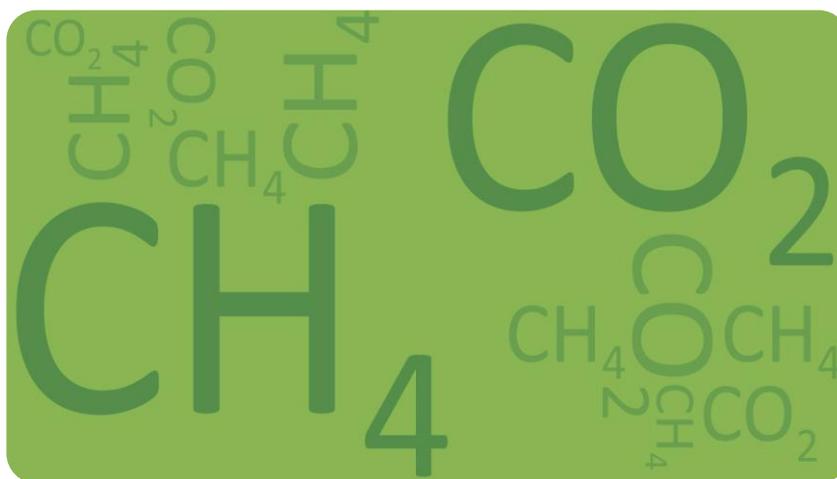


EMISSIONS REDUCTION PROFILE

Belize

UNEP RISØ
JUNE 2013

SUPPORTED BY
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United Nations
Framework Convention on
Climate Change



UNEP
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ENERGY, CLIMATE
AND SUSTAINABLE
DEVELOPMENT

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Brief Profile

Full name:	Belize	Major religion:	Christianity
Population:	312,900 (UN, 2010)	Life expectancy:	75 years (men), 79 years (women) (UN)
Capital:	Belmopan	Monetary unit:	1 Belizean dollar = 100 cents
Area:	22,965 sq km (8,867 sq miles)	Main exports	Sugar, bananas, citrus fruits, oil, clothing, fish products, molasses, wood
GDP:	\$1.35 Billion US dollars(WB, 2009)		
Major languages:	English (official), Spanish, Mayan, Garifuna (Carib), Creole		

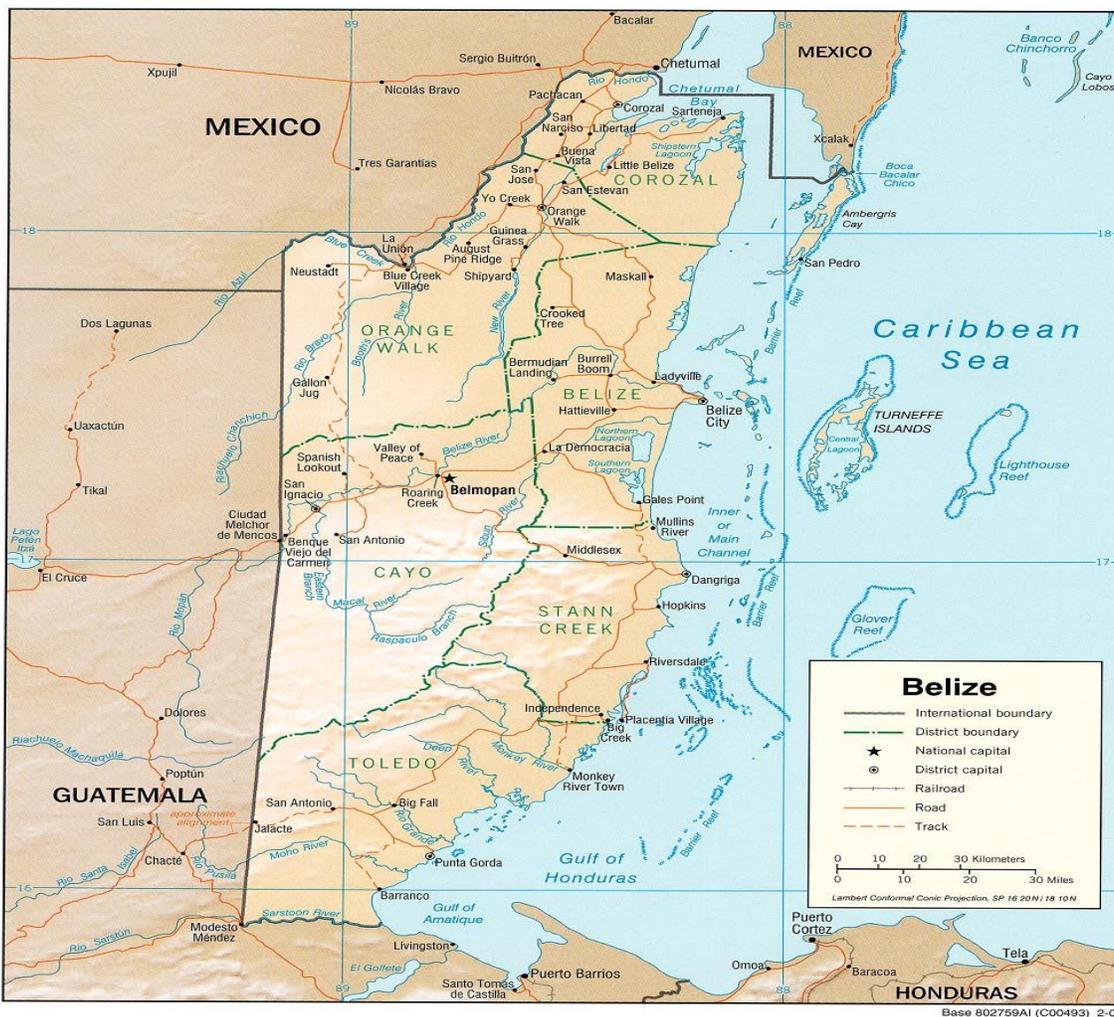


Figure 1. Map of Belize¹

¹ <http://www.belize.com/belize-map>

Economy, Growth and Emissions

Belize is a country situated on the Caribbean coast of Central America. The country achieved full independence from Great Britain on 21 September 1981. Belize has established relations and diplomatic ties with many other countries, individually or through supranational and international organizations. It is a member of the United Nations, the Nonaligned Movement, the World Trade Organization, the Organization of American States and the Association of Caribbean States and the Caribbean Community (CARICOM), and other related institutions.

Despite the yearly population growth rate of 3.3%, Belize still has the lowest population density in Central America -- approximately 2.3 persons/km². The country has vast uninhabited areas with pristine nature. The world's second largest barrier reef is in Belize's waters, attracting a large number of tourists each year, and contributing to the country's economy while providing marine products that are important for the country's export. Recently, oil reserves have been discovered in Belize, but extraction still occurs in limited amounts.

Belize has a small, essentially private enterprise economy that is based primarily on agriculture, agro-based industry, and merchandising, with tourism and construction recently assuming greater importance. In 2006, the exploitation of a newly discovered crude oil field near the town of Spanish Lookout has presented new prospects and problems for this developing nation. It has yet to be seen if significant economic expansion will be made by this. To date, oil production equal 3,000 bbl/d (480 m³/d) (2007 est.) and oil exports equal 1,960 bbl/d (312 m³/d) (2006 est.). The country is a producer of industrial minerals. Sugar accounts for nearly half of exports, while the banana industry is the country's largest employer. Belize imports one and a half times more goods than it exports. In 2006, goods valued at 660 million USD were imported, while 427 million USD were exported. The top imports were machine and transportation equipment (17%), fuels and lubricants (16%), manufactured goods (12%), and food (9%).²

The new government faces important challenges to economic stability. Rapid action to improve tax collection has been promised, but a lack of progress in reining in spending could bring the exchange rate under pressure. The tourism and construction sectors strengthened in early 2009, leading to a preliminary estimate of revived growth at 4%. Infrastructure continues to be a major challenge for the economic development of Belize. Furthermore, Belize has the most expensive electricity in the region. Trade is important, and the major trading partners are the United States, Mexico, the European Union, and Central America.

The largest integrated electric utility and principal distributor in Belize is BEL. The Government of Belize nationalized BEL in 2011, with the GOB owning 26.9%, Social Security Board owning 70.2%, and the remaining shares, just over 1%, to 500 small shareholders. Belize utilizes two main energy sources: oil derivatives and biomass. Oil derivatives are imported, as the country does not have refinery plants. Fuel dependency is a big challenge for Belize, accounting for approximately 66% of the country's energy supply, mostly applied in the transport sector. Diesel generators still provide approximately 4% of the total electricity

² *Second National Communication, p. 48.*

consumption.³ Biomass is used as fuelwood for cooking; in the Belizean remote rural communities, biomass as fuelwood is still an important energy source, accounting for 13.9% of the cooking fuel in the country.⁴

The most utilized source for renewable electricity generation, apart from hydropower, is the combustion of bagasse, a waste from the sugarcane production. Other renewable electricity generation technologies are used in small-scale, mostly isolated, applications and power plants in Belize. The amount of electricity needed in the country has risen by 65% in the last decade, with a faster rise the first 5 years and a slower rate of electricity need in the last 5 years. The trend also shows that the percentage of power imported from Mexico has been about 50% of the total amount, with a decrease in import the last 2 years. This decrease is due to a higher amount of domestic power production by hydropower and the use of bagasse.

Belize's dependency on imported energy sources poses a concern regarding the country's security of energy supply. Measures have been taken to reduce the country's dependence on imported electricity, by enhancing the country's hydropower capacity. Recent hydropower capacity expansion has reached over 50% of the country's peak demand. The Mollejon Hydroelectric Dam has a capacity of 24.9 MW and generates 80 GW to 160 GW per year; the Vaca Dam became operational in January 2010 and has a capacity of 19 MW; the Chalillo Dam became operational in 2005 and has a generating capacity of 7 MW; and lastly, the Hydro Maya which has a rated capacity of 3.5 MW and an available capacity of 0.5 MW.⁵ The total available hydropower capacity is 51.4 MW.⁶

The country's CO₂ emissions show a growing trend in the available reference years, from 10,319 kt CO₂e in 1994, to 22,979 kt in 2000. According to the last reference year, the agricultural sector is the largest emitter of CO₂e, followed by Land Use, Land-Use Change and Forestry (LULUCF), waste, energy, and industry sector.⁷

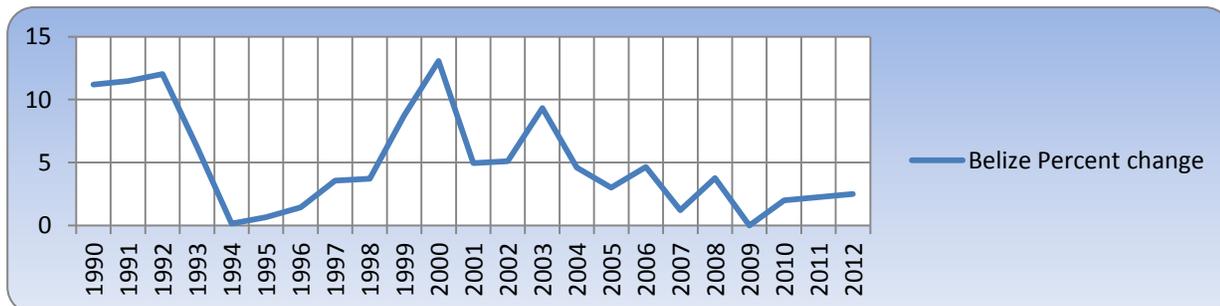


Figure 2. Economic growth since 1990 (GDP percent change)

³ *Second National Communication*, p. 23.

⁴ *Launchpad Consulting*, 2003, p. 8.

⁵ *Becol*, 2011.

⁶ *Electrowatt-Ekono*, 2006, p. 7.

⁷ *Second National Communication*, p. 25.



Figure 3. Economic growth since 1990 (GDP USD billions)

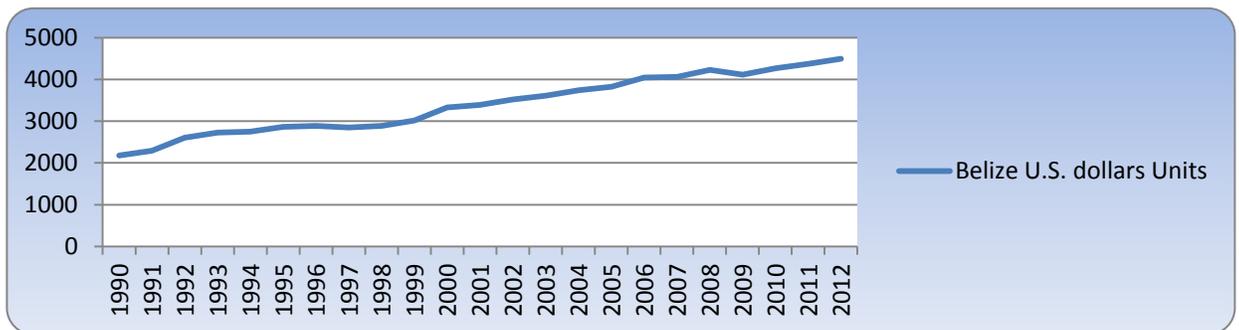


Figure 4. Economic growth since 1990 (GDP per capita)

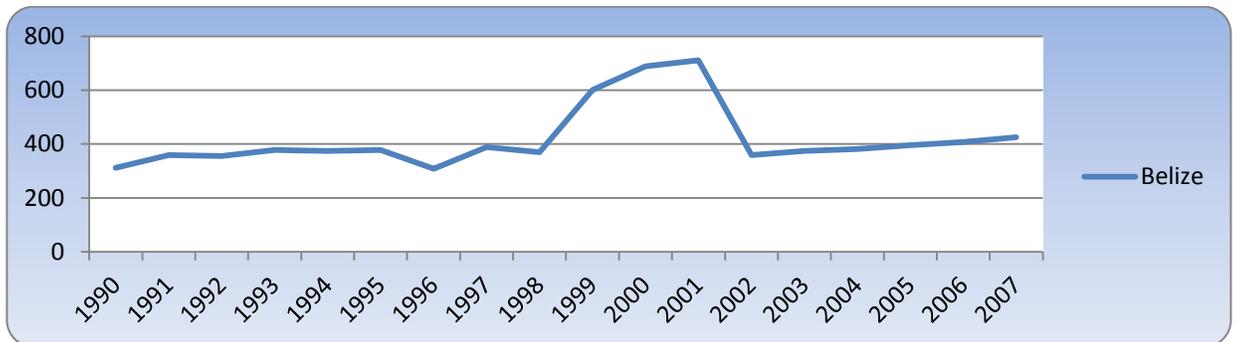


Figure 1. CO₂ emissions per year in ktCO₂/year

Status of CDM Development and Capacity Building in Belize

Belize has established a DNA, and the country approved the Environmental Protection Regulations (Clean Development Mechanism) in 2011. Up until the start of 2012, Belize still had no CDM projects, however, CDM capacity building, information, and workshops, aimed at the public administration and the private sector, have proven helpful. There are currently four PINS submitted to the DNA, and two PDDs are in the developmental stage. The project developers for the two PDDs have applied for participation in the CDM loan scheme.

Overview of CDM Opportunities in Belize

Agriculture and Forests

Illegal logging and deforestation for agricultural purposes has been observed taking place in the country -- particularly along the Guatemalan border. Measures to limit the current rate of deforestation, and implementation of reforestation projects through a CDM Programme of Activities might provide financial opportunities, while safeguarding the natural resource base of Belize. Mangrove clearance is another challenge in Belize, especially when the country's risks of flooding and occasional hurricanes are taken into consideration. Mangrove conservation and reforestation projects would certainly provide a sustainable contribution to the country's current trends, while adding to carbon sinks. Estimates show that approximately 14% of the forested area in Belize is suitable for sustainable forest management for timber production. Sustainable timber production could hinder further deforestation, contributing to the sustaining of current carbon sinks in the country, and renewable energy production from sawmill wastes.

Forest Carbon Options

The forested area in Belize covers 1,366,300 hectares, approximately 62% of the country. Of this, 37% is classified as primary forest, the most biodiverse and carbon-dense form of forest, containing 171 million metric tons of carbon in living forest biomass. From 1989 to 2012 Belize has lost 11.3% of its forested areas, approximately 0.49% per year.⁸ This is mainly due to the expansion of agricultural industry, urban, rural and infrastructural expansion, and growth in tourism. Moreover, the timber production doubled between 1999 and 2002.⁹

The total emissions from The Land Use, Land-Use Change and Forestry (LULUCF) sector accounted for 7,483, 9,803 and 11,950 Kt of GHG emissions for the reference years 1994, 1997 and 2000. Moreover, this is the sector responsible for the largest emissions for 1994 and 1997. The LULUCF sector also shows a fast growing trend in emissions, compared to the other sectors (with the exception of agriculture), likely due to the growth in rural population and the need for agricultural land.

The key sources of GHG in the LULUCF sector were forest and grassland conversion, accounting for 12,077 Kt CO₂e in 2000, which, combined, are also the largest emissions sources in the country. One different feature about this sector is that as deforestation is a source of GHG emissions, reforestation and the growth of biomass serve as removers of CO₂ from the atmosphere. The amount of CO₂ removals from this sector was 2,891, 3,225 and 3,862 Kt CO₂e in 1994, 1997 and 2000, respectively. Using the amount of removed CO₂ from the growth of biomass, a net amount of GHG emissions in CO₂e can be calculated to be 5,117, 7,253 and 9,088 Kt CO₂e for 1994, 1997 and 2000.¹⁰

⁸ http://maps.cathalac.org/Downloads/data/bz/bz_forest_cover_deforestation_2010-2012_summary.pdf

⁹ MNREI, 2002:19.

¹⁰ Sabido, 2007.

Forest carbon activities hold significant potential for Belize, and efforts related to avoided deforestation and sustainable forest management present opportunities under the scope of REDD+. In an expression of interest to join the Forest Carbon Partnership Facility, the Ministry responsible for the climate change portfolio stated that future REDD+ activities will be governed by a Technical Expert Group (TEG) on Forests and Climate, who will report to the Belize National Climate Change Committee, chaired by the CEO of the Ministry. However, significant amounts of funding will be required, especially for putting a strong monitoring in place, reporting and verification (MRV) system, and strengthening the technical capacity. Furthermore, it is crucial that policies addressing drivers of deforestation are clearly defined.

Afforestation and reforestation of degraded forest lands and mangrove habitats are possible under the Clean Development Mechanism. However, despite the potential to mitigate climate change through forest regeneration, A/R CDM activities have remained underdeveloped, compared to other CDM sectors. This mainly related to the complexity of the A/R CDM procedure and the limited market demand for A/R CDM credits, since CERs from these projects are not eligible in the European Emission Trading System. Furthermore, in order to address issues related to non-permanence, only tCERs are issued to A/R CDM projects. Nonetheless, there are some forestry related opportunities that could be worth looking into. Biomass is the second main energy source in Belize, emitting 619.87 Kt of CO₂ in 2000. The two sources of biomass are fuelwood for domestic use, and bagasse. Fuelwood is used for cooking by approximately 16% of the households in Belize¹¹. A possible CDM approach to the use of fuelwood is the distribution of efficient cook stoves (up to 35% efficiency increase), to limit the amount of fuelwood needed, generating CERs while limiting the rate of deforestation.

Calculating the potential emission reductions from REDD+ activities in Belize demonstrates that there is mitigation potential if deforestation is avoided completely. Assuming that the baseline is entirely based on historical emissions, avoided emissions are calculated by multiplying the annual deforestation in Belize, estimated to be 9,650 ha per year, with 36 tC/ha, which is the approximate amount of tons of carbon stored per ha in the country's forests annually.¹² Based on this data, and the conversion factor of 1 ton of biomass carbon to the equivalent of 3.67 tCO₂¹³, avoiding deforestation, alone, in Belize has the potential to contribute to more than 1 million tons in CO₂ emission reductions every year. Reversing the trend, and adding forest regeneration to these estimates would increase this number even more. Afforestation/reforestation initiatives aiming to replant 50% of the loss in forest cover during 1989-2012 (249,727 ha), would require the regeneration of 124,863.5 ha of forest land, which could generate about 16 million tCO₂e reductions every year

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
REDD+ / Avoided deforestation	1,274,958	Historical baseline
Afforestation/ Reforestation	16,496,965	AR-AM1, AR-AM3, AR-AM4, AR-AM5, AR-AM9, AR-AM10, AR-AMS1, AR-ACM1, AR-ACM2

¹¹ National GHG Inventory, 2009.

¹² <ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e04c.pdf>

¹³ <http://aciarc.gov.au/files/node/8864/TR68%20part%202.pdf>

Forestry Industry

Given the existing deforestation problem, using forest resources for biomass-based energy production is questionable, but there is a possibility to utilize wood waste from logging practices. The company River Works has proposed a project regarding the harvest of logs stored underwater in the Macal River. The logs are to be used for the production of planks and beams. The CDM related activity could consist of the utilization of the sawmill waste to produce energy. Additionally, it is expected that this activity will result in a reduction of methane emissions, since the logs would otherwise have remained in anaerobic conditions, contributing to methane emissions.

Biodiesel

As shown by the GHG inventory, while the agricultural sector is responsible for a relatively low amount of GHG by Kt, it is nevertheless responsible for the largest part of CO₂e. The agricultural sector could prove to be a good source for CDM projects through the cultivation of energy crops. The jatropha curcas plant, also referred to as physic nut or piñon, is a native Central American shrub, which has shown great potential as a source of biodiesel. The seeds contain 27-40% oil that can easily be used as biodiesel. The plant is stress and drought resistant, grows on degraded soils that are not suitable for agriculture, and is not edible. Therefore, it is not in competition with food production, and will not affect food prices like other biofuel crops such as sugarcane or corn. Seed cake, the solid biomass residue after oil extraction, can further be used to produce biogas, or directly as green fertilizer. Jatropha curcas could be used in a crop rotation scheme, adding nutrients to the soil, limiting the need for deforestation and burning of forest to access nutrient rich soil, while producing oil for biodiesel ¹⁴.

In the context of CDM, biodiesel must be used in a captive fleet, i.e. a (large) number of identifiable vehicles like city busses or the trucks of specific companies, to allow the generation of Certified Emission Reductions. Alternatively, biodiesel may be used in existing diesel power plants. Given that the 2010 electricity production of 4,461 MWh generated from crude oil, and 7,608 MWh generated from diesel generators, the approximate amount of CERs obtainable by using biodiesel in the existing generators would be approximately 6,400 using the IPCC values for CO₂ content in diesel and crude oil and applying a (relatively high) efficiency of the engines of 50%.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Biodiesel	6,400	ACM0017, AMS-III.AK, AM0041

¹⁴ Achten, W. M., Mathijs, E., Verchot, L., Singh, V. P., Aerts, R. and Muys, B. (2007), *Jatropha biodiesel fueling sustainability? Biofuels, Bioprod. Bioref.*, 1: 283–291. doi: 10.1002/bbb.39.

Ethanol

Bioethanol production could prove to be a future solution to the country's dependency on imported fuels. Belize already has a significant sugarcane production, with Belize Sugar Industry processing approximately 275 tons of sugarcane per hour. By expanding the sugarcane production, the country could create a stimulus for the agricultural sector, and initiate a bioethanol industry. This could limit GHG emissions and fuel imports.

Sugarcane-based ethanol can be mixed up to 5-10%, and fuel gasoline vehicles with no, or very little, engine modification. Fossil fuel is regularly needed for the production processes, but bioethanol, as fuel, emits 90% less CO₂ and less air pollutants compared to gasoline. Therefore, the possibilities of producing bioethanol should be considered. In Brazil, where the use of sugarcane to produce bioethanol is extensive, the cost of bioethanol is 0.25-0.35 USD per litre of gasoline equivalent, which is competitive with gasoline. The prices in other regions tend to be higher, although there is potential for cost reduction.¹⁵

The citrus industry produced 139,083 metric tons of solid waste in 2000. This number appears to be relatively constant, coming down to 131,762 metric tons in 2007. The solid waste consists of orange and grapefruit peel. The citrus industry also produces vast amounts of liquid waste. Run-off from decomposing peels and the liquid waste results in methane emissions, and a high level of biological oxygen demand. When the run-off enters water bodies, it can lower the dissolved oxygen in the water, choking biological organisms and causing eutrophication. Citrus Products of Belize Ltd. is treating their waste through two systems: the liquid waste is being treated by passing through a system of effluent ponds, while the solid waste, peels, pulp and seeds are being used for compost production. The compost is given to farmers to be used as fertilizer, free of charge. This treatment system limits the waste's environmental impact, but there are other alternatives that could exploit the waste resource more extensively.

Studies show that there are two alternatives for the utilization of the waste from the citrus industry that could provide reduction of GHG emissions, energy generation, and a better waste management, while providing savings in energy need and waste disposal expenses. One option is the anaerobic digestion of the solid and liquid wastes for biogas production. This would minimize the environmental problems related to the run-off of waste and nutrients, contaminating water bodies, and at the same time produce energy for the industrial process and/or sale of electricity to the grid. This option could produce enough energy to provide 100% of the electrical requirements on-site, and approximately 50% of the heat requirements.

The other option would be the combustion of the solid waste, and biogas production from the liquid waste. The combustion of the pressed and dried peel could provide enough steam to meet 100% of the heat requirements. Combined with electricity and heat generation from the biogas production from the liquid waste, both the electricity and heat requirements for the production process could displace the need for fossil fuels.¹⁶

¹⁵ EIA – Annual Energy Outlook 2007.

¹⁶ Winrock International Institute for Agricultural Development, 1991:8.

Recent studies show that there is also a possibility to produce both biogas and ethanol from citrus waste. Another by-product is limonene, which can be used in cosmetics, or as a solvent in cleaning products. The study showed that 1 ton of citrus waste with a 20% dry weight resulted in 39.64 litres of ethanol, 45 m³ of methane, and 8.9 litres of limonene. About 29% of the produced methane was required to heat enough steam for the distillation and hydrolysis processes.¹⁷ The costs for investments and operation would depend on many factors: country, location, etc. However, ethanol production costs will be lower the more waste is processed, or if the waste does not need to be transported too far. The costs of ethanol production can be relatively low, when economies of scale are taken into consideration. The highest expense is related to the anaerobic digestion and biogas upgrading. Biogas upgrading is the process where the CO₂ in the biogas is removed, to achieve a high percentage of methane. This process is only needed if the biogas is to be used for vehicles, or mixed with natural gas. For cooking, lighting and electricity production purposes this is not needed, and could bring the costs of investment and operation further down. The ethanol could be used to minimize the dependency on imported fossil fuel for the transport sector; the overproduction of biogas, not needed to power the production process, could be used for in-house electricity consumption in the citrus industry or be sold through the electricity grid.

Given the amount of waste produced by the citrus industry, 131,762 tons (2007), and an average emissions reduction of 0,0025 tCO₂ per litre by substituting gasoline with ethanol, the use of bioethanol would provide 13,057 CERs per year from the citrus industry. This does not take into account the CO₂ reductions that biogas would provide by generating power and/or heat for production, or to be fed to the grid, and the methane that is prevented from being released from the waste's fermentation.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Ethanol	13,057	AMS-III.H., AMS-III.I.

Waste

The emissions coming from the waste sector in Belize are not particularly high, as they account for less than 1% of the total emissions. A key source sub-sector for the waste sector is industrial wastewater, which is the largest emitter, accounting for 1,317.25 Kt CO₂e. Land disposal of solid waste is the second largest emitter, with 23.5 Kt CO₂e of methane emissions in 2000. Emissions from wastewater handling, mainly from anaerobic septic tank systems, accounted for 2 Kt CO₂e in 2000. There has been a decrease in emissions from the waste sector, which is a result of decreased emissions from industrial wastewater handling. This is mainly due to a decrease, over time, in wastewater produced per ton of product, and methane recovery. The waste sector emitted 2617.5, 1,383.5 and 1,317.25 Kt in CO₂e in 1994, 1997 and 2000, respectively¹⁸. In this report, waste will also include agricultural waste from agro-industries and domestic waste in the form of manure from livestock.

¹⁷ <http://hdl.handle.net/2320/5591>

¹⁸ "Second National communication to the Conference of the Parties of the UNFCCC", 2011.

Bagasse Energy Generation

The Belcogen co-generation plant in Belize utilizes sugarcane waste to produce electricity and heat. It receives 82 tons of bagasse per hour, the residue from sugarcane after sugar production, from the original 275 tons of sugarcane, processed by Belize Sugar Industry, per hour. From 82 t/h of bagasse, Belcogen is able to provide 13.5 MW of electricity to the grid, 8 MW of electricity and heat, required for the sugarcane processing (Jobling, 2011). This practice could be developed with an expansion of the sugarcane sector for ethanol production. The potential for power generation from sugarcane bagasse is already partly utilized. In addition to the existing utilization, a PIN has been submitted to the country's DNA, regarding a sugar bio-refinery for ethanol, and electricity generation from sugarcane waste. According to the PIN, the project would have the capacity to reduce annual emissions by approximately 173,000 tons CO₂e/year, over the next 10 years¹⁹.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Bagasse	173,000	AM36, ACM6, ACM2, AMS-I.D., AMS-I.C.

Animal Waste

Approximately 2,150 households in Belize still had no access to electricity in 2011²⁰. The consumption of paraffin for lighting purposes is estimated to be, on average, about 0.5 litres per household per day. Assuming that these rural households have some kind of livestock, the manure could be utilized to produce biogas for lighting. Nevertheless, 0.5 litres per day per 2,150 households gives a yearly national consumption of 365 days * 2,150 households * 0.5 litres * 0.0008 ton/litre = 312.9 ton of kerosene per year. Using the IPCC emission factor for kerosene, the total emissions reduction potential is then 3.22 ton CO₂/ton kerosene * 312.9 ton = 1,010 tCO₂/year. The technology could also potentially replace kerosene fuel for cooking.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Domestic biogas	1,010	AMS-I.A, AMS-I.C, AMS-I.D., AMS-III.H., AMS-III.D., AMS-III.F., AMS-III.L, AMS-III.R., ACM14, AM25, AM80

Industrial Biogas

Presently, the aquaculture industry is a consumer of fossil fuel produced energy. Belize Aquaculture Limited (BAL) utilizes the heat from its generators, running on diesel and crude

¹⁹ <http://cdmbelize.org/images/Documents/the%20project%20identification%20note.pdf>, 2012

²⁰ PUC, 2011.

oil, with a capacity of 24 MW for its production processes, where shrimp are cooked at the plant²¹.

BAL's shrimp farm and industrial process produces a high amount of biological waste, mostly in the form of the shrimp head, accounting for almost 35% of the total production. The amount of waste from the shrimp industry rises with production, accounting for 3,835 tons in 2003, and 5,781 tons in 2005²². The discharge of effluents from aquaculture ponds, and the disposal of the shrimp heads and shells can pose an environmental hazard by leaching out into waterways. An alternative utilization of the waste could be the production of biogas.

The production of biogas in biodigesters will leave a large amount of undigested matter. After the biological waste has been through the digester process, the shrimp waste shows remarkable fertilizer potential, containing nitrogen, phosphorus, potassium and metallic salts²³.

The biogas treatment process is a relatively low-cost, low-tech and low-energy intensive technology. Tests with Greenlandic shrimp wastes show a potential of producing 210 Nm³ of methane (CH₄) per ton of waste (excluding water)²⁴. Methane has a lower heating value of 35.8 MJ/Nm³, and can be applied to produce electricity in a gas engine. A regular gas engine which can utilize 38% of the calorific value for electricity production and 52% for heat, might produce 2,856.84 MJ, or 793.56 kWh, of electricity and 3,909.36 MJ of heat per ton of waste (excluding water).

Given Belize's grid emission factor of 0.1463 tCO₂/MWh, the electricity produced would give an emissions reduction of 793.56 MWh * 0.1463 tCO₂/MWh = 116 tCO₂ per year (2005 shrimp waste generation). The produced electricity could also be used as an alternative to the current use of BAL's generators running on crude oil, reducing the amount of CO₂ emissions by 1,192.77.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Industrial biogas (grid)	116	AMS-III.H., AMS-III.I.
Industrial biogas (crude oil)	1,193	AMS-III.H., AMS-III.I.

Wastewater

The lack of a comprehensive liquid waste management in Belize, poses a serious threat to the environment, the country's water sources, and the health of the Belizean people. It is

²¹ BAL, 2011.

²² Ministry of Natural Resources and Agriculture, 2010.

²³ Roca & Sánchez, 2009.

²⁴ Roca & Sánchez, 2009.

important to connect additional households to the sewage system, where it is available, and alternative treatment systems for the wastewater should be considered. The CDM might provide a solution, making projects that previously were not affordable, financially accessible. Belize City, with its approximate daily production of 5,700 m³ of sewage, could provide a resource for biogas production. Methane is already produced naturally in septic tanks and by the settling of sewage in ponds. This process could be an alternative treatment system, be controlled and exploited for the recovery of biogas, and used for energy production.

The potential of biogas production from sewage is approximately 1.0 cubic foot (ft³) per person per day. This amount of gas can produce about 2.2 Watts of power generation. For each 4.5 million gallons per day that flow through a wastewater treatment facility operating a biogas digester, 100 kW of electricity can be produced²⁵. With Belize City's daily flow of 5.7 million litres of sewage, there could be a daily production of approximately 33 kW of electricity. If the 33 kW gas engine produces electricity all year, it has a potential yearly capacity of 289,000 MWh. Again, using the relatively low grid emission factor, it has the emissions reduction potential of 289,000 MWh * 0.1463 tCO₂/MWh = 42,280 tCO₂. This may also cause an incentive to connect more households to the sewage system, thus minimizing the hazard of water contamination.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Wastewater	42,280	M36, ACM6, ACM2, AMS-I.C., AM36, ACM6, ACM2, AMS-I.D., AMS-I.C., ACM6, ACM2, AMS-I.D. and AMS-I.C.

Landfill Gas

Solid waste, here, is defined as the waste, mainly produced by households, which typically ends up at the landfill or is illegally dumped. Waste is regarded as one of the biggest threats to Belize's environment, water sources, and health²⁶. Open air burning of waste in the Belizean landfills, and private burning by households is common practice in the country. The burning of waste releases toxic fumes and particles into the air, causing air pollution, posing a major environmental and health hazard²⁷, and making the utilization of the resources in the waste impossible. Existing landfills contain organic waste, where anaerobic digestion is already occurring, thus producing methane. The methane emissions from solid waste produced in urban centres in 2000 were estimated to be 22.7 Kt, equal to 476.7 kilotons of CO₂e, and showing a growing trend. These emissions could be avoided by capturing the methane directly from the landfill. The methane could be flared or utilized to produce electricity by using the gas as fuel for a gas engine. A current PIN forwarded to the DNA of Belize is looking into methane recovery and flaring from one of the country's landfills. The PIN is on the Mile

²⁵ EPA, 2007.

²⁶ MNRE, 2010.

²⁷ MNRE, 2010.

24 Regional Sanitary Landfill LFG Project, and is expected to achieve annual average emission reductions of 37,591 tCO₂e per year.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Landfill gas	37,591	AM36, ACM6, ACM2, AMS-I.C., AM36, ACM6, ACM2, AMS-I.D., AMS-I.C., ACM6, ACM2, AMS-I.D. and AMS-I.C.

Conventional Power Production

Primary energy sources in Belize are fossil fuels (66%), biomass (26%), imported electricity (5%), and hydro (3%). Biomass is used as fuelwood for cooking, and combustion of sugarcane waste (bagasse) is used for energy production. Hydropower and biomass are the main sources for electricity production (64%); the remainder is imported from Mexico (33.1%) or generated using diesel generators (4%). The latter are used mostly in the remote areas and cayes (REEGLE, 2010).

With the majority of fossil fuels being imported, the options for reduced CO₂ emissions in the conventional power production are limited. Approximately 85% of households have access to electricity, while the rest are often reliant on diesel generators for electricity production. Since the diesel generators comprise only 4% of electricity production, the options for CDMs in this area are negligible.

Potential CDM activities in the conventional power sector could, in future, involve improved efficiency of existing hydro and biomass energy plants. For the time being, the only biomass power plant is already functioning as a combined cycle plant.

For any future efficiency improvements in conventional power production facilities, it would be beneficial to consider the high share of imported electricity from Mexico. Taking into consideration the electricity imports from Mexico, the grid emission factor is 0.1463 tCO₂/MWh, as opposed to 0.0226 tCO₂/MWh without energy imports.

Renewable Energy

Recent methodology upgrades allow host countries and CDM project proponents to calculate and include an emission factor related to the net electricity imported. Before these changes, the emission factor related to the imported electricity was set to zero. The current grid emission factor in Belize is presented below.

Grid emission factor

Option	W _{OM}	W _{BM}	EF _{grid,CM} (tCO ₂ /MWh)
All Project Activities (except wind and solar)	0.5	0.5	0.1463
Wind and Solar	0.75	0.25	0.2195
All Project Activities - 2nd and 3rd Crediting Period	0.25	0.75	0.0732

Hydropower

Belize has gradually started to utilize its hydropower potential. While the country's hydropower potential is relatively low, there are still potential sites for further hydropower development, without the need to inundate large areas of rainforest for storage reservoirs.²⁸ A 2006 study of Belize's hydropower potential identified several possible hydropower schemes for the country. A list of the possible projects is presented below. For a detailed list with more specific and technical information, see Elektrowatt-Ekono, 2006: *Belize Hydroelectric Development - Technical Report*. Due to the lack of data in certain areas, some of the possible projects are more detailed than others.

Chalillo II Project

Between the existing Chalillo dam and the Mollejon dam, there is an unused gross head (drop) of about 95 m. The development of a project on this site is estimated to have a potential capacity of 16 MW.

Mopan River

A project consisting of a cascade system along the Mopan River has been considered to have a hydropower potential of 15 MW. The Mopan Valley is easily accessible by road, and provided with transmission lines. The environmental impact of a project in the Mopan Valley is estimated to be almost insignificant, but might require some resettlement or adaptation of existing human and tourist activities.

Macal River Project, downstream of Vaca Falls

About 23 km downstream of Vaca Falls there is a slope of 0.13% on a 32 m head. There is a possibility of installing low-head turbines to generate a maximum of 8.4 MW. The site is easily accessible and in proximity to lines of the national power network.

Macal River tributaries

There is a stretch of the Rio On with the right conditions to install a small hydroelectric plant with a 2 MW capacity. A site along the Privassion Rio has features compatible with a 1 MW, or less, power plant. The Macal River tributaries, First Creek, Vaqueros Creek, Planchon Creek, Mahogany Creek, Mollejon Creek, Rio On, Pinol Creek, Oak Burn and Little Vaqueros Creek, are easily accessible, and could be intercepted by a tunnel of approximately 10 km to channel the

²⁸ Elektrowatt-Ekono, 2006, p.23.

water for power generation. An alternative could be to channel the water to a tunnel of the Chalillo station.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Hydro Chalillo II Project	10,885	AMS-I.A. AMS-I.D, AMS-I.F, ACM2
Hydro Mopan River	10,204	AMS-I.A. AMS-I.D, AMS-I.F, ACM2
Hydro Macal River project	5,714	AMS-I.A. AMS-I.D, AMS-I.F, ACM2
Hydro Macal River tributaries	1,865	AMS-I.A. AMS-I.D, AMS-I.F, ACM2

Solar

Solar photovoltaic (PV) power is used to a small extent, mostly by the eco-tourism sector, and in remote off-grid areas. The PV potential for isolated off-grid applications in Belize is estimated to be 50,000 Watt-peak (Wp), by a report on Belize's Energy Sector made in 2003 (Launchpad Consulting, 2003: 47-48). Currently, there is a joint solar power pilot project in operation between the University of Belize and the Government of Belize. This could provide useful information to potential developers of PV CDM projects.

Solar thermal energy for water heating purposes is a highly effective and clean way to save energy, compared to electrical or fossil fuel-based water heating systems. Given Belize's sunny climate, there are many possibilities to reduce electricity consumption from water heating²⁹. Installation of water heaters, and incentives for the switch from butane or electricity powered water heating could be presented as a Programme of Activity. The technology is cost effective and there is a relatively quick return on investment.³⁰

The company Paradise Technology Solutions has submitted a PIN to the country's DNA regarding a possible future CDM project for the installation of a solar PV plant with a 50 MW capacity, near the capital of Belmopan. The project aims to reduce the need for imported power from Mexico, potentially reduce the country's annual CO₂ emissions by 14,500 tons, and could be initiated in 2014.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Solar PV	14,500	AMS-I.A. AMS-I.D, AMS-I.F and ACM2

²⁹ Harris, 2011.

³⁰ Public Utilities Commission, 2003: 22.

Wind Power

Belize has sites with excellent wind resources that could provide a large quantity of renewable energy, compared to the country's needs. On the Baldy Beacon in the Cayo District, the average annual wind speed is 7 m/s. It was estimated in 2001 that a wind farm at the site could provide at least 20 MW of electricity.³¹ An interested developer has presented a project proposal (not as a CDM project) for a wind farm of 250 MW, in this region. From a sustainable development perspective, a project this big in this protected forest area is problematic.

Paradise Technology Solutions has developed a Sustainability Plan to assist the Belizean Government in achieving “*a disciplined approach to Sustainable Growth*”. Amongst other activities, there is a proposal for the development of a 40 MW wind or solar farm. The aim is to provide enough renewable energy to substitute imported oil for energy production. If a 40 MW wind farm operates at 1800 full load hours per year replacing grid power with a grid emission factor of 0.1476, the emissions reduction would correspond to 10,627 tCO₂e/year.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Wind	10,627	AMS-I.A, AMS-I.D, AMS-I.F and ACM2

Energy Consumption

There are a number of activities that could be initialized to minimize the energy demand in Belize. Most of these options will be site specific, improving energy efficiency in industrial processes (see the Industry chapter). Others could target the construction sector and the public by stimulating energy efficient buildings with reduced need for air conditioning, and installation of energy efficient LED lights for residential, industrial and public lighting. For example, Enterprise for Conservation, a UK-based company, in partnership with Ya'axché Conservation, an NGO in southern Belize, are proposing a project for a 200 acre sustainable housing and community development on previously cleared land near Punta Gorda Town. The project aims to build an integrated community self-sustaining in energy, and a positive-energy production.

Belize is almost fully electrified. A small population, notwithstanding, there are options for energy efficiency initiatives in households, as well as in the public sector, most relevant for air conditioning and less so for CFLs or other smaller installations (e.g. pumps). Replacement of ineffective air conditioning systems with energy efficient chillers is one possibility, however it would likely be more efficiently implemented as an HVAC (heating, ventilation, air conditioning) activity -- without the heating component. This more comprehensive approach would include the insulation envelope of buildings that often do not have windows but rather shutters that let the cooled air out of the building, thus significantly increasing the cooling need. Based on considerations in the HVAC small-scale CDM project no. 1794, a conservative estimate is a potential reduction of energy consumption by 50%. If an average Belize

³¹ Launchpad consulting, 2003, p. 47.

customer uses just under 3,000 kWh (calculated from figures on BEL's website), and at least half of that is for cooling purposes, and if half of Belizean households are assumed to run ACs, the reduction in consumption could be as much as 50,000 households x 1,500 kWh x 50% = 37,500 MWh/year. Additional potential are in public and commercial buildings, with likely the same amount of savings. On this basis, a general effort to improve the building envelopes in Belize could roughly be estimated as having a potential of saving up to 100,000 MWh/year.

The main challenge, in CDM terms, for Belize is that the grid emission factor is nearly zero. With the exception of a single generator all domestic production is hydropower, supplemented by import from Mexico. In practice, as hydro is normally 'must run' capacity, any reduction in consumption reduces the import from Mexico, and the real emissions reduction is, therefore, based on the Mexican grid emission factor – which cannot be employed in Belize without the calculation and adoption of a common grid emission factor. A calculation (undertaken by UNEP Risoe) of the Belizean grid emission factor using the tool for import of electricity returns a grid emission factor of 0.1463. So while, in practice, the actual emissions reduction is higher, the CDM tool only credits about 6,000 tCO₂e for a nationwide HVAC activity for households -- or about 15,000 CERs per year for a programme covering all buildings in Belize. Other energy efficiency projects related to electricity, such as LED or CFL projects, would likely hold even less potential.

Biomass is the second main energy source in Belize, emitting 619.87 Kt of CO₂ in 2000. The two sources of biomass are fuelwood for domestic use, and bagasse. Fuelwood is used for cooking by approximately 16% of the households in Belize (National GHG Inventory, 2009: 22). It is not clear, however, which type of stove is commonly used, and to what extent efficiency can be improved. It is also not obvious what the most likely alternative would be -- efficient cook stove or an electric appliance.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Nationwide HVAC	15,000	AMS-II.E.

Industrial Production Processes

Industrial activities cover several industry sectors and reduction options related to energy efficiency, as well as change of processes and substitution of materials. In developing countries there are many cottage industries, such as small-scale brick production, or even household-based production, like textiles, which in most cases are not represented and do not constitute noteworthy emissions reduction options. In many countries, brick kilns are the exception, and may even represent considerable reduction potentials.

Industrial activity in Belize is relatively recent. For most of its history, Belize was dependent on forestry for exports, but as timber, mainly mahogany, came in short supply (as no replanting was undertaken) cultivation shifted to sugarcane, which only recently diversified towards production of citrus, bananas, seafood, and apparel. Domestic industry is limited, though the US Embassy in Belmopan knows of some 185 American companies that have operations in Belize.

Main areas of income have traditionally been sugar, bananas, fisheries, and, increasingly, tourism. Since 2002, a small oil industry has been established in Belize. In May 2012, production from 11 wells in the Spanish Lookout Field, and 5 wells in the Never Delay Field averaged a total of 3,300 barrels of crude oil per day³² or 1.2 million barrels a year. To compare, the Tres Hermanos oil field CDM project (no. 3208) in Mexico, which is thought to be affiliated to the same geological structure, currently produces 2,800 barrels of oil and 10 million Ft³ of associated gas per day. The estimated annual emissions reduction from utilizing the gas that is currently flared in the Mexican project is 118,000 tCO₂e/year. Depending on the current practice in the Belizean oil fields, a smaller amount would be achievable through energy production due to the low grid emission factor (0.1463 compared to Mexico's approximately 0.6), i.e. about 30,000 tCO₂e/year. It would be significantly higher if the methane was currently vented, but it appears that flaring is already installed, according to a newspaper article in February 2012³³.

In the sugar industry, in recent years, both production and prices on the European market (the target of the entire Belizean production) have fallen³⁴, leaving some sugar fields unattended. The sugarcane industry, itself, holds emissions reduction potential in using bagasse for energy production purposes (see the section on biomass for energy production).

The fishing industry contributes significantly to the economy of Belize, mostly from exports of lobster, conch, and shrimp. The sector is characterized as a commercially artisanal industry, except for the industrial trawl fishery of shrimp. Three shrimp processing plants with a capacity of 60 metric ton/day are responsible for all shrimp processing. Assessments made for the shrimp industry in El Salvador³⁵, where the total capacity is about 67,000 MT/year (3 times that of Belize), shows an emissions reduction potential mainly from methane destruction, from wastewater, of 0.25 tCO₂e/MT shrimp (excluding energy). In Belize, this would correspond to a reduction potential of 5,500 tCO₂e, subject to actual conditions at the plants. Shrimp constitute about a third of the production from fisheries, limiting the total reduction potential in the sector.

Emissions reduction potentials in industry are, therefore, limited and mainly linked to the tourism industry, where energy efficiency initiatives, mainly for cooling purposes, may have potential. These potentials are already assessed under energy consumption. There have been efforts and interest in linking Belize to CHENACT, a regional Programme of Activity aiming at utilizing solar water heating to replace electric water heating³⁶. The Inter-American Development Bank (IDB) approved the Caribbean Hotel Renewable Energy and Energy Efficiency Action – Advanced Program (CHENACT-AP), a 2 million USD grant to help the tourism sector in Barbados, Jamaica, The Bahamas, Suriname, Trinidad and Tobago, Belize, Haiti, Dominican Republic and Guyana, to become more energy efficient. IDB studies have

³² <http://belizenaturalenergy.bz/bneteam/production.html>

³³ http://www.theecologist.org/investigations/politics_and_economics/1240082/mayan_people_battle_oil_giants_as_belize_rainforest_threatened.html

³⁴ <http://www.belize.org/tiz/sugar>

³⁵ http://www.globalmethane.org/documents/ag_ecuador_res_assessment.pdf

³⁶ <http://ambergriscaye.com/forum/ubbthreads.php/topics/418874/Caribbean+hotels+to+become+mor.html>

estimated that many of these hotels have the potential to reduce water consumption by 50%, and overall energy consumption by 30% to 50%, when implementing an integral set of efficiency measures and microgeneration with renewable energies. For Belize, however, the challenge remains the grid emission factor of 0.1463, which means that even if the country substituted the entire import of Mexican energy, approximately 170,000 MWh in 2009³⁷, it would amount to only 25,000 tCO₂e.

Belize has no cement production of its own,³⁸ and no other industries with noteworthy emissions.

Technology type	Emission Reduction Potential per year (tCO ₂ e)	Baseline Methodologies
Oil field flaring or methane utilization	30,000	AM37 or AM9
Fisheries (shrimp)	5,500	AMS-III.H.

Transportation

Road transport is the largest GHG emitter per Kt in the energy sector, and related emissions were 263.58, 275.94 and 330.55 Kt CO₂ for the years 1994, 1997 and 2000, respectively. Road transport accounted for 44.2%, 44.6% and 51.4% of all energy-related activities countrywide, in the same reference years (May, 2007).

Due to Belize's size, there are limited possibilities for transport-related projects. A collective transport system servicing the main routes in Belize, where most settlements are, is already in place, and the size of the urban centres is probably too limited to establish an urban collective transport system. It may be possible to convert older diesel engines, particularly for bus transport and heavy trucks, to natural gas or biodiesel, thus limiting emissions from the transport sector. The possibility of biofuel production is already being explored by a CDM project developer under the ACP-MEA programme, though the main objective is usage for power production, partly due to methodological restrictions on CDMs (the requirement of captive fleet usage).

There were 54,000 cars in Belize in 2007³⁹ (a doubling over 10 years). With the high amount of sugarcane production and the access to arable land, Belize has a good starting point for ethanol production, and could potentially run the entire petrol-based stock of vehicles on ethanol. Again, however, the methodological restrictions on CDMs would stand in the way of developing such an activity as a CDM project. The frequent boat services to the barrier reef islands may represent a better option, but there are numerous companies running many small boats, and, therefore, likely impracticable to organize a captive fleet. Thus, while there may be reduction potential in the transport sector, also based on nationally based alternatives, it will

³⁷ *Energy Sector Assessment Belize*, www.sepa-america.net/descarga.php?l=data/...a=Energy...Belize

³⁸ <http://www.cemnet.com/members/gcr/intros/73.pdf>

³⁹ http://www.who.int/violence_injury_prevention/road_safety_status/country_profiles/belize.pdf

not be possible to exploit it in the context of CDM. To put the transport sector into perspective, the entire annual consumption of gasoline, approximately 3,500 barrels per day,⁴⁰ produces about 425,000 tCO₂e. This corresponds to about half of Belize's total consumption of petroleum products.

Summary

There is a wide range of activities that can contribute to a sustainable development and limit GHG emissions, and thus be regarded as possible CDM projects in Belize. Belize produces about 64% of its needed electricity from renewable energy sources, and there is still a great deal of untapped potential. Most of the possible emissions reduction potential in the electricity sector lies in reducing the amount of carbon intensive electricity imported from Mexico. To ensure a higher security of energy supply and meet the future energy demands, possible CDM projects range from an expansion of the hydropower capacity, to the utilization of wind and solar power. Other solutions include the utilization of biomass residue from the agricultural sector for energy production.

Project activities that have a great potential of CER acquirement are also activities that limit emissions at the source. Fugitive gas utilization from oil wells, methane recovery or prevention with energy production from liquid and solid waste, solar water heating to substitute butane gas, and production of biofuels are examples of the kinds of activities that have potential for a larger CER acquisition.

Technology type	Emission Reduction Potential per year (tCO ₂ e)
REDD + / avoided deforestation	1,274,958
Afforestation/Reforestation	16,496,965
Biodiesel (Jatropha)	6,400
Ethanol (Citrus)	13,057
Bagasse (new combined with ethanol)	173,000
Domestic biogas	1,010
Industrial biogas (grid)	116
Industrial biogas (crude oil)	1,193
Wastewater	42,280
Landfill gas	37,591
Hydro power	28,668
Solar PV	14,500
Wind	10,627
Nationwide HVAC	15,000
Oil field flaring or methane utilization	30,000
Fisheries (shrimp)	5,500

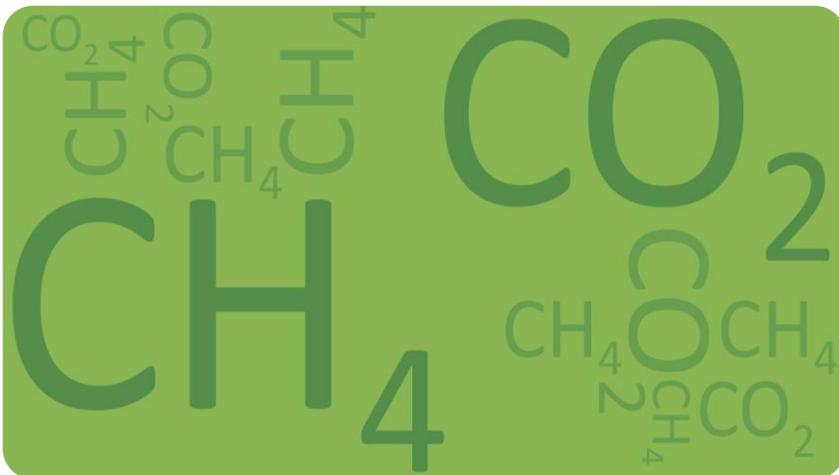
⁴⁰<http://205.254.135.7/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=62&aid=2&cid=BH,&syid=2005&eyid=2009&unit=TBPD>

These estimates should not be regarded as being precise. Rather, they represent a form of calculation that allows comparison among economies, and their relative attractiveness as destinations for carbon finance.

It should be emphasized that while attempting to be exhaustive, the estimates here do not claim to be all-inclusive. There may be unidentified sources of reductions not included in the technology overview, and not represented by existing methodologies, but in all likelihood these would be minor compared to the potentials identified.

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