutions will need to be better qualified in order to assess and detect risks and perceive opportunities. In order to share experiences and combine economic strength within the region, further thoughts should be given to the **establishment of a Regional Guarantee Fund** as proposed at various occasions.¹¹⁴

The “**Energy Efficiency Fund**” for Jamaica, which is currently in the design stage, **should be extended to renewable energy technologies** (not only SWHs), as has been previously discussed.¹¹⁵ An appropriate model for raising fund capital can be found in the Dominican Republic, where a levy is charged on all petroleum imports. Such additional taxes or levies may not necessarily create an additional burden for the population, but can be beneficial on a macro-economic basis. Possibly tax increases can be offset by tax reductions in other fields, like the lowering of the current (high) import taxes for transport vehicles. To save the fund from depletion soft-loans should be the main supporting scheme.

¹¹³ See examples for such obligations in several Spanish communities as well as in Israel and some other countries.

¹¹⁴ See e.g. ECLAC/GTZ, *Renewable Energy Sources in Latin America and The Caribbean*, 2004 (p. 127).

¹¹⁵ See Inter-American Development Bank, *Establishment of an Energy Efficiency Fund in Jamaica*, January 2005 (p. 41).

Since intelligent financing is as important as the technology itself in the renewable energy business, the **Government should do all it can to provide for access to financial resources** and appropriate financing mechanisms. A central information desk would be suitable to assist on financing sources from multilateral banks, investment funds, international donors etc.pp.

Depending on individual cases, the **sale of carbon credits can be a significant additional financing resource** that allows projects to become more competitive. It is therefore proposed that the Ministry of Land and Environment in charge of the CDM process should take a **pro-active role in promoting such project activities and determine focal areas** and specific locations that could be targeted by interested private sectors investors. As to avoid a number of unsolicited proposals, the Government should set priority development goals and draw the attention of potential investors to respective opportunities. Memoranda of Understanding should be signed with potential purchasers of domestically generated CERs.

Jamaica is already involved in a number of regional activities in the field of renewable energy.¹¹⁶ It should further take the opportunity to benefit from international programmes and networks such as the global Renewable Energy & Energy Efficiency Partnership (REEP)¹¹⁷ that was launched by the British Government in 2002 and activities within the Commonwealth community.

Rates for the purchase of renewable electricity need to be based on prospected avoided costs, i.e. on the basis of displaced power plants and their respective production costs, instead of using a least cost principle, and should incorporate a bonus for environmental and social benefits. Such tariffs will only be attractive for operators and financing institutions if they are **fixed for a period of at least 10 years and adjusted to annual inflation** and currency devaluation. Rates should also allow for a sufficient rate-of-return without increasing the overall electricity generation costs and reflect the increase in cost of fossil fuels over the contracted period.

The establishment of uniform net-metering and interconnection standards (as in the US) will give owners of grid-connected photovoltaic plants or other small-scale power generation units simple, equitable access to the grid and fair compensation.

A general prerequisite for the breakthrough of renewable energies is a strong and well established administrative backing. Responsibilities for **policy making should be focussed within one Ministry** and personal **capacities in all institutions involved strengthened**. This includes the easy and unrestricted access to globally available information and know-how.

¹¹⁶ See the participation in the Caribbean Renewable Energy Development Programme (CREDP), executed by CARICOM/GTZ.

¹¹⁷ www.reeep.org

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Annexes

Annexe 1

BOX 1 WIGTON WIND FARM

The Wigton project consists of 23 turbines with a rated capacity of 900 kW each supplied by the Dutch manufacturer NEG Micon.¹¹⁸ The turbines were erected on land designated for bauxite mining,¹¹⁹ though currently it is being mainly used for agricultural purposes. The layout of the wind farm will not inhibit future mining operations. The population density in this area is relatively low.

Long-term wind speed measurements had started near the final site in early 1996. Later an additional two anemometers were installed within the proposed area. At 40m height an average speed of 8.3 m/s was recorded. For the majority of the time, the wind speed was predicted to be in the range of 4 to 14 m/s, blowing from the east or east-south-east. Because of Jamaica's position in the hurricane zone, a IEC¹²⁰-61400 class 1 turbine was specified which means that its survival wind speed will be in excess of a 70 m/s gust. As part of the requirement for the permitting and licensing process of the National Environment and Planning Agency (NEPA) an Environmental Impact Assessment (EIA) was conducted.¹²¹

The wind farm is owned and operated by the Wigton Wind Farm Ltd., a 100% subsidiary of PCJ. Land utilization on a lease basis has been contracted with the property owner for a 25 year period. The actual land use is minimal with only 1 to 2 % of the total site for the towers, access roads and some additional small buildings. Total project costs were in the range of US\$ 25.6 million, with US\$ 5 million coming from an export grant of the Dutch Government, US\$ 3.2 million contributed by PCJ and the remainder provided as a bank loan guaranteed by the Jamaican Government. The project was realised on a turnkey basis by Renewable Energy Systems Ltd.

With the utility JPSCo a 20 year power purchase agreement was negotiated, with rates for the Kilowatt-hour of electricity of US-cents 5.6 during the first five years and US-cents 5.051 during the rest of the period. The purchase price reflects the fact that about 7 MW is considered to be the average available capacity (capacity factor of 35%).¹²² Inflation of the operations and maintenance part of these prices is additionally included at 0.2% per annum. The annual output is estimated to be about 63 GWh.

Activities to develop Wigton as a CDM project started in 2002. The original idea of attracting the interest of financing by the Dutch Carbon Emission Fund CERUPT did not materialize. It is now expected that the multilateral financing institution Corporación Andina de Fomento (CAF – Andean Development Corporation)¹²³ will purchase the Certified Emission Reductions at the amount of almost 500,000 t CO₂ for a 10 year crediting period.¹²⁴

The CO₂ emissions displaced by Wigton have been calculated on the basis of recent plant additions to the public grid, resulting in a weighted average emission factor of 0.782 t CO₂/MWh. At a price of US\$ 5 per tonne of avoided CO₂, the additional benefit (or funding) per kWh wind electricity would be in the range of 0.4 US-Cents.

Source: own elaboration.

¹¹⁸ In the meantime bought by Vestas from Denmark.

¹¹⁹ Owners are Jamalco and Alpart.

¹²⁰ IEC = International Electrotechnical Commission. IEC as well as the other reputed certification institution Germanischer Lloyd are certifying wind turbines according to four different site classes. Class 1 turbines are designed for maximum average wind speeds of 10 m/s at hub height and high sporadic gust and wind speeds. The selection of such turbines has been proven successfully just after the inauguration of the Wigton Wind Farm, when hurricane Ivan hit the site in early September 2004 without causing any damage to the turbines itself.

¹²¹ The EIA can be downloaded from the website of the CDM/UNFCCC: http://cdm.unfccc.int/UserManagement/FileStorage/FS_799557752.

¹²² In a feasibility study for Wigton it was argued that the wind farm would contribute to avoiding future installation of fossil plants by at least 7 MW, thus leading to avoided capacity costs of a minimum of US\$ 1.54 million/a. Based on an assumed average wind production of 61 GWh/a (state of planning in 1999), the total amount of capacity credit would correspond to approximately 2.5 to 3.3 US-cents/kWh. Such argument has been rejected by JPSCo. as being not plausible due to the unreliable nature of wind energy.

¹²³ Despite its name, shareholders of the CAF are almost all South-American countries as well as Mexico, Jamaica, Dominican Republic, Spain and some other non-Andean states.

¹²⁴ A first submission of the baseline methodology had been criticized by the panel in charge of supervising this process within the CDM consultation. A revised version was therefore submitted to the UNFCCC in January 2004 that includes a new methodology proposed under the title “Baseline methodology using Build, Operating or Combined Margin for grid-connected renewable power projects, excluding biomass projects”. This new approach has not yet received final approval.

BOX 2 FROME SUGAR FACTORY

In 2003, the Sugar Company of Jamaica (SCJ) commissioned Gibson Energy Ltd. from Canada to elaborate a pre-feasibility study for a cogeneration project at Frome. This study looked at the present energy requirements and possible efficiency improvements. It assessed several cogeneration models for further consideration.¹²⁵

The Frome sugar factory has currently a grinding capacity of less than 300 tonnes of cane per hour and has been crushing about 634.000 tonnes during the harvest period 2003. Theoretically the factory would be capable of crushing more than 1 million tonnes of cane per harvest.

The inefficient process and the present harvesting and delivery of cane with excessive down times cause a high steam rate (0.693 kg steam per kg cane. At full load about 5.8 MW electricity need to be supplied.

It is suggested that the total process will be improved in first place, reducing the energy requirements in the form of electricity as well as heat. A new cogeneration plant would replace the existing powerhouse and be designed to match the maximum thermal load. The plant would receive bagasse from the sugar factory and supply it with all steam and electricity required for processing cane and sugar.

The new boiler would deliver high pressure steam (82 bar/510°C), achieve high efficiency (about 85 to 90% based on low heat value) and would have multi-fuel capability. In order to secure supply of excess electricity to the public grid year-round the boiler would be fed with fuel wood and (possibly) coal during the out-of-harvest period.

Maintaining the current capacity of 300 tonnes of cane per hour, the new cogeneration plant in combination with process improvements could provide excess capacity of up to 28.8 MW for electricity supply to the grid at estimated installation costs of US\$ 49.8 to 62.3 million.

During about 115 days per year the cogeneration plant would be operated on fuel wood (a total of 136,000 tonnes), while the operation period on bagasse would vary between a low 135 days and a high 210 days, depending on the amount of sugar cane being ground (between 650,000 and 1 million tonnes/year. A low capacity factor would require the supply of additional alternative fuel, such as coal.

To provide the 136,000 tonnes of fuel wood annually, the Frome Cogeneration project will require 7,500 to 8,000 hectares of fuel wood plantation, with about 1,500 hectares harvested every year. The supply of fuel wood to Frome would bring an additional profit of \$J 64 million per year.

The payback period for the cogeneration system is calculated to be in the range of 4-5 years, the rate-of-return is between 20 and 25%, assuming a sales price of 6 US-cents/kWh for the electricity supplied to the grid. The improved energetic process would lead to profits and savings of US\$ 6.9 to 7.5 million and to annual revenues of US\$ 15.0 to 16.7 million.

At the average specific consumption of 0.25 tonnes of oil per MWh electricity for thermal plants, bagasse based cogeneration (not including fuelwood) would save some US\$ 11 million of foreign exchange annually.

Source: own elaboration.

¹²⁵ A previous pre-feasibility study of 1991 had already shown that the export of about 24.5 MW of continuous, year-round power (capacity factor of 85%) was possible by using bagasse and heavy-fuel oil (54% of the total energy input). This study had no immediate consequences, due to inadequate regulation for grid access and remuneration of electricity sold to JPSCo.

BOX 3 ETHANOL FACTS AND FIGURES

Ethanol (or ethyl alcohol or ETOH) can be produced synthetically from crude oil, gas or coal. Agricultural alcohol (or bioethanol) may be distilled from grains, molasses, fruit, sugar cane juice, cellulose and numerous other sources including municipal waste.¹²⁶ Both products, fermentation and synthetic alcohol, are chemically identical. Most of the world production of ethanol of currently about 40 billion litres is being used as fuel in the transport sector (about 70% of the total), where it can reduce CO₂-emissions by up to 90% compared to gasoline.¹²⁷ Other end-uses are found in the beverage production and in industrial applications (mainly for solvents). There is a distinction to be made between hydrous and anhydrous ethanol. The first contains some water and usually has a purity of 96% and is the direct product of the distillation process. Brazil is so far the only country in which this ethanol is being used as a 100% gasoline substitute in cars with dedicated engines (sold on the market as “Álcool”).

Anhydrous (or dehydrated) ethanol on the other hand may be used in fuel blends with gasoline and is then an effective octane enhancer¹²⁸ and oxygenate, substituting the use of MTBE (Methyl-Tertiary-Butyl-Ether).¹²⁹ The use of MTBE can also be replaced by the synthetically produced ethanol derivate ETBE (Ethyl-Tertiary-Butyl-Ether)¹³⁰ which has the advantage of easier handling, but is significantly more expensive than ethanol itself.¹³¹ Several states in the US (California, New York and Connecticut) have already banned the gasoline oxygenate MTBE to curtail potential water contamination and use ethanol now instead. The energy content (lower heat value) of ethanol is only about 65% that of gasoline leading to a 2 to 3% decrease in mileage for a blend of 10% ethanol. For cars running on up to 85% of ethanol a 5 to 15% drop in fuel economy is being reported.

By far the largest producer of fuel ethanol from biomass is Brazil with about 14.7 billion litres (crop season 2003/2004) on the basis of molasses and sugar cane juice,¹³² using about half of the harvest of 360 million tonnes of sugar cane for its ethanol production. It is estimated that the ethanol output will increase to some 23 billion litres in 2010. Exports from Brazil, mainly to Japan and other Asian countries, will more than double within the next five years. The yield for the production of hydrous ethanol from sugar cane is about 75 litres per tonne.¹³³ That means that in the case of Jamaica one hectare of sugar cane could provide a minimum of 4,500 to 5,000 litres of alcohol (without major improvements on the farming side or at the distillery).¹³⁴ The ratio of energy output to energy input is reported to be about 8.3:1 on average for Brazil.¹³⁵ Ex-factory prices have been varying considerably in Brazil in recent years and are between 50 and 120 US-cents/US gallon,¹³⁶ what gives ethanol a price advantage compared to gasoline. This attractive price made Brazil the largest exporter of this commodity, with 770 million litres in 2003 (mostly in the form of beverage and industrial alcohol). In January 2005, the cost share of anhydrous ethanol to the consumer price for gasoline (E-25) in Brazil was 8.5 US-cents per litre.¹³⁷ If the production of anhydrous ethanol is a profitable business in the short-term depends mainly on the price that is paid for the alternative sugar production either on the domestic or the world market. Price per volume for pure (hydrous) ethanol at the petrol station in Brazil is about 30 to 40% lower than for gasoline (E-25), reflecting the lower energy content of ethanol compared to gasoline. Taking into account that the consumption of neat-fuel cars is higher than the consumption of regular gasoline cars, the calculated price for ethanol is currently about 80% of that for gasoline.

Source: own elaboration.

¹²⁶ As starches, which must first be hydrolyzed to fermentable sugar, cassava and sweet sorghum could be of some interest for Jamaica.

¹²⁷ Real CO₂-reductions depend on the different energy inputs at the various stages of the production chain as well as on the amount of substituted gasoline and require complex calculations.

¹²⁸ Ethanol has an octane rating of 113 compared to 87 for regular unleaded gasoline.

¹²⁹ MTBE as well as ethanol are oxygenates used to promote more complete combustion of gasoline, which reduces carbon monoxide and volatile organic compound (VOC) emissions.

¹³⁰ 47% ethanol and 53% isobutylene from oil refineries. ETBE can therefore only partially be regarded as renewable energy fuel, if bioethanol is being used.

¹³¹ The blending of gasoline with up to 15% ETBE (maximum according to European standards) is mainly common in France. In Spain a maximum of 5% ETBE is mixed to the gasoline.

¹³² This is still below the record high 15.4 billion litres in the crop season 1997/98.

¹³³ This figure is at the lower end of the scale. The relatively modern and efficient Brazilian ethanol industry reports 89 litres per tonne of sugar cane for hydrous ethanol and 85 litres per tonne for anhydrous ethanol.

¹³⁴ The productivity in Brazil increased from 4,200 litres/hectare in 1980 to 6,350 litres/hectare in 2003. Assuming that ethanol could also be produced efficiently from bagasse, a process that is under development in Brazil and other countries, land requirements could be reduced significantly, by at least 25%.

¹³⁵ According to a study released by the United States Department of Agriculture in July of 2002, the output:input energy ratio is only 1.34:1 for ethanol from corn and might be even negative in some individual cases. It is obvious that a separate calculation needs to be done on the background of the actual situation in Jamaica.

¹³⁶ The world market price for ethanol stood at US\$ 1.00 per US gallon in October 2004.

¹³⁷ i.e. about 34 US-cents per litre of ethanol.

BOX 4 ETHANOL FUEL PROGRAMMES IN DIFFERENT COUNTRIES

In 2003, a total of 13 countries used ethanol as a fuel component; others had programmes in the planning with most countries targeting a 10% blend (so-called E-10, also often referred to as "Gasohol"). Such mixture does not require any modification in vehicle engines.¹³⁸ In the **European Union**, bioethanol can be used as a 5% blend with petrol under the EU quality standard EN 228 that is covered by vehicle warranties.¹³⁹ With engine modification, bioethanol can be used at far higher levels or even as neat fuel; e.g. E-85 (85% ethanol) is common in the U.S. for passenger cars.¹⁴⁰ In **Canada** it is planned that E-10 blends are to achieve a 35% market penetration by 2010. **India** started the introduction of E-5 blends in several federal states at the beginning of 2003, the same line followed **China** in some provinces. In **Colombia**, the sale of E-10 will be mandatory from 2006 on in cities with more than 500,000 inhabitants to curb air pollution. This programme will require the cultivation of an additional 150,000 ha of sugar cane.

Brazil started its large-scale Proálcool-programme as early as in 1975 after the first world oil crisis. The current share of ethanol in the fuel market is about 30% (after a record high of 50% in the late 1980's). All 18 million light vehicles combined consume about 27.5 billion litres of fuel, of which 16 billion litres are gasoline and 11.5 billion litres ethanol (figures for 2003).¹⁴¹ After the introduction of ethanol as a gasoline additive in the mid 1970s alcohol was introduced as a neat fuel in 1980. Already in 1984, fully alcohol-powered cars accounted for more than 94% of the total car production. On June 1, 2003 the Brazilian Government raised the required alcohol admixture of all automotive gasoline from 22 to 25%. Depending on the technical progress, it is planned to increase the mixing-ratio up to 30% in the next years. Today about 2.4 million cars are running completely on bioethanol.¹⁴² In March 2003, the car manufacturer Volkswagen introduced a first flex-fuel vehicle, which can operate with any mix of ethanol and gasoline (i.e. any combination of Alcool and Gasohol from E-25 to E-100), thus eliminating the dependence on producers of hydrous ethanol with varying prices and outputs. Other manufacturers followed and Volkswagen do Brasil has already announced that the whole fleet's engines would be converted from conventional to flexible fuel by the end of 2006. Sales of flex-fuel cars are already accounting for more than 25% of total vehicle sales on the Brazilian market and are expected to take half the market in 2005 and about two thirds by 2007, the Brazilian Association of Vehicle Manufacturers estimates.

In 2004, Renault brought a flex-fuel car on the Brazilian market that can also run on pure gasoline and will therefore be capable of operating in neighbouring countries as well. In August 2004, General Motors Brasil launched a multi-fuel car that runs on natural gas as well as ethanol or gasoline or a combination of both.

In **Thailand** a premium gasoline with an ethanol blend for the substitution of MTBE is already on the market, but only in relatively small quantities. A first ethanol plant was commissioned in October 2003. The government now wants to replace all regular gasoline with E-10 and will phase out the use of MTBE by the end of 2006.

In the **USA** about 20 states have started ethanol programmes. Some states have mandated the use of E-10 (or lower ethanol blends) to act as a fuel oxygenate to improve air quality and replace MTBE. In California as the largest single market in the U.S. with demand of about 4 billion litres of ethanol per year, most of the gasoline sold has a 6% ethanol content. By the end of 2003, there were about 3 million flex-fuel vehicles in the U.S. capable of operating with E-85 or any blend with a lower content of ethanol.¹⁴³ The sale of E-85 is mainly concentrated in Minnesota and other midwestern states, due to the use of corn as main feedstock for the ethanol production. The federal government and state governments are required to purchase alternative-fuelled vehicles (minimum of 85% ethanol blend or other non-petroleum based fuels) by the Energy Policy Act of 1992.

Sweden is blending gasoline with up to 5% of ethanol and offers E-85 for flex-fuel vehicles and pure alcohol for buses of the public transport system.

Source: own elaboration.

¹³⁸ Problems with rubber damages and metal corrosion have only been reported for old car models which might need adjustment.

¹³⁹ It is generally acknowledged that ethanol blends of 10% and even more do not harm existing vehicle engines.

¹⁴⁰ The small amount of gasoline added to the alcohol helps prevent corrosion of engine parts, and aids ignition in cold weather.

¹⁴¹ Diesel fuel is only consumed by trucks and buses in Brazil.

¹⁴² There was already a fleet of 5 million neat ethanol cars in the mid 1980's, but the recovery of the world sugar price along with bad harvests in the late 1980's and lacking support for the ethanol industry led to significant shortages of ethanol and consumer confidence eroded. Nowadays, Brazil is holding a strategic ethanol stock for the off-harvest season and any possible shortages.

¹⁴³ It is reported that many of the car buyers in the US remain unaware of the option to fuel with E-85 or have no access to this type of fuel.

BOX 5 CDM PROCEDURES

The 2001 Marrakech Accords, signed during the seventh Conference of Parties to the UNFCCC (COP 7), finalized many details regarding CDM participation. These include how projects need to comply with the CDM's sustainable development criteria, the project approval process, performance monitoring and verification, and the process for issuing Certified Emission Reductions (CERs).¹⁴⁴ Marrakech also created the CDM Executive Board, which is the supervisory body of the CDM and is ultimately accountable to the Conference of the Parties.

According to the Marrakech Accords and other Party convention decisions, project developers must take the following steps to obtain CDM project status and generate CERs (see also figure in **Box 7**):

- 1) gain approval of the host country's DNA and affirmation that the project will contribute to the national sustainable development goals;
- 2) obtain authorization from the Party(ies) to the Kyoto Protocol for the voluntary participation of the proposed project participants;
- 3) prepare a Project Design Document (PDD) detailing the project's activities, proposed baseline and monitoring methodology, crediting period, and information on the project participants, environmental impact and stakeholder comments;
- 4) obtain validation of the PDD by a DOE, i.e. an independent evaluation of a project activity against the requirements of the CDM scheme;
- 5) apply for registration of the project after approval of the CDM Executive Board; and
- 6) monitor actual emission reductions achieved and obtain verification from a second DOE.¹⁴⁵

The methodology for estimating the "project baseline" scenario is one of the most important components of a CDM project, and project developers need to document this in a PDD. The baseline is an estimate of emissions that would have occurred in the absence of the proposed project activity, and is used to calculate the quantity of emission reduction credits the project can generate.

Project participants have the opportunity to propose a new methodology for their specific activity. But in order to minimise the expenses for such approaches, the Executive Board is constantly approving methodologies for certain technologies and project settings which if applied have to be taken as a guideline.

The crediting period can be a fixed period of ten years, or a seven-year period, which can be renewed up to two times, for a maximum of 21 years.

The monitoring and verification plan contained in the PDD outlines: the data used to track and quantify emissions (if any) and emission reductions from the project; the method for collecting data, including quality assurance and quality control procedures; and methods for calculating emission reductions from the data collected, including adjustment for exogenous factors such as weather, production levels, and operating hours.

Project participants must monitor activities over the life of the project and periodically arrange for emission reduction verification by DOE, which then issues a verification and certification report. Based on this report, the CDM Executive Board issues CERs for the amount of greenhouse gas abatement that actually occurred during the verification period (1-2 years).

The CDM participation process can be burdensome and costly for any project developer. Transaction costs in the project preparation phase range from 45,000 to 170,000 Euros (excluding purchase agreement negotiation costs) depending on the size and complexity of the project. Fees for registration with the CDM Executive Board are scaled according to the average annual CO₂ equivalent reductions and range from US\$ 5,000 to 30,000. Additional expenditures will occur during the operational phase of the project for monitoring and verification and for the sale of CERs in case that a broker is acting.

Source: own elaboration.

¹⁴⁴ Equal to one metric tonne of carbon dioxide equivalent, calculated using global warming potentials as defined by the Conference of the Parties.

¹⁴⁵ Can be the same DOE as for the validation process in the case of small-scale projects and upon special requests.

BOX 6 SMALL-SCALE CDM (SSC) PROJECTS

In light of the special circumstances that small-scale projects bring to bear, the Executive Board was instructed to develop methods to reduce the cost and complexity of CDM participation for projects defined as small-scale. Those include renewable energy projects with a maximum capacity of 15 MW (or equivalent) and project activities that both reduce anthropogenic emissions by sources and directly emit less than 15,000 tonnes of CO₂ equivalent annually.

Simplified modalities and procedures for small-scale projects were designed to reduce the high transaction costs associated with the low economies of scale that can cripple small projects. (Presented in Appendix B of the Simplified Modalities and Procedures for Small-Scale CDM Project Activities).

Those include as special provisions:

- 1) a **simplified PDD**;
- 2) **pre-approved simplified and standardized methodologies** for determining a baseline and creating a monitoring plan for several categories of SSC project activities;
- 3) the ability to **bundle project activities for the PDD**, registration, and verification to reduce administration costs;
- 4) **simplified environmental impact analysis**;
- 5) **reduced registration fee**; and
- 6) the ability to have **the same DOE validate a PDD** and verify emission reductions for a specific SSC project.

To qualify for these standard procedures, in addition to meeting the applicable scale requirements, SSC projects must indicate why the project activity would otherwise not be implemented due to the existence of one or more of four barriers, as explained below:

Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions;

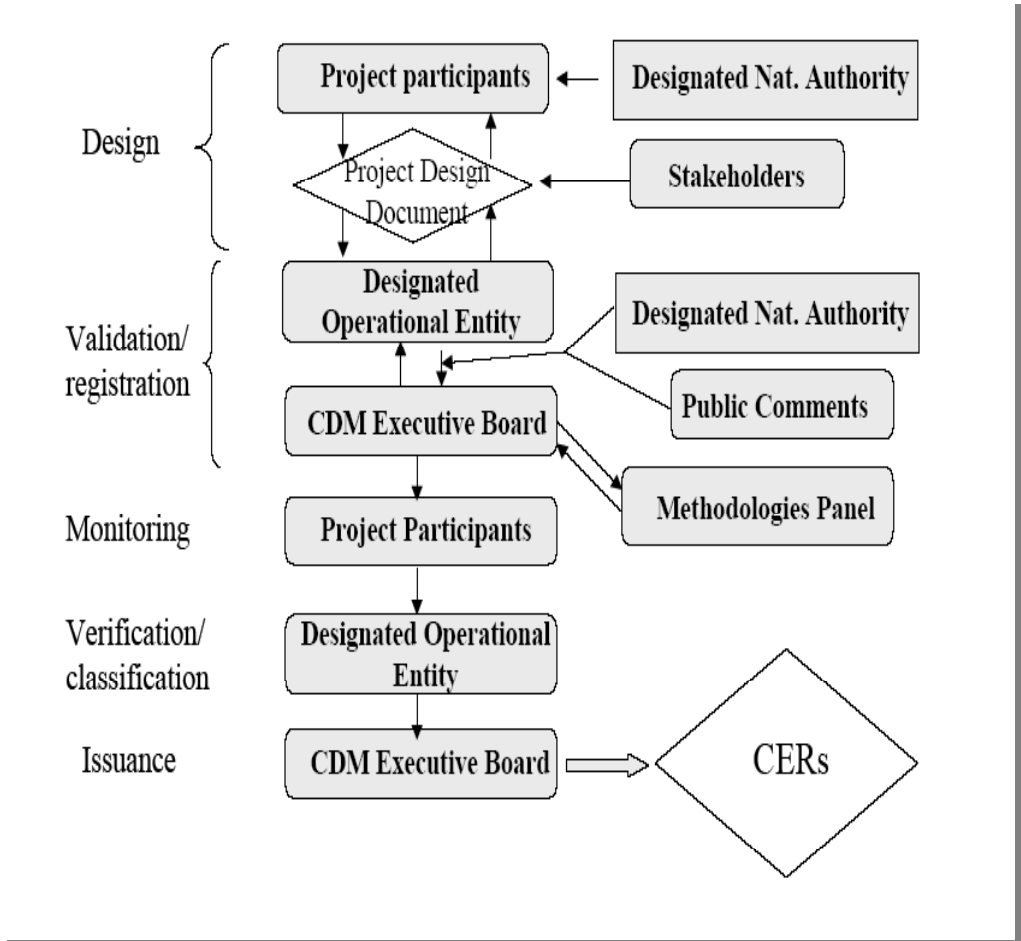
Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions;

Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;

Other barriers: without the project activity, for another specific reason, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.

Source: own elaboration.

**BOX 7
OUTLINE OF THE CDM PROJECT CYCLE**



Source: Ellis and others, 2004.

**TABLE A-1
MAIN STAKEHOLDERS IN JAMAICA WHICH WERE INTERVIEWED**

Name	Address	Tel.	Email	Contact and Comment
Rural Electrification Program Ltd. (REP)	113 Washington Blvd, Kingston 20	933-5504 and -0631	Garvey: kdgarvey@cwjamaica.com Marshall: cengineer_rep@cwjamaica.com	State-owned entity. General Manager: Mr. Keith D. Garvey; Chief Engineer: Mr. Samuel Marshall
Ministry of Commerce, Science and Technology (MCST)	PCJ Building, 36 Trafalgar Rd., Kingston 10	929-8990-9	admin@mct.gov.jm Dixon: jdixon@mct.gov.jm McCain: cmccain@mct.gov.jm Watson: cwatson@mct.gov.jm Edwards: kedwards@mct.gov.jm	Responsible for all Energy matters since Oct. 2002; Minister: The Honourable Phillip Paulwell; Permanent Secretary: Dr. Mrs. Jean Dixon; Assistant to the PS, Mr. Cecil McCain; Senior Director – Energy Monitoring Division: Mr. Conroy Watson; Chief Director – Energy Economics, CEIS Liaison & SIEE Advisor: Mr. Jerico Hanson; Senior Energy Engineer: Mr. Kevin Edwards
Petroleum Corporation of Jamaica (PCJ)	36 Trafalgar Rd., Kingston 10	929-5380/9 Sampson: 929-9006	ica@pcj.com Wright: raymond.wright@pcj.com Sampson: cezley.sampson@pcj.com	Mandated in 1995 with development and application of RE technologies: Group Managing Director: Dr. Raymond Wright; Director of National Energy Efficiency: Mr. Cezley Sampson, also in charge of EE fund.
Solar Dynamics (JA) Ltd.	13-15 Molynees Rd, Kingston 10	968-2049 or -2361 and 960-1439	solarjam@cwjamaica.com	Subsidiary of Barbados company. General Manager: Mr. Hugh Harris; www.solardynamicsttd.com
Automatic Control Engineering Ltd.	29 Phoenix Av., Block D, Kingston 10	968-2521, 929-0110	acekgn@cwjamaica.com	Installation of PV and SHW systems; Mrs. Louise Henriques
Jamaica Sunlife Ltd.	102b Maxfield Av., Kingston 13 Bluefields, Westmoreland	929-0809 and 968-5531 955-8177	ricksunlife@colis.com	Manufacture and Installation of solar water heaters RE suppliers and consultants
Ecological Technologies Ltd. (Eco-Tec)	2 Ardenne Rd., Kingston 10	926-3635; 908-1032; 929-0377; 920-3482 Mrs. Thorpson: 926-3635/6	Mrs. Thorpson: rbrownest@anngel.com	Executive Director: Mrs. Camilla Needham; Deputy Executive Director: Mrs. Thelma Williams; Responsible for USAID-supported project "Environmental audits for sustainable Tourism": Mrs. Racquel Brown Thompson

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TABLE A-1

Name	Address	Tel.	Email	Contact and Comment
Jamaica Energy Partners Ltd.	10 Grenada Way, Kingston 5	920-1746-9		IPP since 1995 with 74 MW
Wigton Wind Farm Ltd.	36 Trafalgar Rd., Kingston	960-3108 or -3994 McLeod: 960-1085	wesley.mcleod@wwfja.com	Subsidiary of PCJ; General Manager: Mr. Wesley McLeod; Assistant Manager – Operations: Mrs. Michelle Chin Lenn
Jamaica Public Service Co. (JPSCO.)	6 Knutsford Blvd., Kingston	926-3190		President & CEO: Mr. Charles Matthews; Chief Operating Officer: Mr. Robert Patrick; Director System Planning and Control: Mr. Dwight Dacosta; Government & Regulatory Affairs: Mr. Samuel Davis
Office of Utility Regulation (OUR)	PCJ Building, 36 Trafalgar Rd., Kingston 10	929-3635 Morgan: 968-6057 and -6053	Central: office@our.org.jm Morgan: pmorgan@our.org.jm Silvera: rsilvera@our.org.jm	Director General: J. Paul Morgan; Deputy Director General: Mr. Raymond Silvera
Caribbean Energy Information System (CEIS)	C/o Scientific Research Council, Kingston 6	927-1779	mwhyte@uwimona.edu.jm	Mrs. Mona Whyte
University of the West Indies – Center for Environment and Development (UWICED)	13 Gibraltar Camp Way Mona Campus, Kingston 7	927-1660-9 Douglas: 977-5479 / -1659	helpdesk@uwimona.edu.jm Douglas: charles.douglas@uwimona.edu.jm Mason: maurice.mason@uwimona.edu.jm	Prof. Al Binger in the Institute for Physics; UWICED: Dr. Charles Douglas – Project Consultant; Mr. Maurice Mason – Project Officer; Mr. Jose L. Gerhartz – Sidsnet Information Officer
Scientific Research Council (SRC)	Hope Gardens, Kingston 6	927-1771-4	Watson: hawthorne@src-jamaica.org	Dept. for Waste Management; focus on agro-industrial sector; also responsible for CEIS Executive Director: Dr. Audia Barnett Mr. Hawthorne Watson (Manager Information Services) Mrs. Julia Brown (Manager Process Development Division)
College of Agriculture, Science and Education (CASE)	Passley Gardens, Port Antonio	993-5436-8	registrar@case.edu.jm	

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TABLE A-1

Name	Address	Tel.	Email	Contact and Comment
Jamaica Solar Energy Association (JSEA)	6 St. Lucia Av, Kingston 5	754-0973		Founded in 1999, based at PCJ
Ministry of Water and Housing	Hope Gardens, Kingston 7	927-1878		Managing Director: Mr. Basel P. Fernandez
Water Resources Authority	65 Half Way Tree Rd., Kingston 5	929-3694	Fernandez: commander@cwjamaica.com meija@infochan.com	Managing Director: Mrs. Sylvia McGill
Meteorological Service (MOW)	16A Half Way Tree Rd., Kingston 5	Ms. McGill: 929-3700 / -3706 920-9117		Mrs. Leonie Barnaby; Rohan Richards; Anastasia Calnick
Ministry of Land and Environment		Barnaby: 929-2792 Richards: 754-9694 Calnick: 960-5032-3	Barnaby: nrcareg@mail.infochan.com Richards: emd.mle@cwjamaica.com Calnick: anastasia.calnick@cwjamaica.com	
(National Environment and Planning Agency (NEPA))	10 Caledonia Av., Kingston 5	754-7543 Ms. Sanguinetti: 754-7540 ext. 2303	Mrs. Sanguinetti: gsanguinetti@nepa.gov.jm	Mrs. Gina Sanguinetti
Ministry of Agriculture	Hope Gardens, Kingston 5	927-1731		
The Sugar Producers' Federation of Jamaica	5 Trevennion Park Rd., Kingston 5	929-2022		See also Sugar Industry Authority
Isratech Jamaica Ltd.	Lot 2 Kendal (Mandeville)	603-3095	jdi-plastro@cwjamaica.com	Importer of solar collectors made in Israel
Planning Institute of Jamaica (PIOJ)	10-16 Grenada Way, Kingston 5	906-4386 Duncan: 906-4463-4	Mrs. Duncan: cduncan@pioj.gov.jm Mrs. Clarke-King: seveline_clarkeking@pioj.gov.jm	Belongs to the Ministry of Finance and Planning Mrs. Christine F. Neves Duncan (Consultant) Mrs. Seveline Clarke-King (Economist)
National Solid Waste Management Authority	61 Half Way Tree Rd, Kingston 10	926-3988 Mrs. Morgan: 754-7466; 399-2280 (cellular)	Mrs. McHarge: mmcharge@nswma.gov.jm Mrs. Morgan: bmorgan@nswma.gov.jm	Head of unit: Mrs. Melissa McHarge; Mrs. Bethane Morgan

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TABLE A-1 (conclusion)

Name	Address	Tel.	Email	Contact and Comment
National Sugar Co. Ltd.	25 Dominica Dr., Kingston 5	926-7548		
National Water Commission	28 Barbados Av. , Kingston 5 7 Cecelio Av., Kingston 7	929.5430-5 926-5311		Also in charge of waste water treatment www.statinja.com
Statistical Institute of Jamaica (STATIN)	18 Trafalgar Rd., Kingston 10	978-7755; 978-3337 ext. 2270	Kerr: rkerr@jamprocorp.com Shakespeare: dshakespeare@jamprocorp.com Evelyn: oevelyn@forestry.gov.jm	Senior Consultant Investment Promotion: Mr. Robert Kerr; Consultant Export Promotion: Mr. Desmond Shakespeare Mr. O.B. Evelyn
Ministry of Agriculture – Forestry Department	173 Constant Spring Rd., Kingston 8			
Sugar Industry Authority (SIA)	5 Trevennion Park Rd, Kingston 5 Sugar Industry Research Institute: Kendal Rd., Mandeville	926-3650-3/ -5930-3 Roberts: 962-2241	Scott: kscott@cwjamaica.com Roberts: sirijam@cwjamaica.com	Manager, Information & Planning: Mr. Keith E. Scott; Director of Research: Dr. Earle V. Roberts (Sugar Industry Research Institute of SIA)
Bureau of Standards	6 Winchester Rd., Kingston 10	926-3140		Consultant for Energy Efficiency: Mr. Roosevelt Dacosta
Office of the Prime Minister	1 Devon Road, Kingston 10	927-9625 / -9941-3	gahylton@opm.gov.jm	Ambassador/Special Envoy: Mr. G. Anthony Hylton (in charge of Energy Policy and LNG study/negotiations); Energy Policy Advisor (External Consultant, formerly World Bank officer): Mr. Zia Mian
Econergy Engineering Services	80A Main St., Ocho Rios	974-5064	econergy@infochan.com	Mr. Eaton H. Haughton; heading first and only ESCO; has funding available for energy efficiency from Rocketfeller Foundation