

## Jamaica's Initial Climate Change Technology Needs Assessment



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## ***Background and Introduction***

There is increasing evidence of human interference in the climate system which has led to global warming. With the concern over global environmental issues, the United Nations General Assembly (UNGA) adopted resolution 43/53 on the protection of the global climate for present and future generations. The UNGA in its resolution 45/202 provided the basis for the negotiations of a framework convention on climate change. Final negotiations with regards to the United Nations Framework Convention on Climate Change (UNFCCC) occurred at the United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil, with the UNFCCC becoming open for signature on 4<sup>th</sup> June 1992. Jamaica signed the 12 June 1992 and ratified the UNFCCC on the 6<sup>th</sup> January 1995.

For Jamaica as a small island developing state climate change is of critical importance. The impacts of a changing climate could have potentially a devastating effect. Sea level rise will cause increased coastal erosion rates, flooding and compound the effect of extreme weather events such as hurricanes. Changes in weather patterns will affect water supplies and negative effects on agriculture.

As a party to the UNFCCC, Jamaica like all parties are subject to a number of commitments, which place obligations on Jamaica to respond to climate change. Articles 4 and 12 of the UNFCCC outline the commitments for countries. Under Article 12 countries are required to communicate to the Conference of Parties through the secretariat (i) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit using comparable methodologies to be promoted and agreed upon by the Conference of the Parties, (ii) A general description of steps taken or envisaged by the party to implement the Convention (iii) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for global emission trends.

Jamaica received US\$232,000 from the Global Environmental Facility (GEF) through the United Nations Development Programme in 1998 for the Initial National Communications from. A climate change committee was established to oversee the project. The initial national communication of Jamaica was completed in November 2000 and submitted to the 6<sup>th</sup> Conference of the Parties of the United Nations Framework on Climate Change, in the Hague Netherlands. The national communications report of Jamaica included a greenhouse gas inventory for 1994, a discussion on Jamaica's vulnerability to climate change and identification of potential adaptation options for climate change. The initial national communications of Jamaica was financed utilizing GEF Phase 1 financing.

Jamaica received an additional US\$100,000 through Phase 2 GEF financing for additional capacity building exercises associated with the initial national communications.

These capacity building exercises include an assessment of the systematic observation systems of Jamaica and a technology needs assessment.

The need for technology transfer and environmentally sound technologies has been recognized as critical in averting the threat of climate change throughout the UNFCCC process. Article 4.5 of the Convention notes that

*“the developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance as appropriate, the transfer of, or access to, environmentally sound technologies and know how to other parties, particularly developing countries Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.”*

Further decision 13/CP.1 of the UNFCCC recalled the relevant provisions of Chapter 34 of Agenda 21 on “Transfer of Environmentally Sound Technology, Cooperation and Capacity Building, and requested the Convention Secretariat to prepare itemized progress report in concrete measures taken by Parties listed in Annex II to the Convention, with respect to their commitments related to the transfer of environmentally sound technologies and know-how, necessary to mitigate and facilitate adequate adaptation to climate change.

The COP’s decision 7/CP.2 also requested the Convention Secretariat to give high priority to the development and completion of a survey of the initial technology needs, as well as, technology information needs, of Parties not included in Annex I to the Convention (non- Annex I Parties), with a view to providing a progress report to the subsidiary Body for Scientific and Technological Advice at its fourth session. Decision 4/CP.4 also urged non-Annex I Parties, in the light of their social and economic conditions to submit their prioritized technology needs, especially those relating to key technologies to address climate change in particular sections of their national economies, taking into account state-of-the-art environmentally sound technologies. Further by its decision 4/CP.4, the COP requested Subsidiary Body for Scientific and Technological Advice (SBSTA) to establish a consultative process aimed at achieving agreement on a framework for meaningful and effective actions to enhance implementation of Article 4.5 Following decision 4/CP.4, three regional workshops were held in Africa, Asia and the Pacific Region, and Latin America and the Caribbean. Through the consultative process, a framework for technology transfer was developed. This framework became the subject of negotiation during the second part of the Sixth Conference of Parties (COP6 bis) as part of Bonn Agreement for implementation of the Buenos Aires Plan of Action. At the Seventh Conference of Parties (COP7), by decision 4/CP7 the framework for meaningful and effective implementation of Article 4.5 was formally adopted.

In October 2003 in Port of Spain, Trinidad and Tobago a workshop was held on Technology Needs Assessment and Technology Information for the Caribbean Region.

The main objectives of this workshop were to discuss regional concerns and priorities in assessing technology needs, including information tools and resources relevant for the Caribbean Region, and to discuss a framework to assist countries in conducting comprehensive technology needs assessment including addressing adaptation issues and concerns. Key recommendations and outcomes of the workshop included the fact that adaptation issues are inherently cross-sectoral and are often interrelated with mitigation options, and that the Technology Needs Assessment process and activities should not be conducted in a vacuum but ensure links with national development priorities and needs.

The development of this initial technology needs assessment report is therefore in fulfillment of the above relevant decisions of the COP of the UNFCCC and also assisting Jamaica to meet the commitments under the UNFCCC.

### ***The Technology Needs Assessment Process***

Technology transfer is concerned with the flow of experience, know how, and equipment between and within countries. Technology transfer is a priority action under the UNFCCC. Decision 4CP/7 of the UNFCCC notes that technology transfer has five key elements connected within an integrated framework. These elements are:

- (i) the technology needs assessment,
- (ii) improving access to technology information,
- (iii) improving and strengthening local capacity,
- (iv) creating enabling environments, and
- (v) instituting technology transfer mechanisms.

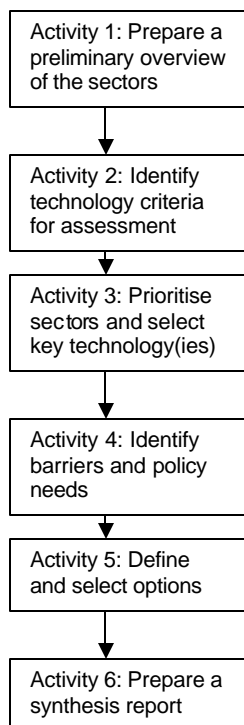
Decision 4CP/7 defines the technology needs assessment process as a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building. The purpose of a technology needs assessment is to assist in identifying and analyzing priority technology needs, which can form the basis for a portfolio of environmentally sound technologies projects, and programmes which can facilitate the transfer of, and access to, the environmental sound technologies and know-how in the implementation of Article 4, paragraph 5, of the Convention.

The technology needs assessment process as suggested by the United Nations Development Programme is primarily comprised of six activities. Figure () below outlines the technology need assessment process. The first activity is a preliminary overview or assessment of the sectors which are to be analyzed. The assessment involves

collecting and analyzing the various data and information which exists on this sector, so that a comprehensive overview of the sector is complete. The second activity involves the identification of technology for criteria for investment. This depends on a number of factors as it relates to the technology. Key questions such as the contribution to development goals and the possible market potential of technology have to be considered. The third activity is the identification of priority sectors and key technologies, which will be based on the key criteria for the technology and the importance of the sector. The availability and the possible access to the technology should be considered. The fourth activity allows the identification of barriers to applying specific technologies, and the identification of policy needs which are required to improve technology transfer. The fifth and six activities involve selecting technological options for the short and long term, and the preparation of a report for review. The entire technology needs assessment process should involve stakeholder consultation and engagement along with barrier analysis.

For Jamaica the technology needs assessment process consisted of a series of expert workshops with key sectoral experts present to discuss issues relating to technology in Jamaica. The first workshop focused on mitigation and energy issues, while the second workshop looked at adaptation issues as it relates to the coastal zone and water sectors in Jamaica. Both workshops used the initial national communications of Jamaica as the document of reference.

**Figure 1 UNDP Technology Needs Assessment Process**



## The Energy Sector

### Greenhouse Gas Emissions/Current Situation

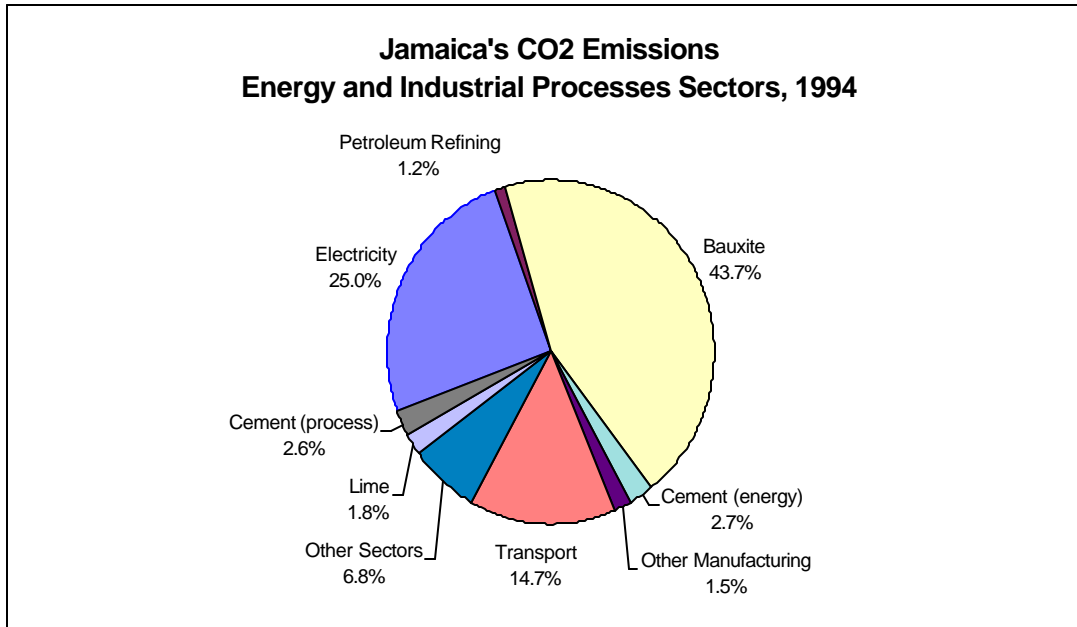
The initial national communications of Jamaica was completed in June 2000. The greenhouse gas inventory was a key component of that initial communication. The greenhouse gas emissions and removals by sinks was calculated for the year 1994 utilizing the 1996 revised Intergovernmental Panel on Climate Change Guidelines for the National Greenhouse Gas Inventories. Table 1 below shows that in 1994 the Jamaica's emissions of carbon dioxide was 8,585 gigagrams. Jamaica also emitted 58.47 gigagrams of methane

**Table 1 Greenhouse Gas Emissions of Jamaica**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO <sub>2</sub> Emissions	CO <sub>2</sub> Removals	CH <sub>4</sub>	N <sub>2</sub> O
<b>Total National Emissions and Removals (Giga-Grams)</b>	<b>8,585</b>	<b>-167</b>	<b>58.47259</b>	<b>344</b>
<b>1 Energy</b>	<b>8,182</b>	<b>0</b>	<b>1</b>	<b>0</b>
A Fuel Combustion (Sectoral Approach)	8,182		1	0
1 Energy Industries	2,245		0	0
2 Manufacturing Industries and Construction	4,111		0	0
3 Transport	1,257		0	0
4 Other Sectors	586		0	0
5 Other (please specify)	-18		0	0
B Fugitive Emissions from Fuels	0		0	
1 Solid Fuels			0	
2 Oil and Natural Gas			0	
<b>2 Industrial Processes</b>	<b>403</b>	<b>0</b>	<b>0</b>	<b>0</b>
A Mineral Products	403			
B Chemical Industry	0		0	0
C Metal Production	0		0	0
D Other Production	0			
E Production of Halocarbons and Sulphur Hexafluoride				
F Consumption of Halocarbons and Sulphur Hexafluoride				
G Other	0		0	0
<b>3 Solvent and Other Product Use</b>	<b>0</b>			<b>0</b>
<b>4 Agriculture</b>			<b>43</b>	<b>343</b>
A Enteric Fermentation			36	
B Manure Management			7	4



C Rice Cultivation			0	
D Agricultural Soils				339
E Prescribed Burning of Savannas			0	0
F Field Burning of Agricultural Residues			0	0
G Other (please specify)			0	0
<b>5 Land-Use Change &amp; Forestry</b>	<b>(1)</b>	<b>0(1)</b>	<b>0</b>	<b>0</b>
A Changes in Forest and Other Woody Biomass Stocks	(1)	0(1)		
B Forest and Grassland Conversion		88	0	0
C Abandonment of Managed Lands				
D CO <sub>2</sub> Emissions and Removals from Soil	(1)	0(1)		
E Other (please specify)		0	0	0
<b>6 Waste</b>			<b>14.40987</b>	<b>0</b>
A Solid Waste Disposal on Land			14.408181	
B Wastewater Handling			0.0016889	0
C Waste Incineration				
D Other (please specify)			0	0



**Fig 2 Emissions from Energy and Industrial Processes Sectors 1994**

The majority of carbon dioxide which is emitted in Jamaica is caused as a result of fossil fuel combustion for energy, with the manufacturing industries and the construction sector being responsible for over 4,000 gigagrams of carbon emissions. Figure 2 above shows that 43.7% of the emissions in the energy and process sectors are due to the bauxite industry. Thus the bauxite industry is responsible for the majority of emissions of carbon dioxide from energy combustion. Currently in Jamaica there is 780 Megawatts (MW) of installed electricity generating capacity. 5.6% of the electricity generated comes from renewable energy sources. The Wigton Wind Farm in Manchester provides 20.7 MW. Other current sources of renewable energy come from the utilization of bagasse and small scale hydro electricity generating plants.

Jamaica is not a producer of fossil fuels and is therefore heavily dependent on the importation of fuels to meet its energy needs. Currently 65% of foreign exchange earned is spent on imported fuel and this amounts to about 15% of Gross Domestic Product. Thus a reduction on the amount of fossil fuel imported will directly aid in improving the Jamaican economy. Table 2 below shows the importation of petroleum products for 2003, whilst Table 3 shows the consumption of petroleum products for 1998 and 2003.

**Table 2 Importation of petroleum in 2003 (Draft Power/Electricity Policy for Jamaica September 2004)**

Items	Volume (million bbls)	Value ( US\$ Million)
Bauxite and Alumina	9.03	212.3
Marketing Companies	3.03	133.0
Petrojam-Crude Imports and Refined Products	15.04	467.7
Total	27.10	813

**Table 3 Fuel Consumption by various Sectors 1998& 2003-(Draft Power/Electricity Policy for Jamaica September 2004)**

Activity Sectors	Million bbls 1998	Percentages	Million bbls 2003	Percentages
Rail and Road Transport	5.75	25.00	6.07	23.5
Shipping/Aviation	1.60	7.00	2.01	7.8
Electricity Generation	5.12	22.00	6.47	25.1
Bauxite/Alumina	8.67	38.00	9.54	37.0
Cooking	0.84	4.00	0.90	3.5
Manufacturing/Processing	0.64	3.00	0.53	2.1
Other	0.19	1.00	0.25	1.0
Total	22.81	100.00	25.78	100.0
Non-bauxite/bunkering	12.54	55.0	14.23	55.4
Bauxite/bunkering	10.27	45	11.55	44.6

From table 2 US\$212 million of oil was imported (in 2003?) for alumina and bauxite operations, US\$133 million imports by the marketing companies and US\$467 million by the Petrojam oil refinery. The 9.03 million barrels of oil imported for the alumina sector in 2003 was at a cost of US\$24 per bbl. Crude prices for 2003 averaged US\$28 per bbl compared to US\$34 for finished products. The average price of oil imports was US\$29 per bbls in 2003. Between 1998 and 2003 the cost of imported oil for the alumina sector went up from US\$91 million to US\$212 million, an increase of more than 130 %.

Fuel imports can be broken down into two basic categories, the first category consists of the bauxite/alumina/shipping/aviation sector, and the second is the electricity generation/road transport. The first category is export based while the second is import based. Thus the implications for the economy are slightly different. Increased alumina production will result in increased oil consumption. Fuel oil for the bauxite/alumina sector is paid from the industry's export earnings, and hence there is little drain on the foreign currency reserves. Fuel oil for electricity generation/road transportation/cooking is import based and thus will have an effect on foreign currency reserves.

The increased electricity consumption in recent years has come mainly from higher quality of life; including the wider use of electrical equipment and devices in homes and factories such as air conditioners, television sets, computers, washing machines, rather than from expansion of the industrial base.

There has also been a rapid expansion in oil consumption for local transportation. This took place, immediately after implementing the motor vehicle liberalization policy in the

mid 1990s. The transportation share of oil consumption increased from 16% in the early 1990s to 25% in 1998. There are now more vehicles on the road, and this accounted for the increased oil consumption, rather than higher consumption by existing vehicles. With the reduction in the age of second hand vehicle imports in the latter part of the 1990s the rate of used vehicle additions has slowed. The fuel efficiency of the vehicle imported has also increased. The result is that the rate of increase for fuel oil consumption for local transportation has slowed.

Jamaica unlike many countries in the English speaking Caribbean has a liberalized energy market. This allows for auto generators or self generators such as the sugar factories and alumina plants to sell excess capacity to the Jamaica Public Service Company Limited (JPSCo) as if they are independent power producers. They can also wheel electricity from their own generation plant along JPSCo's transmission and distribution network to owned end use points, so long as no third party sale is involved. Electricity, however, remains the most important area in terms of opportunity to reduce the imported energy bill.

Jamaica has a well established energy policy. The objectives of the energy policy of Jamaica are as follows:

- a) To ensure stable and adequate energy supplies at the least economic cost in a deregulated and liberalized environment
- b) To diversify the energy base and encourage the development of indigenous energy resources where economically viable and technically feasible; and ensure the security of energy supplies
- c) Encourage efficiency in energy production, conversion and use with the overall objectives of reducing the energy intensity of the economy
- d) Complement the country's Industrial Policy recognizing the importance of energy as a critical in out to industrial growth and stability
- e) Minimize the adverse environmental effects and pollution caused by the production, storage, transport and use of energy, and minimize environmental degradation as a result of the use of fuel wood and;
- f) Establish an appropriate regulatory framework to protect consumers, investors and the environment

In order to achieve the objectives of the energy policy an enabling environment has been created to:

- a) Encourage private sector participation and investments through a policy of divestment and an appropriate regulatory framework conducive to new investment
- b) Promote the development of indigenous energy source where appropriate technically and economically feasible
- c) Encourage energy conservation/efficiency on the supply side as well as demand side management

- d) Fully protect the environment while ensuring that adequate energy supplies are available to the country and to sustain the desired rate of economic growth, and at the same time stimulate industrial development by encouraging synergies from co-generation; and
- e) Maintain appropriate institutional arrangements to ensure that the stated objectives achieved

The energy policy of Jamaica is designed to continue to foster, facilitate and encourage the development of all new and renewable energy sources, improve information dissemination with regards to energy conservation systems and promote and support Demand Side Management. With regards to economic incentives, the energy policy notes that the tax applied on energy conservation equipment and materials and supplies will be such that it will ensure that the items involved are available to the public and that the consumers will be encouraged to invest in the most efficient end use device or technology.

### ***Criteria for Mitigation Technology for Jamaica***

A number of issues were considered with regards to criteria for the transfer and development of technologies for mitigation. These included the overall integration with the current energy policy, and the linkage to development goals.

In order for a technology to be suitable for Jamaica there a number of key criteria which have to be met. These are:

- (i) affordability and low cost,
- (ii) environmental and economic impact,
- (iii) social acceptability
- (iv) job creation potential

The identification of these key criteria was done utilizing expert judgment and stakeholder analysis. It was noted that any technology which is to be transferred to Jamaica should aid in reducing the amount of foreign exchange which is utilized to purchase energy, in addition the technology should be durable, be commercially proven and aid in the development of Jamaica. Further the proposed technology should be in line with future projected energy scenarios. One possible scenario sees the expansion of capacity from the current 780 MW to 1250 MW by 2015. Table 4 below shows the possible fuel source which could be used to meet the scenario.

**Table 4 A possible future energy scenario for 2015**

Fuel Sources	MW
Heavy fuel oil and diesel	380
Natural Gas and coal	700
Wind	70
Hydropower	35
Solid Waste	10
Bagasse and Fuelwood	35
Ocean energy	10
Solar Photovoltaics	0.2
Fuel Cells	9.8
TOTAL	1250

### ***Mitigation Technologies Requirements for Jamaica***

#### **Natural Gas Technology**

Natural is the cleanest burning fossil fuel, and is available for transport in the form of liquefied natural gas (LNG) or compressed natural gas (CNG). Natural gas since the 1990's is one of the fastest growing source for electricity generation, with combined cycle gas technology increasing levels of competition and efficiency. The problem for Jamaica as a small island developing state is that LNG is far away from the source. Natural gas has to be transported in specialized LNG ocean tankers and thus a terminal to receive natural gas is required, so that Jamaica could benefit from its importation. This has been identified as a priority for Jamaica. There are plans for the construction of a natural gas terminal, to import 1.1 million tonnes per year of LNG. Given the considerable energy requirements of bauxite industry this natural gas will be used to generate electricity which will be shared among the major bauxite companies to remove their dependence on fuel oil.

Technology to extract methane from landfills and generate electricity is also required and is a priority. This has the potential to generate at least 10MW of electricity in Jamaica and initial plans are in place to pursue the generation of electricity from landfill gas

#### **Transport Sector**

With increase in the amount of motor vehicles in Jamaica the transport sector was also highlighted as priority sector where new technologies need to be applied. There is a need to examine the mass transit possibilities in Jamaica. The possibilities for light rail transit need further consideration in the Jamaican context

Given the large amounts of foreign exchange which is spent on the importation of gasoline for vehicles there is a need to look at alternative fuels and vehicles for Jamaica. Compressed Natural Gas (CNG) can be used in vehicles, and there are a number of manufactures of natural gas engine vehicles which could be used in Jamaica. Utilizing natural gas vehicle in Jamaica would have a number of benefits including promoting energy security, and reducing the amount of particulate matter and NOx which are emitted . Fuel cell vehicles could also be utilized in Jamaica, but there are a number issues related to fuel storage and facilities which would need to be addressed, such as the increase in the number of retail points

Diesel is cheaper than gasoline and there have been many developments in diesel engine technology which Jamaica could benefit from, and an increase in the number of vehicles utilizing low emission diesel engines would be beneficial in Jamaica. Electric vehicles and hybrid vehicle would also be desirable in Jamaica, as these vehicles have little emissions and will help reduce the dependency on gasoline.

## ***Renewable Energy Technologies***

With the increasing amount escalating fossil fuel prices and the ever increasing amount of foreign exchange being spent on fossil fuels, the development of a vibrant renewable energy sector will help in improving energy independence.

Jamaica like many other small island states has an abundance of resources for renewable energy projects. The value of renewables lies in their ability to respond simultaneously to the two challenges which confront the energy sector, which are sustainable development, security and economic growth. Renewable energy technologies options for Jamaica are highlighted below.

### **Wind Energy**

Jamaica already has a 20.7MW wind farm. Jamaica also has several other sites where the wind is in excess 8 metres per second and thus is suitable for the generation of electricity by wind. Generation of electricity by wind is very competitive with conventional mechanisms. Wind has been identified as priority technology for Jamaica given that it is proven and the wind resource is free.

## **Small Scale Hydro Power**

Jamaica was one of the first countries in the world outside of the United Kingdom to install a hydro plant, just outside of Spanish Town in the 1890's. Currently there are nine hydro plants ranging from 0.2MW to 6MW with an overall generating capacity of 23 MW installed in the Jamaica. There is potential for the installation of at least an additional 30 MW of hydro capacity in Jamaica. With the continued increase in oil prices world wide hydro power has become a priority in Jamaica, as it now more competitive. There are small specialized hydro power technologies which are suitable for Jamaica

## **Cogeneration and Biomass**

With the changes in the international market and the end to preferential treatment for sugar, alternative uses have to be found for sugar cane. Jamaica has vibrant sugar industry and currently there are seven sugar mills which generate around 30MW of power for bagasse for their own use. There is considerable potential to improve cogeneration possibilities in Jamaica. Cogeneration offers the opportunity to meet multiple objectives: improving energy efficiency and integrating energy policy into the industrial development policy. Cogeneration technologies characterized by high output ratios of electricity to steam for example, reciprocating internal combustion engines and fuel cells make it possible for cogeneration to play an important role in the power generation and energy efficiency in Jamaica.

The seven sugar factories could meet all their energy needs, while supplying excess power to the national grid from cogeneration renewable resource. Some initial estimates note that between 80 to 100MW of additional capacity is feasible, and this would allow the sugar industry to export 70 MW of power in the crop season to the national grid and provide significant foreign exchange savings to the country while contributing to the commercial sustainability of the industry.

Ethanol can also be produced by the sugar cane industry in Jamaica, thus adding to the products which the sugar cane industry can provide. Ethanol can be used for a variety of purposes in Jamaica, these include replace octane enhancers in gasoline, as a transport fuel as is done in Brazil. The ethanol which is produced can also be exported. Technology for ethanol production is therefore a priority. Currently there is a 40 million gallon ethanol production plant is being commissioned in Jamaica



## Solar Energy

Jamaica is ideally suited for the application of solar technologies. Many areas in Jamaica have solar insolation of 8kWh per sq.mt per day which is excellent for utilizing solar energy for the supply of electricity.

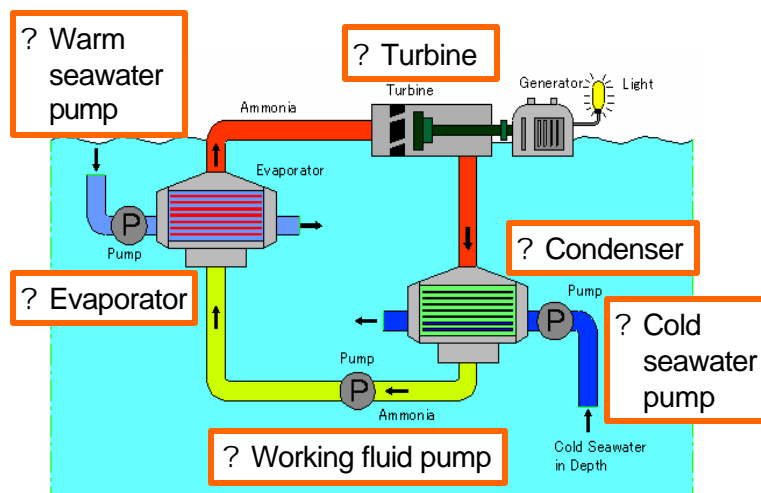
While there are a number of photovoltaic systems scattered across the island there is room for improvement with regards to solar energy in Jamaica. There some street lighting systems which use photovoltaics, but there is a need for more photovoltaics to be used throughout the country. Some other islands in the region have developed solar hot water heating technologies and these have been transferred to Jamaica. There however a need for the more widespread use of these systems in Jamaica. Perhaps if some economic incentives are put in place this will allow for more use of solar hot water systems

The potential for solar crop drying has not been fully realized in Jamaica although it is a means of preventing spoilage which affects as much as 30% of crop production. Crops such as bananas, papaya, sorrel, sweet potato, yam, ginger, nutmeg, pimento, grasses and leaves can be dried by solar dryers which range from the simple wire basket dryer to approximately two square metres of roof solar collectors.

## Ocean Thermal Energy Conversion

Ocean Thermal Energy Conversion (OTEC), an energy source using the difference in temperature between surface ocean waters and deep water. OTEC uses only seawater as energy resource. It provides an inexhaustible energy resource which is stable, with zero greenhouse gas emissions. OTEC basically utilizes the differences in the temperature gradients in between the warm surface water and the cold deep waters to drive a turbine to provide electricity. Figure 3 below shows the principle behind OTEC. There are number of deepwater sites around Jamaica which can be used for OTEC. OTEC technology is suitable for Jamaica, and there are many commercial spins such as mariculture.

**Fig. 3 The principle of OTEC**



## ***Energy Policy, Efficiency, Conservation and Demand Side Management***

Jamaica unlike many countries in the Caribbean has a fully liberalized energy sector. Thus Jamaica has long recognized the need for effective energy efficiency measures. The Jamaican Public Service Company (JPSCO) has had a demand side management programme which occurred through a Global Environmental Facility (GEF) demonstration project.

Future government policy with regards to energy efficiency and conservation will revolve around an Energy Efficiency Building Code, a Home and Small Business Energy Efficiency Scheme, an Energy Efficiency Commitment Scheme for large Commercial and Industrial Users, a Public Sector Energy Efficiency Programme, an Energy Efficiency Monitoring and Rating Programme, an Efficiency and Renewable Energy Fund, a Special Tax Incentive Package for Energy Efficiency Products and Investments, and an Energy Efficiency Advice and Public Education programme. The policy will be built around the use of energy efficient devices and equipment and proper control and maintenance of energy consuming equipment. Energy audits will also take place for many commercial and industrial users

A new demand side management programme may also be put in place, developed jointly with JPSCO and the government with a possible target of 3 % reduction in demand over the next 5-7 years or 20 MW of capacity. JPSCO may be provided with a mechanism to recover through the tariff base or energy fund investments made on demand side management measures.

## ***Technologies for Adaptation in the Coastal Zone and Water Resources Sectors***

From the initial national communications of Jamaica the coastal zone was identified a critical sector for Jamaica. The National Environment and Planning Agency-NEPA (formerly the National Resources Conservation Authority -NRCA) of Jamaica reported that “90% of the GDP of Jamaica is produced within the coastal zone.” Jamaica coastline is approximately 886km in length and has diverse ecosystems, which include sandy beaches, rocky shores, estuaries, wetlands, sea-grass beds and coral reefs. Table (5) below shows the different natural regions, which the coastal zone of Jamaica can be divided into.

**Table 5 The various natural regions within the coastal zone of Jamaica**

<b>Natural Region</b>	<b>Natural Features</b>	<b>Characteristic Developments</b>
Negril	Coastal sand barrier and morass	High density tourism, plantation, mixed farming
Negril	Cliff and hill coast	
The south-western coastal plain and wetlands coast	Savannah La Mar – Surinam Quarters – Black River. Sandy bays coastal barriers, patch and fringing reefs	Livestock, mixed farming, fishing, low density tourism, port facilities
The Pedro Plains – To Hill	Hill and cliff coast with minor beaches and limited fringing reefs	
Long Bay Hill and Vere Plains	Wetland coast with fringing reefs between Rocky Point and Jackson Bay	
Portland Scrubland Ridge and Portland Bight	Low cliffs, hill and low plains wetland coast with few sand beaches, scattered fringing reefs and patch reefs	Fishing, low density tourism, port facilities
Hellshire Scrubland hills and bay	Low cliff and sandy erosive barrier and lagoon with poor mangrove, patch reefs and limited fringing reefs	
Kingston	Domestic area	High density urbanization, tourism port facilities
St David bush hill	Bush hill and gravel beach system from the Palisadoes to Yallahs	
The Morant River gravel beach system	Low Hills with cane fields, a wide wetland without major drainage channels, very long sand beaches in the western part and a wide coral zone.	Plantations mixed farming, gravel excavation
The Morant Point Great Morass	Low hills with cane fields, a wide wetland without major drainage channels, very long sand beaches in the western part and a wide coral zone.	
The Eastern Coast	Hilly, cultivated, open rocky cliff coast with few small bays and sand beaches except Long Bay and with scattered nearshore fringing reefs	
The North-Eastern Portland Coast	Mixed wood/cultivated cliff coast with many narrow bays and pocket beaches	Plantations, low density tourism, port facilities
The Western Portland St Mary Coast	Cultivated hills with large open bays with partly unstable gravel beaches and in some section a wide fringing reef zone	
St Mary Coast	Hilly, steep rocky cliff coast with few bays and partly well developed fringing reefs	Low/high density tourism, mixed farming
The straight northern mixed coast	The mainly cultivated lowland coast from Oracabessa to Silversands with few bays scattered white sand beaches and wetlands and widely distributed coral reefs. The hilly woodland coast from Silversands to Falmouth with a narrow shore terrace with lagoons. The Falmouth lowland/wetland coast. The St James low, coastal foothill terrace, open coast with minor white sand beaches and nearshore fringing reefs	Mixed farming low density tourism
The Montego Bay	Dominated by coastal constructions	High density tourism urbanization, mixed farming, port facilities

Natural Region	Natural Features	Characteristic Developments
The Hanover Coast	The northern rocky cliff coast with coves and limited fringing reefs: the northwestern coast with large coves, wetland and fringing and patch reefs.	

The coastal zone in Jamaica has critical infrastructure which is located within it. Port facilities, tourism infrastructure are located within the coastal zone, along with dense population centres. The coastal zone is also rich with biodiversity, with coral reefs, sea grass beds and mangroves. The coastal zone of Jamaica is thus very susceptible to sea level rise. Sea level rise will cause increased beach erosion rates and higher incidences of coastal flooding. Permanent inundation could occur in some areas. Climate change could compound and amplify the effect of tropical storms and hurricanes. Jamaica has suffered in recent times from extreme weather events, with Hurricanes Dennis and Emily affecting the island during 2005. During September 2004 Hurricane Ivan struck Jamaica causing approximately US\$580 million dollars worth of damage, through direct damage and indirect losses. The initial national communications noted that the cost estimated by the Intergovernmental Panel on Climate Change in 1990, to protect Jamaica from one metre of sea level rise to be US\$462 million. The potential for damage from climate to the biodiversity of the coast and the coastal infrastructure is very high. The economic value of all of the resources in the coastal zone will be adversely impacted as a result of sea level rise and a changing climate. A large percentage of Jamaica's population (approx. 25%) is concentrated near to the coastline, thus a rise in the sea level will cause a displacement with regards to coastal settlements

Jamaica's freshwater reserves come from a variety of sources. There are surface sources in the form of river and streams, and underground sources in the form of wells and springs. There is some rainwater harvesting in Jamaica, with groundwater supplies most water of the water demands in Jamaica. The initial national communication of Jamaica noted that water demand distribution in Jamaica is based on the location of irrigated lands population concentrations, tourism development and other water consuming industries. The demand in the south of the island is greater due to the extensive agriculture in the areas of little rainfall. Demand in the north of Jamaica tends to be less because there is greater rainfall and less cultivable land. Bauxite and sugar cane processing industries which are located in the south also consume large amounts of water.

Changes in rainfall patterns could cause a decreased surface and groundwater supplies. Climate change will present additional water management challenges in Jamaica. There are predictions of increased short intense rain events under certain climate change scenarios. This would cause low percolation and recharge of aquifers and high run off. Reductions in rainfall as a result of climate change will affect water sources and supply. The reductions in rainfall will mean that less water will be available for domestic demand. Decreasing rainfall will mean that there will be an increase in irrigation requirements for agriculture. Water resources are an important for all aspects of the economy thus with a changing climate, key sector such as tourism, and agriculture will be affected negatively

## ***Criteria for technologies for Adaptation***

A number of issues were considered when criteria for the transfer and development of technologies for adaptation were considered. Stakeholder consultation and expert judgment were used to determine the criteria for technologies for adaptation. It was noted that technologies for adaptation should be cost effective, proven, flexible, aid in vulnerability reduction and be easy to use. Technologies for adaptation should look at technologies in the broadest sense.

## **Technological Needs for Adaptation in the Coastal Zone and Water Resources Sectors**

The coastal zone is critical for Jamaica and a number of technologies for adaptation have been suggested to aid in improving coastal zone management and hence reduce the overall vulnerability of the coast to sea level rise. While it was noted that beach protection measures such as groynes and revetments will be required, the reinstating of the tidal gauge network so as to get data was highlighted as a priority. This reinstating of the tidal gauge network should be coupled with improved data collection for the geographic information system. Beach profiling needs to be expanded in Jamaica to aid the improved data collection. The regeneration of mangroves has also been highlighted as a priority. Data collection also needs to be improved along with an improvement with the current in the geographic information systems. Improvement in the geographic information systems will aid in planning and project designs, thus ensuring that vulnerability reduction will occur.

There is a need for an improvement and rationalization of the hydrometric network. There is a need for additional river gauges and more automatic weather stations to aid in data collection and planning to reduce vulnerability. There is also the need for additional flood warning systems. Additional software such as waterware, riverware, and mikebasin are also required to aid in the improvement of water management in Jamaica.

## ***Barriers to Technology Transfer in Jamaica***

The main barrier to the transfer of technology to Jamaica identified is capital cost. Often Jamaica is not in a situation where it can afford the high initial capital cost of technologies. There is thus often a need for flexible financial measures in order for new technologies to be adopted.

Attitudes, perceptions and lack of information have also been highlighted as a key barrier to the transfer of technology. Often a lack of understanding of the technology aids in the

prevention of the transfer of that technology. Lack of political will was also highlighted as a barrier preventing the transfer and adoption of technologies.

Lack of data also has been considered as a barrier and the lack of a central decision making entity to handle issues with regards to technology. There is also a lack of data with regards to vulnerability issues which prevents adoption and applications of technologies for adaptation.

## ***Conclusions and Recommendations***

This technology needs assessment for Jamaica is an initial examination of the technology needs of Jamaica. The technology needs assessment process should be continued in Jamaica. As a result there is a need to revisit this issue in the near future. Technology issues as they relate to agriculture have not yet been examined in detail. There is thus a need to have an in depth analysis of the technology requirements for the agricultural sector given the critical nature of the sector to the Jamaican economy.

There should also be a specific consultation with the industrial sector so that the specific technologies for industry can be identified and transferred to the sector. These issues can be addressed in the second national communications, which can be used to detail technology needs.

Public education, information and awareness with regards to new technologies needs to be improved. It was highlighted that a biogas project in Jamaica was not very successful as a result of a lack of effective public education initiatives. Education and sensitization to new technologies should be targeted to every level of the society, and perhaps there is a need for a specific education and sensitization programme which should be specifically tailored for policy makers.

There may also be a need for a clearinghouse with regards to technology to be put into place. Perhaps providing more information on TT:Clear to specific stakeholders would aid on more information about technologies which can be useful. It may be necessary for a specific

There needs to be improvements in the data which is collected and this was highlighted as concern by many stakeholders. However the lack of data should not prevent projects from proceeding. It was noted that the Kingston Area, was particularly susceptible to sea level rise and that perhaps a project looking at the vulnerability of the area should be developed.

Natural gas technology has been highlighted as a priority for Jamaica with a proposal for the construction of a natural gas terminal. Jamaica should also exhaust all of its hydropower potential, and establish more wind farms. This would help reduce the dependency on fossil fuels as well save valuable foreign exchange. OTEC technology

was also highlighted as an area for further investigation, with the possible identification of sites. It was also noted by many of the stakeholder that there is a need to encourage Jamaican entrepreneurs and business into the energy business. However there is a need for financial incentives to not only allow more entrepreneurs into the energy business, but also to allow citizens to utilize renewable energy options rather than standard technologies.

## ***References Used***