

DRAFT Executive Summary

BACKGROUND DISCUSSION PAPER

on Bio-energy Potential for St. Kitts and Nevis



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Executive Summary

Background

St. Kitts and Nevis is a Small Island Developing State (SIDS) that is confronting multiple socio-economic challenges. For over 350 years sugar production was an important component of its economy. For many of those years sugar meant wealth and jobs. But, this nonstaple and essentially nonnutritive commodity, grown as a mono-crop, faced with fluctuating world prices, resulting in significant economic hardships dating back over 100 years. As a result of the nationalization of sugarcane fields and the central sugar factory during the 1960s, subsequent losses (or profits) were attributed to the federation government.

During the late 1990s and early 2000s, the spread between the world price for sugar and the cost of production grew to the point at which, in the summer of 2005 the St. Kitts Sugar Manufacturing Company (SSMC) was forced to stop its operations. With it, all agricultural activities related to sugar were halted.

In an effort to maintain many of the benefits of sugarcane production – including environmental aspects, erosion protection, agricultural employment, cultural and tourism benefits – the Federation Government instituted a Sugar Transition Team to investigate alternatives for the industry, with a focus on possible use of the sugarcane for electricity and/or bio-fuel production.

Through its activities in the Caribbean islands, the Global Sustainable Energy Islands Initiative (GSEII) committed to supporting the activities of the Sugar Transition Team. GSEII is a consortium of international NGOs and multilateral institutions organized to support the interest of all small island states and potential donors by bringing renewable energy and energy efficiency projects, models, and concepts together in a sustainable plan for small island nations. GSEII seeks to showcase national efforts to significantly reduce greenhouse gas emissions. Recent efforts by the GSEII have focused on the island nations of St. Kitts and Nevis, St. Lucia, Grenada, and Dominica. As part of the national sustainable energy planning process activities have included, clean energy project identification, policy support, capacity building and institutional strengthening, and financing facilitation. Key GSEII partners include the Organization of American States (OAS), the Energy and Security Group, and Climate Institute. Funding support for the work in St. Kitts has been provided by the UN Foundation (UNF), and its implementing agency the United Nations Industrial Development Organization (UNIDO), and the Italian Government.

Study Purpose and Objectives

The purpose of this document is to provide a realistic assessment of the potential – both economic and technical – for the conversion of biomass¹ feedstocks to energy on a

¹ *Biomass* is the organic matter, coming from products, waste and residues from agricultural (including animal and vegetal substances), forestry and related industries, as well as the organic fraction of industrial and municipal waste.

sustainable basis, given the current and/or potential conditions in St. Kitts and Nevis. It is expected that this Biomass Energy Systems Assessment Study (BESAS) may be used as a benchmark study for identifying key criteria to aid the Government of St. Kitts and Nevis in the evaluation and selection of commercial biomass energy systems. In addition to this study, the Federation Government has received a number of proposals (largely unsolicited) from private developers proposing a biomass-to-energy path. The authors of this BESAS study are not making comment nor reference to the quality nor any of the specific aspects of those proposals.

When considering bio-energy one may consider a large diversity of biomass-to-energy conversion options, end uses, and applications involved. In the context of St. Kitts, there are two main sources of biomass: one is sugarcane and the other is the organic portion of Municipal Solid Waste (MSW)². These biomass sources have to either be cultivated or collected, transported, and if necessary pre-treated and/or stored. The biomass can then be converted to energy through a variety of processes. The primary energy outputs to be considered by this study include biomass-to-ethanol (for use as a transportation fuel) and biomass-to-electricity. The ultimate process choice depends on the type and quality of the available biomass feedstock, desired end-use application, energy regulations, environmental standards, economic conditions, and socio-ethical factors.

This report provides an overview of the available quantities and quality of the biomass resources on St. Kitts. Relevant biomass energy systems for St. Kitts are identified and a pre-selection is made to describe possible biomass energy system scenarios, as well as the technical, economic, and socio-environmental characteristics of these scenarios. The results of this report are presented to the Government of St. Kitts and Nevis for their ultimate determination on how (or whether) to move forward with a sustainable biomass energy program for the island.

The key objectives of this study are twofold:

- 1) To analyze the technical, economic, and socio-environmental characteristics of biomass-to-energy systems for converting the locally available biomass to energy in the context of St. Kitts and Nevis.
- 2) To identify key criteria to select sustainable and commercially viable biomass-to-energy systems in the context of St. Kitts and Nevis.

The priority is placed on biomass energy systems that use sugarcane as the primary feedstock to produce ethanol and/or electricity. In cases where the feasibility of this system is limited, the organic portion of available MSW may function as an additional feedstock for the conversion system to generate electricity and/or bio-fuel in a more cost-effective manner.

² Cuba de, K.H., "Towards a Sustainable Energy Plan for St. Kitts and Nevis," Department of Science, Technology and Society, Utrecht University, 2006.

Report Highlights

The following areas were addressed in the study:

Study approach

The report provides a detailed discussion of the BESAS study approach, the methodologies used, and the types of information that are addressed in the report. Figure ES-1 provides an overview of the BESAS assessment process.

Biomass-to-Energy Assessment Process

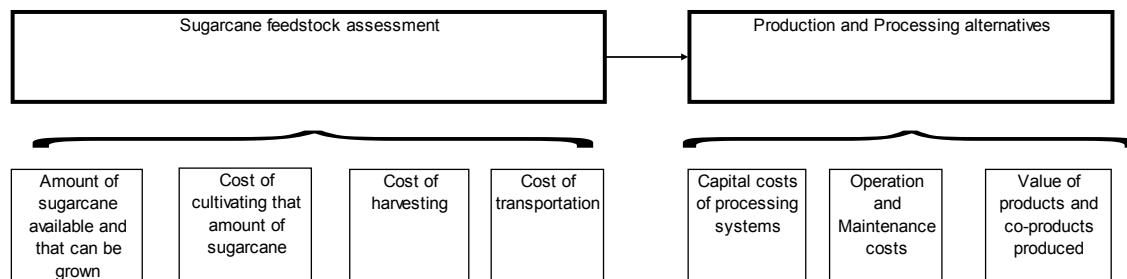


Figure ES-1. Schematic Overview of the Biomass-to-Energy Assessment Process

Baseline information St. Kitts' Demography, Energy and Transport Sector

The Federation of Saint Kitts and Nevis is located in the north-eastern Caribbean region. The islands cover a total area of 269 sq. km (104 sq. mi.), of which St. Kitts is 176 sq. km. (68 sq. mi.) in size. The two islands are separated by a two mile stretch of water.³ The population of St. Kitts and Nevis is about 42,740 (2005). The population on St. Kitts is around 32,397 (75.8% of the total of) with a population density of 186 persons per sq. km, where about 40% of the St. Kitts population lives in the Basseterre capital region.

In St. Kitts there is one utility that manages the production, transmission, and distribution of electricity. The St. Kitts Electricity Department (SKED) is a state-owned utility with installed power production capacity of 33.5 MWe (as of 2006). The SKED operates one power plant, the Needmust power plant, which contains seven diesel No. 2 fuel oil-fueled generators. The generators range in size from 3.5 MW to 7.9 MW in capacity. The SKED's total electricity production in 2005 was 124,741 MWh. This electricity is transmitted via two busses, an 11.2 and an 11.4 kV, to the national grid. The average capacity factor of the power plant was 0.43, with a load factor of 0.71 and with an average fuel consumption rate of 17.4 kWh/imperial gallons (IG) (14.5 kWh/US gallon).⁴ The total fuel consumption at the Needmust power plant in 2005 was 7,156,452 IG⁵

³ Climate Institute, <http://unfccc.int/resource/docs/natc/kitncl.pdf>

⁴ Renewable Energy Research Laboratory, University of Massachusetts, *Wind Power: Capacity factor, Intermittency, and what happens when the wind does not blow*, Amherst.

⁵ "Needmust Gensets Performance Indicators 2005," St. Kitts Electricity Department (2006).

(204,632 US barrels⁶). The total cost of generation in the year 2005 amounted to EC\$60.5 million⁷ (US\$22.4 million), including fuel costs, O&M costs, and capital charge, this lead to an electricity generation cost of EC\$0.45/kWh (US\$0.17/kWh).

The transportation sector is the second largest energy-intensive sector in St. Kitts. The total number of registered vehicles on the island of St. Kitts in the year 2005 was 12,217 vehicles. The vehicle fleet consists primarily of cars manufactured during the 1970s and 1980s, and studies show that there is a possibility of mixing ethanol in up to 10% of the tank capacity for these vehicles without modifying the engines.⁸ The total imported amount of gasoline and diesel to the island of St. Kitts in 2005 was 3.3 million (MM) gallons and 9.1 MM gallons respectively. There is no significant use of the imported gasoline other than for transportation. In the year 2005, about 10.6 million US\$ was spend on importation of gasoline. Limited data on the gasoline prices indicate that it has been fluctuating from EC\$6.90/gallon in the first quarter of 2005 to EC\$8.30/gallon in March 2005, rising to EC\$10.50/gallon in November 2005. There is no data available for 2006. Assuming that the current price is the weighted average of these values, the price would be EC\$8.57/gallon or 3.17 US\$/gallon at the pump.

Biomass costs, availability, and characteristics

The study addressed the availability and characteristics of biomass resources in St. Kitts. As part of this assessment, two primary types of biomass sources were considered — sugarcane (which would be considered a dedicated energy crop for these purposes) and the organic portion of the municipal solid waste (MSW) stream, also know as the biodegradable municipal waste (BMW). The BMW in this study is considered to be the combination of organic materials and paper/cardboard.

In order to evaluate the potential for converting biomass to energy, one must consider the quantity, characteristics, and the frequency of supply availability of these resources. With regard to sugarcane, this study assumes that the Federation Government would make available approximately 6,000 acres (2,428 hectares) for this energy crop. This figure is based on estimates provided by the current government officials and incorporates the fact that several thousand acres of sugar lands have been removed from cultivation since the closure of the sugar industry in 2005. The majority of the lands removed from cultivation have been allocated for other economic land use purposes including tourism (golf courses and hotel infrastructure development).

Based on the sugarcane cultivation and harvesting practices in 2005, this study provides estimates regarding the potential quantity, characteristics and availability of sugarcane for energy production. (See Table ES.1 below). In addition to the general resource data provided in Table ES.1, technical/composition data pertaining to sugarcane is available in Chapter 3 of this Study.

⁶ 1 UK gallon = 0.02859 U.S. barrels; source: UNEP Guidelines for Calculating GHG Emissions, <http://www.uneptie.org/energy/publications/files/ghgind.htm>.

⁷ “Generation Costs SKED & Effect of PetroCaribe 2006-2008,” St. Kitts Electricity Department (2006).

⁸Renewable Fuels Association. ‘Ethanol Facts’ <http://www.ethanolrfa.org/resource/facts/engine/2006>

Table ES.1. Sugarcane Quantities and Characteristics for St. Kitts

Parameter	Typical	Value range	Unit
Available cultivable area	6,000	5,500 – 6,500	acres
Sugarcane yield ⁹	24.5	20.5 – 32.3	tons/acre
Average distance of fields to mill	12.4	10–15	Miles
Sugarcane production	147,000	112,750 – 209,950	tons/yr
Sugarcane production	1,225	805 – 2,100	tons/day
Sugarcane fiber content (d.m.)	18.5	-	% d.m.
Projected bagasse production	27,930	21,423 – 39,891	dry tons/yr
Average length of grow cycle	303	303 – 365	days/yr
Duration of crushing/harvesting season	120	100 – 150	days/yr
Amount of reaping per ratoon ¹⁰ planted	5	5 – 6	reaping/ratoon
Estimated cost of sugarcane as delivered to the processing plant	32.7 ¹¹	32.7-49.5	US\$/ton
Amount of reaping per ratoon ¹² planted	5	5 – 6	reaping/ratoon

As an energy feedstock, sugarcane is a high quality resource in many regards. However, the fact that it is only available on a limited basis according to its harvest cycle – in this case approximately 120 days or 4 months of the year. And, as an energy feedstock raw sugarcane offers virtually no storage capabilities once harvested because it quickly decomposes. The baseline assessment in this report, therefore assumes that sugarcane would only be available during the harvest season. Several storage/fuel preparation alternatives are discuss and presented in the full Study.

In order to compliment the limited availability of the sugarcane additional biomass resources were explored during this study. The only significant resource that is immediately available is the organic fraction of the municipal solid waste stream. Based on interviews and reviews of the waste management facility (there is one landfill site on the island of St. Kitts) statistics, the total amount of BMW has been estimated at 8,500

⁹ The sugarcane yield incorporates the ratio between reaped and cultivable area of 0.84.

¹⁰ The ratoon is the shoot sprouting from the plant base.

¹¹ The lower end of the sugarcane production costs are assumed, because it is most likely that any new bio-energy investments in St. Kitts would adopt the basic production efficiency improvements, including mechanized harvesting, transportation improvements and use of stillage as fertilizer in order to reach this value. Further efficiency improvements below this value of at least 10% is possible given advanced agricultural practices.

¹² The ratoon is the shoot sprouting from the plant base.

tons per year. Table ES.2 below provides an overview of the key characteristics of this biomass source.

Table ES.2. Municipal Solid Waste Quantities and Characteristics for St. Kitts

Waste category	2004 Weight (ton)	Organic fraction (%)	BMW (ton)
Green waste	1,455	90	1,310
Household	10,390	42.5	4,416
Land clearing	3,514	75	2,636
Institutional	150	90	135
Sludge (Septic tank waste)	1,876	-	-
Ship generated waste	6	42.5	2.6
Total			8,500

Based on the available quantities and characteristics of biomass in St. Kitts, this study estimates the potential primary energy content that may be available for conversion into commercial energy products. This Study assumes that all of the sugarcane product would be used in an energy production scenario. In this case the primary energy content of the resources (sugarcane and BMW) ranges between 983 – 3,180 TJ per year. See Table ES.3 below.

Table ES.3. Biomass Availability and Energy Supply Potential for 2004.

Source	Biomass supply (tons/ year)	Energy content (GJ/ton) HHV	Moisture content (% of wet material)	Ash content (% of dry material)	Energy supply, primary (TJ/year)
Sugarcane (directly fired)	112,750 – 209,950	17.0 – 18.1	30 – 50	2.2 – 2.4	958 – 2660
-Bagasse alone ¹³	21,423 – 39,891	16.5 – 19.0	40 – 50	2.2 – 2.4	177 – 456
BMW	8,500	7.4 – 15.0	50 – 60	N.A.	25 – 64
Sugarcane + BMW	121,250 – 218,450	-	-	-	983 - 3180

Biomass-to energy technology overview

The report reviewed the relevant commercially available biomass-to-energy conversion technologies to narrow the field for viable solutions in St. Kitts. It examined the conversion processes, technical parameters/limitations, and socio-economic impacts of the technologies discussed. The report also looked at case studies for bio-energy production in other small island nations. A selection of technology options was identified based on three criteria: (1) commercial availability; (2) existing processing capacities based on the available biomass feedstock types/quantities in St. Kitts; and (3) existence of companies with experience in the commercial implementation of these

¹³ For the bagasse amount an assumption is made on the operation or running time of 120 days (harvesting period) * 24 h * 0.8 (load factor) = 2304 h/yr (96 days/yr), for the BMW since this is not depending on seasonal harvesting is assessed using 365 days * 24 h * 0.8 (load factor) = 7008 h/yr (292 days/yr)

projects/technologies. The baseline set of bio-energy conversion technologies identified and analyzed in detail in the study included:

- electricity production via direct combustion, and
- ethanol production through fermentation/distillation.

Additionally, several optimization scenarios were reviewed in an effort to improve the economic and/or technical feasibility of the scenarios. These alternative approaches included:

- adapt ethanol production system to produce hydrated ethanol for export,
- adapt electricity generation system to co-fire with alternative fuels (i.e. coal) during non-harvest periods;
- utilize innovative electricity generation technologies (i.e. gasification).

Biomass-to-energy conversion results

Based on the above inputs, including the biomass resources – their characteristics, quantities, and costs – and the available technologies, a series of economic models were developed to identify one or more scenario through which an economically viable energy production system might be developed. Multiple techno-economic and sensitivity analyses was performed for the key scenarios.

Biomass-to-Ethanol Findings

The primary end use application in this scenario is dehydrated ethanol, or simply ethanol, a finished product which can be blended with gasoline (functioning as a replacement for methyl tertiary butyl ether MTBE) for transportation use. Ethanol can be mixed up to 10% of tank-volume with gasoline without the need for adaptations in existing transport vehicles. Further, it is also that the process will result in excess electricity that may be sold to the national grid; this will depend on the amount of heat and electricity that is required to produce ethanol.

In order to calculate the overall costs of an ethanol production system appropriate to the amount of available feedstock projected, the initial investment costs are based on a 3 million gallon/year facility (for this study it is estimated the such a facility would cost US\$19 million).

Given the cost and expenses shown in this study, as well as the income and financing requirements of such a plant, the following results were obtained for this potential ethanol facility. The annual outputs in this case are estimated at 2,736,872 gallons of ethanol and 8,609 MWh electricity for sale to the national grid. The costs of production derived by this analysis suggests an ethanol production cost in the range of US\$2.07 to US\$3.15 and an electricity generation cost of US\$0.084 to US\$0.13 per kWh. Note: The projected costs are based on current costs of inputs, and it is likely that reductions in output costs for ethanol may be derived by improving feedstock processes, in particular, the agricultural procedures to reduce the costs of the sugarcane as a feedstock (from the current costs of US\$32.7-49.5/ton).

Table ES.4 below presents a summary of these results

Table ES.4. Summary of the Results for Scenario 1 –Ethanol Production

Input/Output	Average Value	Unit	Range
Land under cultivation	6,000	Acres	5,500 – 6,500
Sugarcane feedstock	147,000	Ton/yr	112,750 – 334,100
Ethanol Produced	2,736,872	Gallons/yr	2,099,199 – 6,220,332
Estimated Cost of Ethanol Production	2.13	US\$/gallon	1.856-2.867
Electricity Available to the Grid	8,609	MWh/yr	6,603 – 19,566
Estimated Cost of Electricity Production	0.087	US\$/kWh	0.075-0.117

Biomass-to-Electricity Findings

It is assumed that the sugarcane may be used directly as fuel for a direct combustion electricity generation system. Sugarcane availability depends on the harvesting period; which in this case is estimate to be between 3 – 5 months per year; or 100-150 days of available harvest per year. Based on the available 6,000 acres of land at the time of this study, and a yield of 24.5 tons per acre (based on the 10-year average of full operation of the SSMC), there is a baseline sugarcane production of 147,000 tons per year. If the full quantity of the sugarcane produced (147,000 tons/yr) were fully converted into electricity during the 100-150 available days, according to the average energy content, efficiencies, and load factors, a power plant in the range of 30 to 50 MW would be feasible.

However, a 30 to 50 MW power plant is not an option given the current and near term projected demand for power in St. Kitts. Biomass electricity is best utilized in a baseload situation. According to the current and projected demand (as shown above) the optimal baseload supply from this operation is projected to be 19.6 MW of installed capacity. The estimated investment costs for such a facility is US\$29 million (based on an estimate of US\$1,500 per kilowatt installed).

Accordingly, such a plant would produce approximately 39,000 MWh over the period of 100-150 days per year. The estimated cost of electricity resulting from this baseline strategy ranges from US\$0.085 to US\$0.170 per kWh, with a projected average estimate of US\$0.13/kWh.

The required land to cultivate the necessary feedstock to supply a 19.6 MW facility over 100-150 days is approximately 2,625 acres (to produce 64,313 tons per year of sugarcane). Several strategies may be pursued to extend the period of operations of the plant beyond the harvest season. These strategies may include: developing revolving crop cycles to vary/extend the crop availability; importing biomass materials from other countries; importing coal or other fossil fuels; and utilizing the BMW as a feedstock. If

no co-firing strategy is pursued, this plant would remain off-line during the remainder of the year. See Table ES.5 below.

Table ES.5. Summary of the Results for Scenario 2 Electricity Production

Input/Output	Quantity	Unit	Notes; Cost range
Sugarcane feedstock required for 19.5 MW power plant	64,313 536	Ton/yr Ton/day	
Land required to product necessary sugarcane feedstock	2,625	Acres	
Estimated power conversion load factor	0.7		Biomass-fueled Rankine cycle plant
Electrical efficiency	0.26		
Electricity to grid	39,484	MWh/yr	The entire electricity supply is generated and delivered during 100-150 days per year
Excess energy (heat)	52,684	GJ/yr	More primary energy available than consumed by the power plant
Estimated Cost of Electricity	0.13	US\$/kWh	0.085-0.170

Energy market analysis

The report examined the key factors regarding bio-energy inputs and outputs to evaluate the cost-effectiveness of an investment in biomass to electricity or biomass to ethanol in St. Kitts. This included the price of agricultural products, related support subsidies, local and global policies related to bio-energy development (e.g., EU Sugar Protocol, U.S. Tariff Rate Quota, CAFTA, etc), productivity of agricultural activities, world market prices for ethanol, local prices for gasoline, and local prices for electricity. These markets are highly volatile and the prices are derived by forces external to St. Kitts.

Ethanol Prices

Figure ES.2 below shows the ethanol market prices over a period of 18 months, from September 2005 through March 2007 varied from US\$1.70 to US\$4.00 per gallon. Note, these reflect the prices per gallon of ethanol delivered at several ports in the USA. The latest figures list the port delivered price of ethanol at US\$2.20-US2.40/gallon as of March 2007. The wholesale cost of ethanol produced in other countries of the Americas is estimated to be (several sources cited below):

Brazil:

- US\$0.68 – 0.95 /gallon (cane based ethanol production cost) (UNEP, IEA, 2004)
- US\$0.76 per gallon (cane based ethanol production cost) (Centre for Strategic Management and Studies - CGEE, Brazil)
- US\$0.83 per gallon (cane based ethanol production cost) (OECD, 2006)

USA:

- US\$1.779 per gallon (corn based ethanol production cost)(Centre for Strategic Management and Studies - CGEE, Brazil)
- US\$1.80 – 2.06 per gallon (corn based ethanol whole sale price) (CRS, 2006)

Guyana

- 0.308 – 0.408 US\$/L -> 1.166 – 1.544 US\$/gallon (cane based ethanol production cost) – ECLAC, 2007

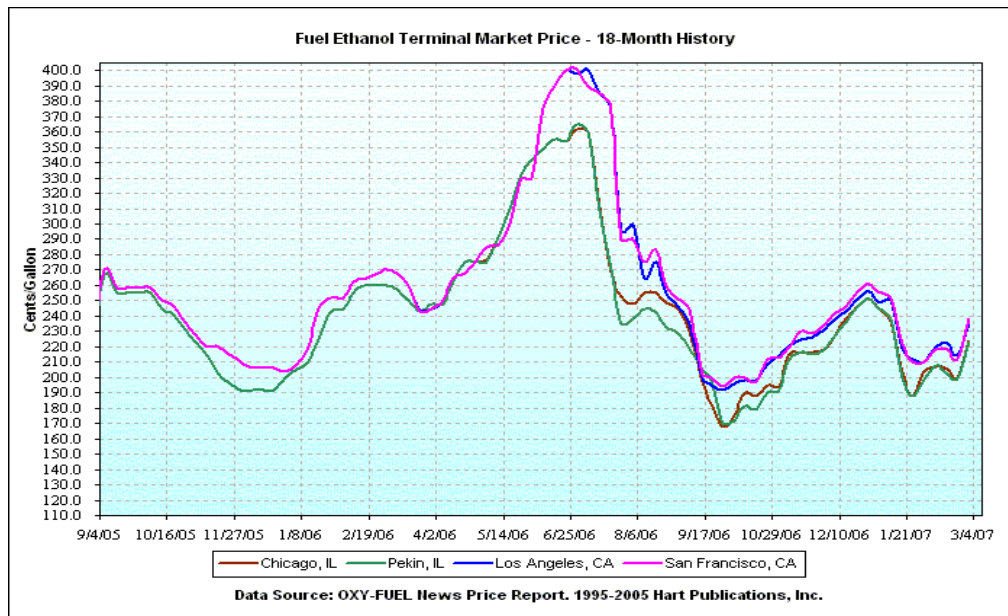


Figure ES.2 U.S. Ethanol Market Price Over the Last 18 Months

St. Kitts Gasoline and Electricity Costs

As described above, in St. Kitts there is one utility that manages the production, transmission, and distribution of electricity. The St. Kitts Electricity Department (SKED) is a state-owned utility with installed power production capacity of 33.5 MWe (as of 2006). The SKED's total electricity production in 2005 was 124,741 MWh. The total cost of generation in the year 2005 amounted to EC\$60.5 million¹⁴ (US\$22.4 million), including fuel costs, O&M costs, and capital charge, this lead to an electricity generation cost of EC\$0.45/kWh (US\$0.17/kWh).

With respect to the transportation sector, the total imported amount of gasoline to the island of St. Kitts in 2005 was 3.3 million (MM) gallons. In the year 2005, about 10.6 million US\$ was spend on importation of gasoline. Limited data on the gasoline prices indicate that it has been fluctuating from EC\$6.90/gallon in the first quarter of 2005 to EC\$8.30/gallon in March 2005, rising to EC\$10.50/gallon in November 2005.

¹⁴ "Generation Costs SKED & Effect of PetroCaribe 2006-2008," St. Kitts Electricity Department (2006).

Report Conclusions and Recommendations

In reviewing the report conclusions, one has to keep in mind that St. Kitts and Nevis is a small island state in a globalizing market economy, where the market value of its products are subject to international market price fluctuations and competition. The conclusions and recommendations offered in this report are intended to serve as a starting point, or baseline for evaluating or considering a possible bioenergy development initiative in St. Kitts. The evaluation focused on off-the-shelf, current technologies and the agricultural system in place with minimal changes or advancements. It is expected that commercial developers may be able to beat the estimates provide here.

The broad conclusions as a result of this study suggest that there is a reasonable expectation for a competitive bioenergy business based on sugarcane crops. The Government of St. Kitts and Nevis, is therefore encouraged to seek viable offers/private sector partners for the development and implementation of this opportunity.

Principal Product: Ethanol

The projected wholesale cost of ethanol for St. Kitts according to this study is US\$1.85 to US\$2.87 per gallon. This compares with ethanol production costs of approximately US\$0.75 per gallon in Brazil, US\$1.80 per gallon in the United States, and US\$1.40 per gallon in Guyana. This suggests that without significant advancements in the technology and/or processing systems, ethanol production in St. Kitts is challenging proposition from a market competition perspective. When considering the domestic use of ethanol as a transportation fuel, near term local ethanol demand is limited to approximately 10% blending capacity with gasoline. This amounts to 409,619 gallons/year of ethanol while the projected ethanol production is approximately 2.7 million gallons per year. As a result, an excess of 2.3 million gallons of ethanol would be available for export. Without significant reductions in the projected costs, it would seem that the export potential for this fuel is limited.

In considering alternatives to improve the economics of an ethanol-based strategy the following issues warrant further consideration:

Importing hydrated ethanol from Brazil:

Economies of scale can be improved by importing hydrated ethanol mainly from Brazil for distillation into de-hydrated ethanol for further export to the U.S. market under the Caribbean Basin Initiative (CBI). The feasibility of this alternative needs to be further analyzed.

Aggregating biomass feedstocks or an intermediate product (i.e. hydrated ethanol) among several Caribbean countries in an effort to improve the economies of scale:

Locally produced hydrated ethanol could be exported to a centralized distillation unit elsewhere in the Caribbean to contribute to the improvement of the economies of scale of that alternative process system. Also sugarcane juice may be considered an export product for further processing elsewhere in the Caribbean.

Principal Product: Electricity

The projected electricity production costs for St. Kitts according to this study are US\$0.085 to US\$0.17 per kWh. Given that these projected costs are lower than the estimated current production costs of electricity, it is suggested that this represents a promising opportunity for development.

In considering alternatives to improve the economics of an electricity-based strategy the following issues warrant further consideration:

The seasonal availability of sugarcane as a feedstock:

Sugarcane is seasonal in its nature and is as feedstock limited to the harvesting period (3-5 months per year). This limits the opportunity for a base load operation of the biomass power plant where lower operating cost can be achieved. Options as sugarcane drying and storage may be of interest (detailed exergy and economic analysis required). Also alternative fuels (e.g. coal) can be imported and co-fired to extent the fuel availability, provide base load electricity and improve operating economics.

The relatively high cost of sugarcane as a feedstock:

The baseline operation conditions on St. Kitts resulted in the sugarcane feedstock cost of 49.5 US\$/ton, this reflected an inefficient harvesting system with limited mechanization and high transport costs (antiquated equipments). With minimal advancements this price may be reduced to 32.7 US\$/ton, but even at this level it still remains the highest cost factor for the system and were further optimization (using efficient and low-maintenance equipments) is deemed feasible and recommendable.

The relatively small demand for electricity on St. Kitts:

The energy demand on St. Kitts forms a determining factor for the scale and design of the sugarcane-to-electricity power plant. The available 6,000 acres of land would provide excessive energy. This suggests for the downscaling of the available primary energy (less land) to supply a projected base load demand of 19.6 MWe over the period 2008 – 2010.

Optimizing the heat and power production

When opting for a CHP plant the heat to electricity rate can be adjusted to the respective demands. One needs to assess the heat demand (e.g. for other industries, households or hotel sector) to evaluate the viability of this alternative.

Build in the incentives available via carbon credits:

The Federation as signature to the Kyoto Protocol has Carbon Financing Mechanisms as the Clean Development Mechanism (CDM) to its disposal whereby a biomass or biomass/coal co-firing system is recognized as a GHG emission reduction system. This will provide additional credits the lower the initial capital investment for such a system.

Export to Nevis:

Since the current available 6,000 acres could yield enough energy to install a 44.8 MWe power plant, there may be possibilities to interconnect the island of St. Kitts with Nevis via submerged cables to export the excessive electricity produced. Alternatively the

biomass feedstock could be exported to the island of Nevis to make it possible to combust this feedstock with the available MSW on the island of Nevis.