



3/31/2020

# Final Feasibility Study Arundo Donax

The Investment Proposal - Arundo  
Donax Renewable Bio-mass Fuel for  
Belize -Contract#  
07/2019/GCF/Belize/CCCCC



ATOM Solutions Incorporated  
BOOKER TATE

Copyright © 2020 by Caribbean Community Climate Change Centre  
Published by Caribbean Community Climate Change Centre, Belmopan, Belize

Digital Edition (March 2020)  
Printed Edition (March 2020)

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) and may be downloaded and shared as long as the Centre is credited. No use of this publication may be made for resale or for any other commercial purpose whatsoever. The Caribbean Community Climate Change Centre (CCCCC) would appreciate a copy of any publication that uses this report as a source. The views and interpretations in this document are those of the authors and do not necessarily reflect the views of the CCCCC, its Board of Executive Directors, or the governments they represent. Caribbean Community Climate Change Centre, Ring Road, P.O. Box 563, Belmopan, Belize

Visit our website at <http://www.caribbeanclimate.bz>

ISBN-13 978-976-8269-47-8 (paperback)  
ISBN-13 978-976-8269-48-5 (pdf)



# CONTENTS

	<b>Page</b>
<b>Executive Summary</b> .....	v
<b>List of Acronyms</b> .....	viii
<b>List of Tables</b> .....	x
<b>List of Figures</b> .....	xi
<b>1.0 Introduction</b> .....	1
<b>1.1 Background</b> .....	1
<b>1.2 Objectives</b> .....	4
<b>1.3 Description</b> .....	5
<b>2.0 Belize Energy Sector</b> .....	7
2.1 Government of Belize.....	7
2.2 The Regulator.....	8
<b>2.2.1 Regulator’s Role</b> .....	9
<b>2.2.2 Regulator’s Scope</b> .....	10
<b>2.2.3 Relevant PPA</b> .....	12
2.3 Power Supply.....	14
<b>2.3.1 Energy Sources and Capacity</b> .....	14
<b>2.3.2 Energy Generators and Capacity</b> .....	17
<b>2.3.3 Total Generation</b> .....	18
<b>2.3.4 Importation</b> .....	21
2.4 Energy Demand.....	21
2.5 Forecast.....	23
<b>2.5.1 Supply</b> .....	23
<b>2.5.2 Consumption</b> .....	24
2.6 Emissions.....	25
<b>3.0 Technical Feasibility</b> .....	26
3.1 Current Situation.....	26
<b>3.1.1 Generation Capacity</b> .....	26
<b>3.1.2 Technology and Configuration</b> .....	26
<b>3.1.3 Technical Limitations/Challenges</b> .....	27
<b>3.1.4 Current Processing and Logistics</b> .....	28
<b>3.1.5 Outputs</b> .....	28
3.2 Assumptions:.....	29
3.3 Proposed Changes with Costs.....	30
<b>3.3.1 Capacity Changes</b> .....	30
<b>3.3.2 Technology Changes</b> .....	31
<b>3.3.3 Operating Environment/Configuration Changes</b> .....	31
<b>3.3.4 Process and Logistics Changes</b> .....	32
<b>3.3.5 Output Changes</b> .....	34
<b>4.0 Financial Feasibility</b> .....	35
4.1 Current Situation.....	35
<b>4.1.1 BEL Electricity Financials</b> .....	35
<b>4.1.2 BELCOGEN Electricity Financials</b> .....	37
<b>4.1.3 Bagasse Biomass Cost</b> .....	39
4.2 Assumptions.....	39
<b>4.2.1 General Assumptions</b> .....	40
<b>4.2.2 Specific Assumptions</b> .....	40
4.3 Proposed Changes.....	41
<b>4.3.1 Distribution (BEL)</b> .....	42
<b>4.3.2 Generation (BELCOGEN)</b> .....	42
<b>4.3.3 Handling &amp; Delivery (WC-CHD)</b> .....	43
<b>4.3.4 Cultivation (WC-CHD)</b> .....	43
<b>4.3.5 3<sup>rd</sup> Party Service Providers</b> .....	44
4.4 Financial Outputs.....	44
<b>4.4.1 Indicators</b> .....	44
<b>4.4.2 Statements</b> .....	45
<b>5.0 Economic Feasibility</b> .....	49
5.1 Stakeholders.....	49

5.1.1	Regulator .....	51
5.1.2	Central Bank of Belize .....	51
5.1.3	Ministry of Economic Development .....	51
5.1.4	Ministry Responsible for Energy .....	52
5.1.5	Ministry of Agriculture .....	53
5.1.6	Belize Chamber of Commerce .....	53
5.1.7	Beltraide .....	54
5.1.8	Financers .....	54
5.1.9	Caribbean Community Climate Change Centre .....	55
5.1.10	BELCOGEN .....	56
5.1.11	Belize Electricity Limited .....	57
5.1.12	Biomass Cultivators/Associations .....	58
5.2	Economy .....	59
5.2.1	General Outlook .....	59
5.2.2	Employment .....	62
5.2.3	Belize Sugarcane Industry .....	63
5.3	Cost Benefit Approach Framework .....	63
5.3.1	Net Present Value (NPV) .....	63
5.3.2	Cost Benefit Ratio (CBR) .....	64
5.3.3	Incremental Cost Benefit Ratio (ICBR) .....	65
5.3.4	Payback Period (PP) .....	65
5.3.5	Internal Rate of Return (IRR) .....	66
5.3.6	Other Economic Methodology .....	66
5.4	Economic Impacts .....	67
5.4.1	Key Stakeholders .....	67
5.4.2	Outcomes .....	68
5.5	Assumptions .....	74
5.5.1	Economic Assumptions .....	74
5.5.2	Fixed Inputs .....	76
5.5.3	Key Sensitivities .....	76
5.6	Base Scenario .....	77
5.6.1	Base Scenario Input .....	77
5.6.2	Base Scenario Outputs .....	78
5.7	Future Benefits .....	81
6.0	Model .....	83
6.1	Setting up Assumptions .....	83
6.2	Interpreting Results .....	83
6.3	Discount Rate Sensitivity .....	83
6.3.1	Discount Rate Scenario Inputs .....	83
6.3.2	Discount Rate Scenario 1 Outputs .....	84
6.3.3	Discount Rate Scenario 2 Outputs .....	86
6.4	Selling Price Sensitivity .....	88
6.4.1	Selling Price Scenario Inputs .....	88
6.4.2	Selling Price Scenario 3 Outputs .....	89
6.4.3	Selling Price Scenario 4 Outputs .....	91
6.5	Purchasing Price Sensitivity .....	93
6.5.1	Purchasing Price Scenario Inputs .....	93
6.5.2	Purchasing Price Scenario 5 Outputs .....	94
6.5.3	Purchasing Price Scenario 6 Outputs .....	96
7.0	Investment .....	98
7.1	Areas of Investment .....	99
7.2	Type of Required Investments .....	99
7.3	Potential Investors .....	99
7.3.1	Local Investment .....	99
7.3.2	International Investment .....	101
7.4	Investment Considerations .....	103
8.0	Project Implementation .....	107
8.1	Component 1 - Preparation .....	109
8.1.1	Administration .....	109
8.1.2	Procurement .....	110
8.1.3	Training .....	110
8.2	Component 2 - Cultivation .....	111
8.2.1	Land Preparation .....	112
8.2.2	Plant Care .....	112
8.3	Component 3 – Harvesting and Delivery .....	112
8.3.1	Harvesting .....	113

8.3.2	Delivery .....	113
8.4	Component 4 - Knowledge Management and Public Education .....	114
8.4.1	Knowledge Management .....	114
8.4.2	Public Education .....	115
	References .....	117
	Appendix A – Assumption Data .....	118
	Appendix B – Equipment .....	120
	Appendix C – Energy Balance .....	123
	Appendix D – Justification .....	129
	Appendix E – Scenario Data.....	131

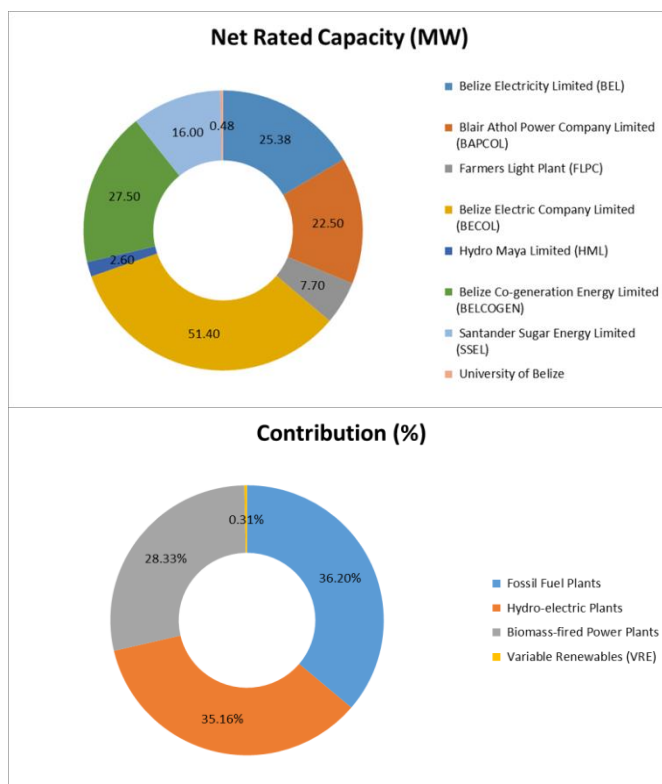
## Executive Summary

The Government of Belize's (GoB) plan to utilize more biomass to expand the utilization of renewable energy to contribute to its energy needs and reduce its carbon footprint is being supported by the Caribbean Community Climate Change Centre's (CCCCC or 5C) initiative to study the use of Arundo Donax. This is proposed for the BELCOGEN electricity plant and comes under the scope of the Public Utility Commission (PUC) which is an autonomous institution governed by the provisions of the PUC Act. The existing supply relationship between BELCOGEN and the Belize Electricity Limited (BEL) is governed by a Power Purchase Agreement (PPA) which is administered by the PUC.

Belize has a generation capacity of 153.56 MW with 54% renewable. Electricity is supplied by 9 energy producers; 1 being from Mexico. Its annual consumption is 631MWh and it is responsible for over 200,000 tons of CO<sub>2</sub> annually. This project will avoid 202,441 tons of CO<sub>2</sub> in 20 years (10,122 annually).

BELCOGEN runs 2 water tube Biomass Boilers with a capacity of 27.5 MW and utilize bagasse biomass from another ASR subsidiary; Belize Sugar Industries. 382,300 tons of bagasse are produced

during their 36-week cane crushing season but the BELCOGEN plants which runs for 10 Months, produces 91GWh annually and sells 71 GWh to BEL at \$0.1034 per KWh. By mixing a blend of 90% bagasse and 10% wild cane a modified BELCOGEN generation process can increase its output to produce 103GWh annually and sell an additional 11.78 GWh to BEL to earn an additional US\$1.2 Million using 42,533 tons of wild cane.



Key to realizing this output is the establishment or identification of an entity which will function closely with BELCOGEN, the Farmer community and other service providers. For ease of referencing the entity will be identified as WC-CHD<sup>1</sup>.

Having made key assumptions about the financial and economic climate in Belize, a base scenario was developed. The study recommends 2,000 acres of land to be used in wild cane production. It should be allocated to farming communities based on criteria set by the Ministry of Agriculture and the WC-CHD. Using an initial purchase price for wild cane of \$6 per ton and a Selling price to BELCOGEN of \$15.90 per ton, over a 20-year period, the study showed that the required investment of \$3.06 Million yields a positive gross profit for scenarios with moderate operational costs and a discount rate of 15%. These profits could be used to support climate actions and farming communities in Belize, particularly those in the Northern districts, to adapt to the effects of climate change as well as provide an opportunity to secure their livelihood.

The required investment includes the cost of establishing the necessary cultivation capacity and the establishment and operationalisation of the WC-CHD, which is critical to de-risking the market and spurring private sector (framers among others) interest in bio-mass projects in Belize. The excess returns from the sale of biomass will go into a fund to support the implementation of adaptation and mitigation projects. This will encourage the private sector across the Caribbean to implement this model which leverages local resources for further climate action. It is estimated that BELCOGEN requires no further investment and will see an additional gross profit of \$10,595,546 over the same period. This will lead to an accelerated return on investment and should trigger a review of the related PPA to reduce the applicable tariff. This will save the economy of Belize \$16,030,080 in foreign exchange transactions and lower cost of electricity by substituting expensive partially fossil based imported Mexican power with clean indigenous biomass fuel. This could lead to a review of the related public electricity rates and an improvement in the investment environment. The economic impact will be positive.

---

<sup>1</sup> Wild Cane Cultivation, Harvesting and Delivery

The overall investment of \$3.06 Million has a payback of 1.93 years, NPV of \$7.5 Million, CBR of 3.47, IRR of 49.52% and net cash flow of \$39.9 Million. Project indicators are also encouraging when sensitivities are varied. However, it is important to note that in some cases, the WC-CHD is not viewed as being viable or sustainable. As such, grant fund is most attractive for catalysing the paradigm shift. Possibilities exist for a private-non-profit relationship model of social enterprise providing a mutually beneficial business partnership between a for-profit company and WC-CHD or a traditional PPP for-profit relationship. The for-profit partners may also benefit from enhanced social or environmental impacts alongside financial returns. This may come through improved community relations or public image or increased sales; however, identifying such a private partner may prove to be difficult, at least in the market making stages. It is against this background that we recommend the use of grant resources to setup the WC-CHD and initiate some of the activities necessary for the cultivation and harvesting of wild cane, as well as develop a private sector model for the sustainability of the project and the promotion of spill-over effects into other sectors and actions gear to mitigate, combat and cope with climate change. It is estimated that project implementation requires 3 years and inputs from a wide range of stakeholders to guide and support the WC-CHD.



## List of Acronyms

Acronym	Definition
AE	Accredited Entities
BAPCOL	Blair Athol Power Company Limited
BCC	Belize Chamber of Commerce
BECOL	Belize Electric Company Limited
BEL	Belize Electricity Limited
BELCOGEN	Belize Co-generation Energy Limited
BSI	Belize Sugar Industries
BTM	Benefit Transfer Methodology
CBA	Cost Benefit Analysis
CBoB	Central Bank of Belize
CBR	Cost Benefit Ratio
CDB	Caribbean Development Bank
CFE	Comision Federal de Electricidad
CROSQ	CARICOM Regional Organisation for Standards and Quality
DFC	Development Finance Corporation
DNA	Designated National Authority
EMB	Energy and Mass Balance
ESP	Electro Static Precipitator
FEL	Front End Loader
FLPC	Farmers Light Plant
GCF	Green Climate Fund
GHG	Greenhouse gas
GoB	Government of Belize
HFO	Heavy Fuel Oil
HML	Hydro Maya Limited
IDB	Inter-American Development Bank
ICBR	Incremental Cost Benefit Ratio
IEA	International Energy Agency
IPP	Independent Power Producers
IRR	Internal Rate of Return
LCoE	Levelised Cost of electricity
LDC	Least Developed Countries
MCC	main control centre
MDB	Multilateral Development Banks
MoU	Memorandum of Understanding
MPSEPU	Ministry of Public Service, Energy and Public Utilities

Acronym	Definition
NDC	National Determined Contribution
NPV	Net Present Value
OTE	Operational Time Efficiency
PP	Payback Period
PPA	Power Purchase Agreements
PUC	Public Utility Commission
PV	Photo Voltaic
R&D	Research and Development
RFP	Request for proposals
RoR	Rate of return
SDG	Sustainable Development Goals
SIB	Statistical Institute in Belize
SIDS	Small Island Developing States
SIRDI	Sugar Industry Research and Development Institute
SPACC	Special Programme on Adaptation to Climate Change
SSB	Social Security Board
SSEL	Santander Sugar Energy Limited
TA	Turbo Alternator
UNFCCC	United Nations Framework Convention on Climate Change
UB	University of Belize
WC-CHD	Wild Cane Cultivation Harvesting and Delivery

## List of Tables

Table	Description	Page
Table 2.1	Capacity by Energy Sources	15
Table 2.2	Capacity by Energy Generator	16
Table 2.3	Belize Energy Generation	18
Table 2.4	Belize Energy Consumption	21
Table 2.5	Belize Capacity Utilization	22
Table 3.1	Energy output from blended biomass	30
Table 3.2	Equipment cost and staffing needs	32
Table 4.1	BEL Revenues	34
Table 4.2	BELCOGEN 2018 Revenues	36
Table 4.3	Financial Indicators for 10 year period	43
Table 4.4	Income/Expense Statement for Cultivation Operation - 10 years	44
Table 4.5	Income/Expense Statement for Harvesting & Delivery Operations-10 years	45
Table 4.6	Income/Expense Statement for Generation - 10 years	46
Table 4.7	Income/Expense Statement for Distribution - 10 years	47
Table 5.1	PPA Tariffs	56
Table 5.2	Unemployment Rates by District and Gender	60
Table 5.3	Employment in Corozal and Orange Walk	60
Table 5.4	CBR Interpretation	63
Table 5.5	Projected Project Outcomes	67
Table 5.6	Wild Cane Harvesting Activities	69
Table 5.7	Fixed Inputs	74
Table 5.8	Sensitivities	74
Table 5.9	Base Scenario Inputs	75
Table 5.10	Base Scenario Summary Data	76
Table 5.11	Base Scenario Outputs	78
Table 6.1	Discount Rate Scenario inputs	81
Table 6.2	Discount Rate Scenario 1 Outputs	82
Table 6.3	Financial Indicators for Discount Rate Scenario 1	83
Table 6.4	Discount Rate Scenario 2 Outputs	84
Table 6.5	Financial Indicators for Discount Rate Scenario 2	85
Table 6.6	Selling Price Scenario Inputs	86
Table 6.7	Selling Price Scenario 3 Outputs	87
Table 6.8	Financial Indicators for Selling Price Scenario 3	88
Table 6.9	Selling Price Scenario 4 Outputs	89
Table 6.10	Financial Indicators for Selling Price Scenario 4	90
Table 6.11	Purchasing Price Scenario Inputs	91
Table 6.12	Purchasing Price Scenario 5 Outputs	92
Table 6.13	Financial Indicators for Purchasing Price Scenario 5	93
Table 6.14	Purchasing Price Scenario 6 Outputs	94
Table 6.15	Financial Indicators for Purchasing Price Scenario 6	95
Table 7:1	Comparison of options	101-103

## List of Figures

<b>Figures</b>	<b>Description</b>	<b>Page</b>
Figure 2.1	Energy Sources Contribution	15
Figure 2.2	Energy Capacity By Source	17
Figure 2.3	Belize Energy Generation and Purchases for 2018 by KWh	19
Figure 2.4:	Belize Energy Purchases for 2018 by Percentage	17
Figure 2.5	Belize Energy Consumption by sector	21
Figure 4.1	BEL Revenues	34
Figure 4.2	Purchase and Sales Tariffs	35
Figure 4.3	BEL Gross Profits	35
Figure 4.4:	BELCOGEN Annual Revenues	37
Figure 4.5:	BELCOGEN Gross Profits	38
Figure 5.1	Stakeholder Mapping	49
Figure 5.2	Percentage changes in Primary Industries	59
Figure 5.3	Percentage changes in Secondary Industries	59
Figure 5.4	Base Scenario Feasibility Performance	78
Figure 6.1	Discount Rate Scenario Output 1	83
Figure 6.2	Discount Rate Scenario Output 2	85
Figure 6.3	Selling Price Scenario Output 3	88
Figure 6.4	Selling Price Scenario Output 4	90
Figure 6.5	Purchasing Price Scenario Output 5	93
Figure 6.6	Purchasing Price Scenario Output 6	95
Figure 8.1	Project Schedule	105

# Final Feasibility Study Arundo Donax

---

## **1.0 Introduction**

### **1.1 Background**

The Caribbean region is faced with several threats stemming from changing climatic conditions. As a result, combinations of mitigation and adaptation interventions are necessary to cope and advance their Sustainable Development Goals (SDG) as set by the United Nations General Assembly in 2015 for the year 2030 (UN, 2015). The SDGs are part of Resolution 70/1 of the United Nations General Assembly, the 2030 Agenda.

Given the challenges of climate change and the vulnerability of several developing states across the globe, the Green Climate Fund (GCF) was established by the 194 countries who are signatories to the United Nations Framework Convention on Climate Change (UNFCCC) in 2010. The GCF is a global facility designed to respond to climate change needs by financing projects which target low-emission and climate-resilient development. Its scope includes: 1) mitigation projects which seek to limit or reduce greenhouse gas (GHG) emissions and 2) adaptation projects which seek to cope with the impacts of climate change. Particular attention is focused on the Least Developed Countries (LDCs), Small Island Developing States (SIDS), and African States.

A significant investment of financial and other resources is required to fund the work that is necessary. Unfortunately, the CARICOM Member States already struggle with their individual economic challenges which are often exacerbated by the current climate change challenges and as assessed in the 5Cs report, are unlikely to be able to do the financing (CCCCC, 2012). Traditional modalities formerly used with the Caribbean Development Bank (CDB) and other Multilateral Development Banks (MDBs) were deemed inappropriate for the required project

## Final Feasibility Study Arundo Donax

---

frameworks. This makes the GCF both an attractive and a relevant option for the Caribbean region.

The GCF provides grants, loans, equity or guarantees towards the implementation of qualifying projects and programmes. It does not implement projects directly but rather, works through Accredited Entities (AE) which meet the standards of the Fund. AEs execute various activities including the development of funding proposals, management and monitoring of projects.

With CARICOM's approval in 2002, the Caribbean Community Climate Change Centre (CCCCC, 5Cs) became fully functional in 2004. It has now also become a registered AE for the GCF. Its mandate is to coordinate the region's response to climate change. The 5Cs early work has laid the framework for successful projects utilizing the GCF. A key programme was the implementation of the Special Programme on Adaptation to Climate Change (SPACC) which aided in the development and implementation of pilot projects aimed at developing resilience and mitigating the negative effects of climate variability and change. It included:

- 1) The installation of a Saltwater Reverse Osmosis (SWRO) System, using a renewable energy source on the Island of Bequia in Saint Vincent and the Grenadines
- 2) A Strengthened Critical Infrastructure in the form of the Marchand Community Centre and Hurricane Shelter in Castries, Saint Lucia
- 3) A Public-Private Partnership arrangement that saw the construction of a Hybrid Rainwater, Sewerage and Irrigation System for Coconut Bay Beach Resort and Spa, in Vieux Fort, Saint Lucia
- 4) The Development and Implementation of Management Plans for The Commonwealth of Dominica's National Parks at the Morne Trois Pitons National Park and Morne Diablotin National Park

## Final Feasibility Study Arundo Donax

---

Additionally, the Centre developed the CARICOM Regional Framework for Achieving Development Resilient to Climate Change (2009 – 2015) and its implementation Plan (2011-2021).

Since CCCCC does not receive any subventions from CARICOM Member states, it relies mainly on international donations to fund its work. This project presents a model whereby 5Cs with the assistance of donors like the GCF, may mobilise the necessary resources to accelerate climate action in Belize through engagement with the private sector. This model would also enhance financial sustainability while encouraging other parties to engage in the implementation of mitigation and adaptation projects in Belize and across the Caribbean.

The 5Cs is now in the process of developing a Funding Proposal for submission to the Green Climate Fund (GCF) seeking financing for investment in a biomass renewable energy project using the grass Arundo Donax in Belize also referred to a “Wild Cane”. This Feasibility Study is required to ascertain the viability of the project so that a decision may be made on a full-scale Funding Proposal for submission to the GCF for consideration. This is consistent with the Government of Belize’s (GoB) objective of expanding the utilization of biomass to meet some of the country’s energy needs and achieve the dual aim of reducing the country’s carbon footprint.

This Feasibility Study will assess the technical, financial and economic viability of this potentially significant source of green energy for Belize. This energy can displace the costlier and more highly polluting imported fossil-based energy, thus lessening the strain on an already heavily burdened national economy and creating greater energy security along with: -

- Mobilising resources for climate action in Belize
- Encouraging farmers to adapt climate resilience technologies to crop cultivation

# Final Feasibility Study Arundo Donax

---

- Stirring interest in biomass projects
- Supporting a fund to finance adaptation and mitigation projects
- Demonstrating a model that can leverage local resources for further climate action
- Building capacity across sectors like energy and agriculture
- Creating a knowledge base for energy production and management

The services of the Consultant have been procured to undertake the referenced Feasibility Study which will assist in the preparation of the Funding Proposal in accordance with the prescribed GCF requirements.

## 1.2 Objectives

The overall objective of the Consultancy is to conduct a Feasibility Analysis of the investment proposal entitled “Arundo Donax Renewable Biomass Fuel for Belize” that will provide the decision makers in Belize, CCCCC and the GCF with enough technical, financial and economic information on proposed project.

The consultancy aims to address or contribute towards: -

- 1) The development of an enabling framework which includes the policies and procedures needed to realise the market, potential PPP models, training for prospective beneficiaries and a potential adaptation and mitigation fund
- 2) The cultivation of Arundo Donax including identifying and quantifying the resources needed to successfully cultivate the plant
- 3) The harvesting and delivery of the Arundo Donax including the resources needed to supply the feedstock to BELCOGEN
- 4) Knowledge Management and Public Awareness



# Final Feasibility Study Arundo Donax

---

## 1.3 Description

Three main consultants will perform the Feasibility Study.

The Technical Consultant will: -

- 1) Look at utilizing the Arundo Donax biomass fuel in an existing Electricity Co-generation plant operated by the Sugar Company and provide recommendations to address possible impacts on the existing system
- 2) Identify the required modifications to the conveyor equipment and anywhere else in the operations in order to be able to integrate the additional fuel stock/source into the existing structure
- 3) Assess the feasibility of this investment initiative from a technical standpoint having regard to the preferred/recommended mechanical system of operation of any facility from which energy generated using Arundo Donax will be used to supply power to the national grid
- 4) If a particular /technical/technological solution has been chosen, describe in detail why it would be the most appropriate for this project/investment
- 5) Provide the Details of the logistics of operationalizing and operating this investment initiative
- 6) Prepare a Detail plan for the project activities, technologies involved, design specifications, required resources (institutional and human), timing/phasing and estimated costs

The Financial and Economic Consultants will: -

- 1) Analyze the financial and economic feasibility of the project/investment from the standpoint of GCF's investment criteria
- 2) Perform a detailed assessment of the potential sustainability of the investment/project after donor funds are exhausted. This should include the development of integrated financial and economic models that include projections covering the period from financial closing through final maturity of the proposed GCF financing with detailed assumptions and rationale

## Final Feasibility Study Arundo Donax

---

- 3) Identify all financial, economic, social and environmental costs and benefits associated with project and as much as possible assign monetary value
- 4) Detail possible PPP investment options for the long-term sustainability of the investment.
- 5) The Financial and Economic Models must be in an Excel spreadsheet and/or other appropriate/suitable media/programme. The model must also:
  - allows for modification of assumptions and performance of sensitivity analysis (e.g. separate sheet on assumption and questions of attribution);
  - explicitly describe how the attribution to the project has been modelled;
  - provide succinct explanation of the underlying assumptions that is easy to understand by non-expert third party
  - contain at least calculations of the internal rate of return, net present value and discounted and nominal cost-benefit relations and other management ratios considered as relevant in this context
  - For presentation purposes, charts, graphs and tables should be included.
- 6) Baseline information, interpretation and critical evaluation of the findings from the model must be presented in 20-page report (not including appendices) and an executive summary (maximum 2 pages). The report must:
  - Include a brief description of the project.
  - Contain baseline information about the energy, financial and labour markets, the economy and other relevant information.
  - Describe the model, assumptions and methodology(ies)
  - Provide reasonable, explanations concerning estimations & findings
  - Make recommendations as necessary, to ensure- from a financial and economic standpoint the most – viable model or form of the investment
  - Present Details of options for the long-term sustainability of investment, considering the policy, regulatory, cooperation and operational environment, institutional and management environment, demand, supply, financial and economic environment and the environmental and socio-cultural environment

# Final Feasibility Study Arundo Donax

---

- Recommend the next steps and any further actions necessary to secure project financing and implementation and, possibly, draft tender documents for the selection of consultancy services.

## **2.0 Belize Energy Sector**

Belize is an independent Caribbean territory bordered by Mexico in the north, Guatemala to the west and south and the Caribbean Sea to the east. It has an abundance of terrestrial and marine species and a diverse ecosystem. Spanning an area of 22,970 sq. km (8868 sq. miles), Belize had a population of 398,050 in 2018 (SIB, 2019). It is the only English-speaking country in Central America.

### **2.1 Government of Belize**

The Government of Belize has as one of its objectives, the expanded utilization of biomass to contribute to its energy needs and achieve a reduction of its carbon footprint (GoB, 2016). 5Cs is supporting Belize's energy sector by examining the use of the Arundo Donax as biomass fuel in Belize, in accordance with a Memorandum of Understanding (MoU) with the Government of Belize. This is seen as a critical partnership to pursue a common Climate change goal.

Belize sustainable development goals (SDG) to be achieved by the year 2030 are expressed in their intention to realize Belize's biomass potential. This is incorporated in the framework document for Belize's long-term development entitled Horizon 2030 (Barnett 2011). The strategy to generate Green Energy is planned through: -

- Creating institutions with the responsibility for producing a viable energy policy that will support the development of an energy sector that is dynamic, competitive, reliable, effective, affordable and environmentally sustainable with minimum adverse impact on safety, health and the environment

## Final Feasibility Study Arundo Donax

---

- Creating the regulatory framework to improve the efficiency and quality of energy services, implement international standards for services and waste, and monitor the production and supply of services to attain the highest quality and best value for money
- Creating an energy office that will be responsible for promoting investment in and development of renewable energy in the areas of wind, solar, biomass, geo-thermal and hydroelectricity
- Providing incentives for energy saving and for using “green”, cost effective and environmentally sustainable sources of energy such as solar, wind, hydro, biomass and geo-thermal energy
- Providing an energy purchase arrangement for those who have excess energy to sell to the main grid
- Adopting a national transport policy that will address vehicle, marine or aquatic transport and air transport to ensure safety and efficiency with the lowest environmental impact
- Educating the public on various energy sources, their uses, services, safety, danger, cost and any areas that would be deemed useful including laws, amendments, rate changes, latest research and development

### **2.2 The Regulator**

The Public Utility Commission (PUC) in Belize is an autonomous institution governed by the provisions of the PUC Act. Its powers are defined within the PUC Act and may also include additional powers provided by any other law conferred by the parliament of the GoB. The PUC fulfils much of its statutory obligations through Regulations, Bylaws, Orders, Directives or other subsidiary legislation or administrative orders made under the Electricity Act, the Telecommunications Act and the Water and Sewerage Act (PUC, 2018).

The published vision of the PUC is to be “Committed to being a legitimate economic regulator that balances the interests of stakeholders (which includes

# Final Feasibility Study Arundo Donax

---

consumers and utility providers) through the implementation of a best practice approaches to regulation”. Their role in overseeing the energy sector including existing and new implementations is therefore of primary relevance to the proposed project.

## **2.2.1 Regulator’s Role**

The role of the PUC extends beyond the energy sector and covers several other areas including to: -

- Ensure that all reasonable demands for electricity are satisfied
- Promote competition and economy in the generation and supply of electricity and the efficient use of electricity supplied to customers
- Approve and grant licences authorizing any person and grant a Consent for any facility to: -
  - Generate electricity for the purpose of giving a supply or enabling a supply to be so given
  - Transmit electricity for that purpose in that person’s authorized area
  - Supply electricity to any premises in that person’s authorized area
- Ensure that licence-holders conduct their affairs in a manner consistent with applicable government policies, sound utility practice and thereby earn financial returns that are fair and reasonable
- Ensure that every rate demanded by any public utility provider shall be fair and reasonable
- Ensure that every public utility provider shall construct and maintain his property and equipment in such condition as to enable him to provide service to the public in all respects which are safe, adequate, efficient and reasonable
- Actively promote the public interest, economic efficiency, align provider and ratepayers’ interests, replication of competitive outcomes, respect for legitimate expectations
- Make Regulations and By-Laws relating to any subject matter prescribed by Law

# Final Feasibility Study Arundo Donax

---

- Conduct Rate Reviews in accordance with the following principles:
  - Afford a provider an opportunity to recover the reasonable costs of providing service and secure a reasonable rate of return on investment when operating in an efficient manner
  - Reasonably allocates to particular customer-classes, the cost of serving such customers, subject to implementation of rates for the needy
  - Achieve established quality of service standards, or pay the penalties for non-observance or failure to meet such standards
- Collect information and conduct analytics in respect of commercial activities connected with electricity carried on in Belize and the persons by whom they are carried on with
- Must first give Notice to and invite Comments from any person who may be interested or affected by such Order, Decision or Directive. In the case of Regulations and By-laws, the Commission must genuinely consult with affected persons
- May investigate and hear a Complaint from any person in respect of rates, or the service or facilities of any provider are unsafe, inadequate, or unreasonable, or unreasonably discriminatory, or the alleged breach, of any law which the Commission has jurisdiction to administer or of any Regulation or Order of the Commission

## **2.2.2 Regulator's Scope**

The PUC functions in four main areas of planning, procurement, dispatch and delivery (PUC, 2018).

### Planning

Planning for new investment is done using demand forecasts rather than through price signals. Belize Electricity Limited (BEL) provides the PUC with forecasts of the generation capacity required over a 20-year horizon. This means that the level

## Final Feasibility Study Arundo Donax

---

of required capacity is administratively determined by the regulator, after consultation with BEL and the Minister with responsibility for Public Utilities.

### Procurement

Procurement for new generation and associated auxiliary services is done through a competitive tender process with private sector participants. The PUC conducts a Request for proposals (RFP) that is technology neutral, for the required capacity determined in the Planning Process. The PUC then requires BEL to sign a Power Purchase Agreements (PPA's) with successful developers. That is, Generators are paid under long term contracts by the single buyer. The PPA's are typically for 15 years but may be extended for the economic life of the generation plant.

### Dispatch

Dispatch of generation is controlled centrally by BEL which distributes all generated electricity having received it from contracted producers. Energy from hydroelectric plants is optimized across wet-dry seasons while variable renewables are taken as produced. Sugar mills have minimum production takes based on the seasonality of their crop; thereafter all other sources are usually dispatched in merit order. There is limited reliance on market interactions across the supply chain, except when BEL trades in Mexico's power pool. There were eight independent power producers (IPP) in 2018, including BELCOGEN which may be increasing its output through the implementation of this project.

### Delivery

Delivery of electricity to end-use customers is through a monopoly franchise which owns the physical infrastructure. All providers of electricity are granted an authorized area; that is a designated area to supply any and all premises in that designation.

# Final Feasibility Study Arundo Donax

---

## 2.2.3 Relevant PPA

All power generated outside of BEL is provided based on a PPA which is developed with the input of the PUC and signed by producer, seller and other relevant parties (Ministry of Environment, Central Bank, PUC, local government). Each PPA is separate and the terms and conditions and tariffs depend on the specific operation.

### BEL-BELCOGEN PPA

The PPA which is most relevant to this project is that which governs the supply of electricity to BEL by BELCOGEN. The key characteristics of this PPA are: -

- 1) BELCOGEN supplies energy from Bagasse fuel
- 2) BELCOGEN supplies additional energy from fossil fuel
- 3) A Committee exists with equal participants from purchaser and seller to address issues of construction, operation, maintenance and interconnection
- 4) The effective tariff is a composite one considering the cost of energy from biomass and the cost of energy from fossil fuel; i.e. a base tariff of US\$0.0728 per KWh, a 2003 tariff of US\$0.0843 per KWh up to December 2017 and US\$0.1034 from January 2018.
- 5) Capacity of 31.5 MW; 27.5 MW Thermal and 4MW HFO
- 6) BELCOGEN to provide BEL with a baseload of 13.5MW
- 7) BELCOGEN to provide 106GWh annually
- 8) BELCOGEN to meet the Belize Sugar Industries (BSI) energy need during the sugar crop season; 9 MW of powers and 135 t/hour of low-pressure steam
- 9) Plant specifications include: -
  - Boiler – 2x90t/hr bagasse and Heavy Fuel Oil (HFO) (64Bar and 485°C)
  - Turbo Alternators –1x12.5MW Backpressure, 1x15MW Extraction/ Condensing



## Final Feasibility Study Arundo Donax

---

- Engine Generators – 2x2MW with medium speed HFO engines
- 10) Power is generated at a nominal 13,800V 60Hz

### Tariff Setting

The PUC has developed rate setting methods which are used to perform all the requisite analysis to arrive at the effective tariff. In summary there are 4 methods to choose from (PUC, 2018).

#### 1) Base rate + Annual escalation

This is the simplest of the 4 methods used in Belize. The “base rate” is normally set to make the first operating year profitable, and each year thereafter this base rate is then escalated using a fixed percentage or a reference index. Thus, in future years as the tariff escalates the profit to the developer gets ever larger on a compounded basis. The base year for the BEL-BELCOGEN PPA was 2001 and set the tariff to \$0.0728. An escalating percentage of 1.5% was used for subsequent years. If also used a reference index for the Fossil fuel-based portion of the composite tariff. This method is no longer being used since the Regulator believes it conflicts with the PUC Act.

#### 2) Rate of return (RoR)

Under a RoR regime, prices are set to recover the producer’s input costs, his depreciated capital and derive a fair rate-of-return on capital investment but not yet expensed. This is probably the most widely used pricing method used by regulators globally; because it provides a business environment conducive to investors’ willingness to replace or expand production assets.

#### 3) Nominal Levelized cost of electricity (Nominal LCoE)

LCoE is the constant unit cost (per kWh) of a payment stream that has the same present value as the total cost of building + a return and operating a generating plant over its economic life based on anticipated operating

# Final Feasibility Study Arundo Donax

---

outcomes. LCoE has become the preferred method for pricing electricity from renewable energy technology (RETs) being deployed by IPP's in Belize.

## 4) Marginal cost (MC) approach

The marginal generator is the last unit within a merit order stack; when dispatch power plants under economic dispatch. In the case of BEL, this is the cost of electricity from the Mexico's wholesale electricity market.

### Tariff Revisions

Any movements in Capital cost, Operating Cost or Financial terms may initiate an application for a change in tariffs. While this project proposes clear changes to BELCOGEN's operations and their BEL relationship, a request from BEL to the PUC to hold any such adjustments for 3 years while the research and development activities are conducted, has been granted. No applications or revisions will become due until 2021. The normal four-year cycle for a full tariff review proceeding was scheduled for July 1<sup>st</sup>, 2020. The Annual tariff review proceeding is also due in July 1<sup>st</sup>, 2019 but this only seek to make any necessary corrections to the previous 2016 full review decisions. This review would not consider any events since June 30<sup>th</sup>, 2016.

## **2.3 Power Supply**

### **2.3.1 Energy Sources and Capacity**

Belize's energy landscape includes multiple technologies while many of the other Caribbean territories depend on a single fossil-based energy source with small contributions from solar thermal and wind. In addition to Belize, Suriname and Dominica are two notable exceptions by way of significant hydropower. Belize's

## Final Feasibility Study Arundo Donax

---

mix of technologies presents several options to the country for expansion. They are: -

- Fossil Fuels
- Hydro
- Photo Voltaic (PV)
- Biomass

Table 2.1 and Figure 2.1 below show the in-country installed capacity by type of energy source in 2018 (PUC, 2019).

## Final Feasibility Study Arundo Donax

Types of Energy Sources	Net Rated Capacity (MW)	Contribution (%)
Fossil Fuel Plants	55.58	36.20%
Variable Renewables (VRE)	0.48	0.31%
Hydro-electric Plants	54.00	35.16%
Biomass-fired Power Plants	43.50	28.33%
<b>Total</b>	<b>153.56</b>	<b>100.00%</b>

Table 2.1: Capacity by Energy Sources

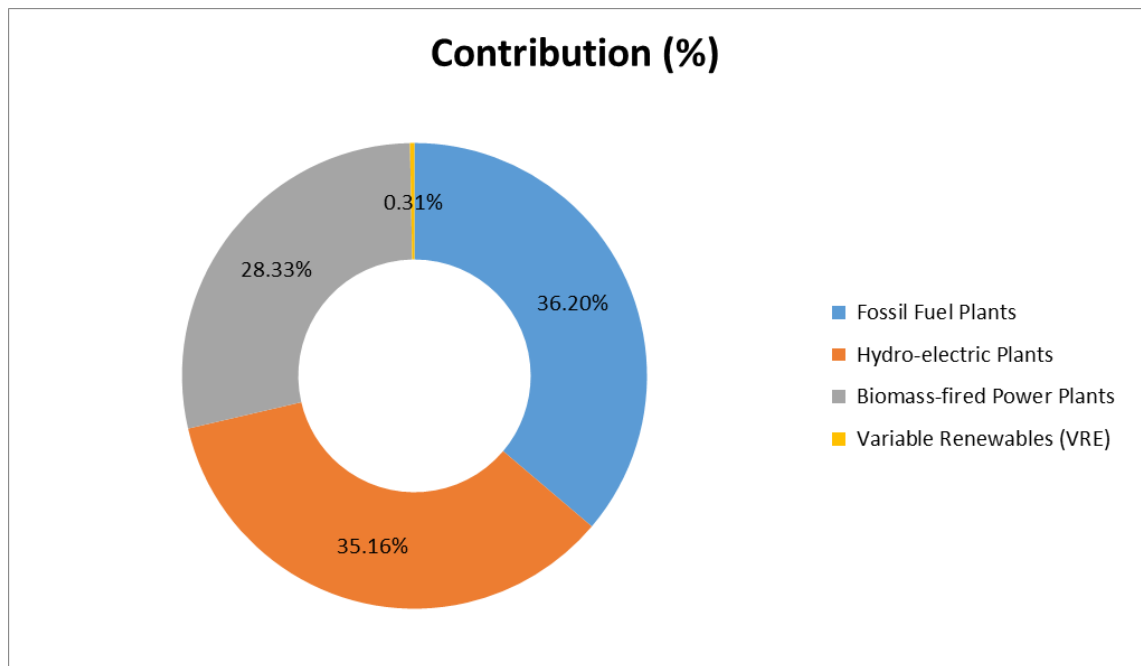


Figure 2.1: Energy Sources Contribution

# Final Feasibility Study Arundo Donax

## 2.3.2 Energy Generators and Capacity

The energy capacity in Belize is owned by a number of potential suppliers which vary significantly in size. These are shown below.

- Belize Electricity Limited (BEL)
- Blair Athol Power Company Limited (BAPCOL)
- Farmers Light Plant (FLPC)
- Belize Electric Company Limited (BECOL)
- Hydro Maya Limited (HML)
- Belize Co-generation Energy Limited (BELCOGEN)
- Santander Sugar Energy Limited (SSEL)
- University of Belize (UB)

Table 2.2 and Figure 2.2 below show the in-country installed capacity by energy supplier.

Local Energy Generators	Net Rated Capacity (MW)	Contribution (%)
Belize Electricity Limited (BEL)	25.38	16.53%
Blair Athol Power Company Limited (BAPCOL)	22.50	14.65%
Farmers Light Plant (FLPC)	7.70	5.01%
Belize Electric Company Limited (BECOL)	51.40	33.47%
Hydro Maya Limited (HML)	2.60	1.69%
Belize Co-generation Energy Limited (BELCOGEN)	27.50	17.91%
Santander Sugar Energy Limited (SSEL)	16.00	10.42%
University of Belize (UB)	0.48	0.31%
<b>Total</b>	<b>153.56</b>	<b>100.00%</b>

Table 2.2: Capacity by Energy Generator

# Final Feasibility Study Arundo Donax

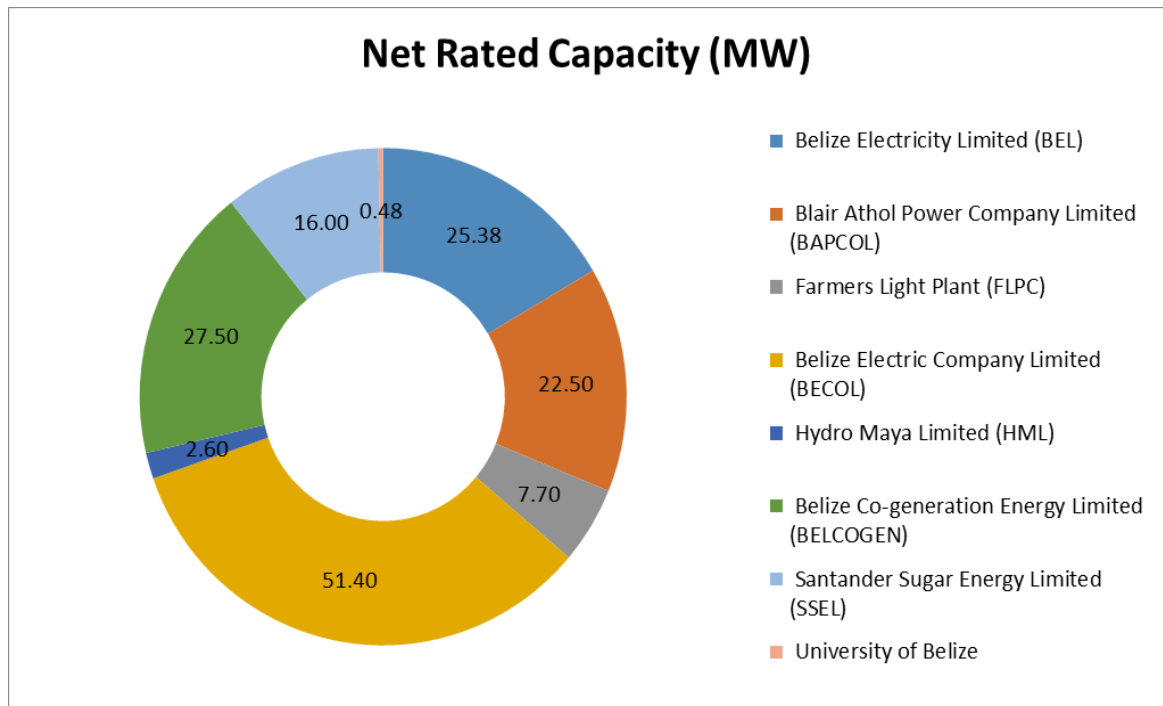


Figure 2.2: Energy Capacity by Source

## 2.3.3 Total Generation

The energy generators listed in table 2.2 (except UB) dispatched their electricity to BEL in accordance with their PPA. The electricity generated from their generation infrastructure is shown below. It is important to note a few key points.

- 1) BELCOGEN has two turbines and a portion of their generated energy is used for internal purposes
- 2) SSEL has a single Back-pressure steam turbine and a portion of its generated energy is used for internal purposes
- 3) Farmers Light Plant did not supply BEL in 2018
- 4) Comision Federal de Electricidad (CFE) supplies electricity generated in Mexico

## Final Feasibility Study Arundo Donax

---

The electricity generated and received by BEL for distribution is shown in Table 2.3 below for the last 3 years. The annual generated electricity from inside Belize for the last year (April 1, 2018 to March 31, 2019) was approximately 425,685 MWh as reported by PUC. There was also approximately 235,155 MWh purchased from Mexico bringing the supply for this period to 660,840 MWh for the year ending March 31, 2019.

The PUC reported generated energy for the last three calendar years. BEL also reported their 2018 purchases for 2018. See table 2.3 and figure 2.3 below.

Energy Suppliers	2018 BEL Purchase MWh	2018 Generated MWh	2017 Generated MWh	2016 Generated MWh
BEL	16,848	17,043	15,903	14,731
BAPCOL	37,051	37,051	19,436	17,497
FLPC	0	17,120	16,906	16,407
BECOL	232,480	232,480	267,650	247,012
HML	15,131	17,158	14,509	13,491
BELCOGEN	71,897	103,410	99,930	115,102
SSEL	21,937	31,670	27,229	0
UB	593	593	41	0
CFE	235,155	235,100	230,138	243,433
<b>Total</b>	<b>631,092</b>	<b>691,626</b>	<b>691,742</b>	<b>667,674</b>

Table 2.3: Belize Energy Generation

## Final Feasibility Study Arundo Donax

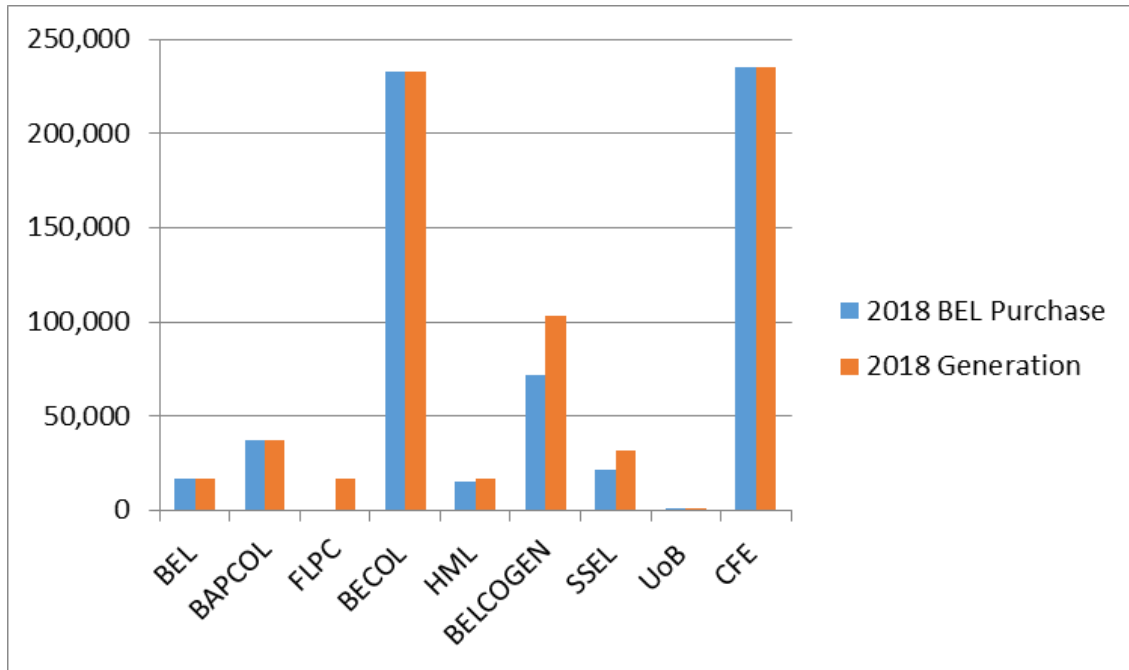


Figure 2.3: Belize Energy Generation and Purchases for 2018 by KWh

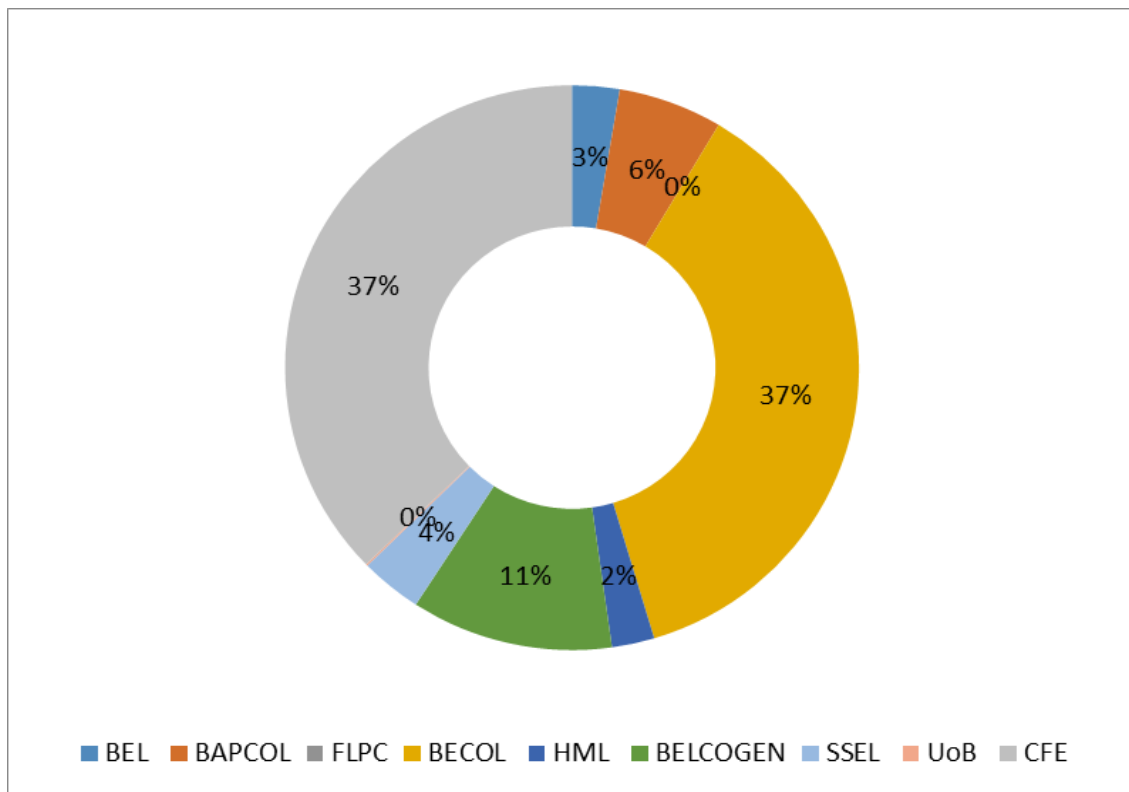


Figure 2.4: Belize Energy Purchases for 2018 by Percentage



## Final Feasibility Study Arundo Donax

---

The generated electricity reported in 2018 is 60,534 MWh more than that purchased by BEL in the same year. This is due to internal use by generators and possible losses; 31,513 MWh related to BELCOGEN, 9,733 MWh related to SSEL and 17,120 MWh related to FLPC and 2,167 MWh in losses.

### **2.3.4 Importation**

Belize also imports energy from Comision Federal de Electricidad (CFE) in Mexico with which it shares a border. Even though this electricity is generated outside of Belize, it is still responsible for CO<sub>2</sub> emissions into the atmosphere. Despite Mexico's expected growth in demand over the coming years, energy use in Mexico is still relatively low. Electricity use per capita is 30%; below the average for International Energy Agency (IEA) countries. This creates an export opportunity for Mexico across future years but does not guarantee long term security for importing countries such as Belize.

Mexico's energy mix is predominated fossil based (oil and gas), with oil accounting for around 50% of its energy generation. Its power generation from renewables is projected to increase significantly from its wind and solar resources. Since 2000 reductions in coal and gas imports (2%) has avoided over 12 MT CO<sub>2</sub>-equivalent in emissions in the residential sector and passenger transport. They record about 450 Mt CO<sub>2</sub> equivalent in emissions overall from fossil fuel consumption (IEA, 2018). Energy from this regime would therefore be a primary target for substitution in the Belize energy source mix. This position is further supported by a 37.7% increase in the per KWh cost in 2018 contributing to BEL's reported losses that year (BEL, 2019).

### **2.4 Energy Demand**

The BEL annual report reported a Peak demand of 104.2 MW and system losses of 11.9%. This consumption for the past 3 years is shown in table 2.4 and figure

## Final Feasibility Study Arundo Donax

2.5 below (BEL, 2019). The customer's mean electricity rate for 2018 was US\$0.1940 per KWh and the cost was US\$0.1515 per KWh.

Consuming Sectors	2018 Consumption MWh	2017 Consumption MWh	2016 Consumption MWh
Residential	218,657	209,181	199,843
Commercial	305,601	302,506	297,220
Industrial	61,953	74,693	68,577
Street Lighting	24,896	26,168	26,653
<b>Total</b>	<b>611,107</b>	<b>612,548</b>	<b>592,293</b>

Table 2.4: Belize Energy Consumption

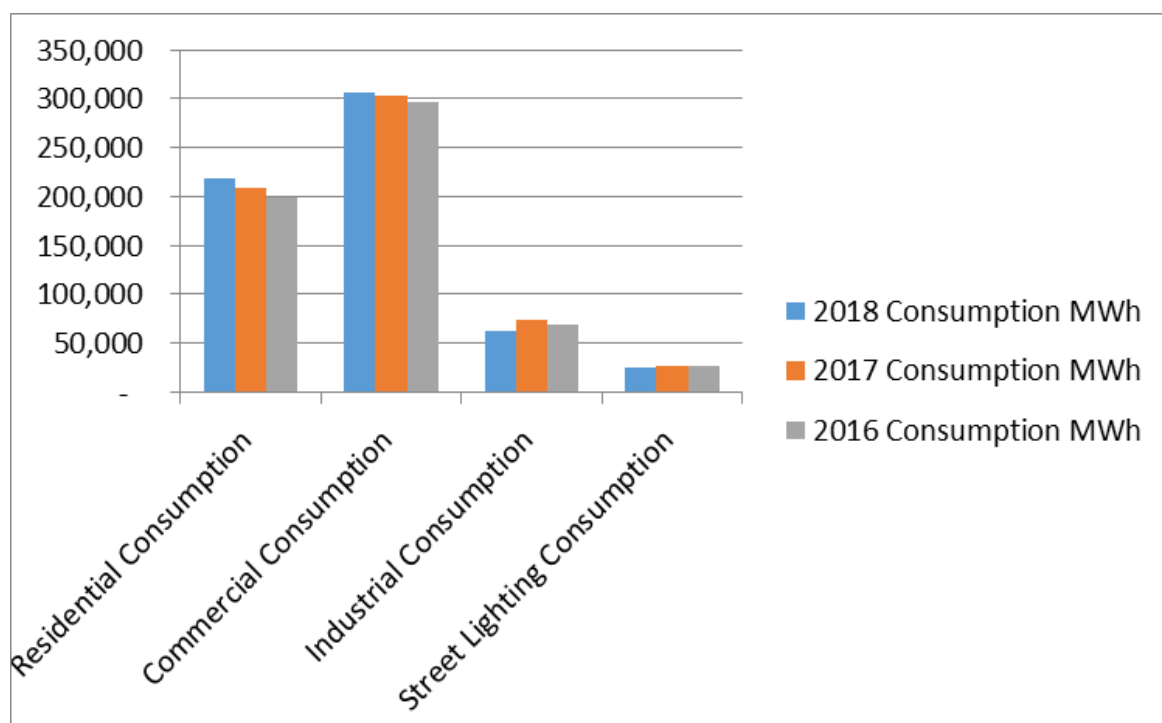


Figure 2.5: Belize Energy Consumption by sector

# Final Feasibility Study Arundo Donax

## 2.5 Forecast

### 2.5.1 Supply

BEL has no plan to increase their generation capacity in the immediate future in order to match customer demand. However, this project focuses on increasing generation at the BELCOGEN plant. With a local capacity of 153.56 MW and actual generation of 456,525 MWh in 2018, there would appear to be significant unused capacity. The generation capacity in Belize only needs to be in production 34% of the time to deliver what is required for the country. This number is artificial (24x365) because of the varying technologies and practical circumstances. See table 2.5 below for 2018.

Types of Energy Sources	Theoretical Annual Generation (MWh)	2018 Annual Generation (MWh)	Capacity Utilization (%)
Fossil Fuel Plants	486,907	71,214	14.63%
Hydro-electric Plants	473,040	249,638	52.77%
Variable Renewables (VRE)	4,205	592	14.09%
Biomass-fired Power Plants	381,060	135,080	35.45%
<b>Total</b>	<b>1,345,212</b>	<b>456,525</b>	<b>33.94%</b>

Table 2.5: Belize Capacity Utilization

#### Fossil Fuels

The fossil fuel technology contributes the most (36.2%) to the Belize demand for electricity. The electricity produced is however far less (14.63%) than the installed capability can deliver. Unfortunately, based on global and national strategies, there is no desire to pursue an increase in generation from fossil fuel sources because of the related emission and potential unpredictable costs of imported fuel oils. This opportunity therefore does not align with national plans and would not be a recommended path.

#### Hydro

Hydropower is the second largest contributor to the Belize demand (35.16%). It however utilizes a good 52.77% of its capacity. While an increase in generation

## Final Feasibility Study Arundo Donax

---

would be ideal given its clean nature, its supply is dictated by the seasonality connected to the rivers flow. Increasing electricity generation via this technology is therefore not an easy path to pursue.

### Photo Voltaic

The PV capacity in Belize is small (0.48MW) and can contribute less than a fraction of a percent to the local demand. UB did not sell to BEL in 2018. An increase in generation would require an increase in installed capacity since its supply is dictated by the sunlight received during a day.

### Biomass

Biomass technologies contribute 28.3% of the electricity required in Belize. It utilises 35.45% of its capacity with significant room for improvement. Specifically, BELCOGEN generates 43% of their current capability. Since their plant produces clean energy (net-zero CO<sub>2</sub> emissions) (Mendoza, 2018), it would be in line with Belize's development strategy to pursue an increase in production from their existing 2 turbines. The extent to which this is possible will depend on the supply of biomass, its compatibility with the existing boilers and the availability of investment among other technical factors.

Additional electricity generated by BELCOGEN may be used to substitute for fossil-based electricity, imported electricity or more expensive electricity. The feasibility analysis will explore these options. The same rationale may be applied to any similar future expansion at SSEL.

### **2.5.2 Consumption**

The electric company BEL expects the growth in demand for the next three years (2020-2022) to remain constant around 3.3%. However, the existing supply is expected to comfortably meet the forecasted demand. Realistically, the consumption in any growing economy is expected to grow. However, the Ministry

# Final Feasibility Study Arundo Donax

---

responsible for energy is working towards reducing electricity consumption in the residential sector by restricting the importation of inefficient household appliances into Belize. This should result in a lower national net consumption growth rate.

## **2.6 Emissions**

Belize is a signatory to the Kyoto Protocol having ratified it in 2003. The National Designated Authority (NDA) of Belize is in the Ministry of Economic Development and Petroleum. Like several countries around the globe, Belize faces challenges in attaining their goals and meeting the target set out in their National Determined Contribution (NDC).

As detailed above, the grid is managed by BEL. BEL receives energy from multiple sources and types. Of the 631GWh generated in 2018, 46% was mostly fossil based and 54% renewable. As indicated in section 2.3.4 Mexico contributes a portion of this electricity which comes from a combination of energy source types. The Mexican supply is characterized by an emissions factor of 0.8890 tons per KWh. A UNEP report on Belize (Carqueija, 2013) supports the position that countries like Belize with high percentages of RE in their energy mix and low grid emission factor, do not propose projects which are prime candidates on the carbon financing market like the Clean Development Mechanism (CDM). This is just one type and source of funding and this assessment does not mean that the project is unattractive to other funders. Any effort to reduce emissions is still a valid mitigation intervention and remains attractive to the GCF. Displacing high emission electricity from the main grid and replacing it with electricity from RE sources reduces the overall country's GHG emissions.

From approximately 122,876 tons of CO<sub>2</sub> in 2011 when 64% of generated electricity was renewable, Belize generated over 200,000 tons of CO<sub>2</sub> in 2018 with 54% renewables. Even though consumption is rising, efforts to reduce emissions are still very achievable.

### **3.0 Technical Feasibility**

#### **3.1 Current Situation**

This section describes and quantifies the current operational condition and potential performance while operating BELCOGEN on bagasse only.

##### **3.1.1 Generation Capacity**

The BELCOGEN Power station facility's main plant items consist of the following:

- Two 90 T/H 64 Bar 485°C Water tube Biomass Boilers,
- One 12.5 MW 64 Bar Passout Turbo Alternator
- One 15MW 64 Bar Passout / Condensing Turbo Alternator
- Complete Boiler Feed Water Plant
- Two 2MW HFO engines (not operational)
- Rest of plant and auxiliaries.

It's worth noting that while both boilers have their HFO burners, they are fully decommissioned.

The overall condition of the plant, except for the Electro Static Precipitator (ESP) plant, was reported and found to be in good condition with only normal maintenance being required. These are required today and not because of the proposed Arundo Donax addition. ESPs remove particulate matter and do not impact CO<sub>2</sub> emissions.

##### **3.1.2 Technology and Configuration**

The BELCOGEN power station utilises technology standards widely used in similar steam plant operating throughout the world, where high pressure steam (HP) raised in the water tube biomass boilers is expanded in the steam turbines. During the crushing season the exhausts from both turbo alternator's (TA) are feed to BSI

## Final Feasibility Study Arundo Donax

---

as process steam with the condensed steam returned back to BELCOGEN. During the Out-of-Crop period, only the Condensing TA is run with all steam being condensed.

The geared motive force of the turbines drives high voltage alternators directly coupled in parallel at 13kV 60Hz and evacuated to the national grid.

### **3.1.3 Technical Limitations/Challenges**

The BELCOGEN plant is sized and configured to match both the process steam and power requirements of BSI during the crushing season, and to maximize the stored biomass generating potential during the out-of-crop period. Both on and off crop scenarios have been simulated in an Energy and Mass Balance (EMB) simulation. The output from the EMB model is used to establish a Base Case model and has been included in Appendix C.

Although the plant is operating well overall and within specifications, the areas where a few challenges exist(ed) include:

- Achieving the required emission standards in the Electro Static Precipitator
- Upgrading and replacing the original plant control and instrument hardware
- The operational and maintenance cost to run the HFO engines have necessitated they be decommissioned
- Inefficient steaming rates due to turndown ratios of the boilers in the off-crop period

There is a 10% maximum limitation recommended for the blending ratio of wild cane biomass to bagasse. Although the production of larger amounts of wild cane would create a greater opportunity, the 10% limit was reported by the BELCOGEN boiler inspector. Above this 10% blend, ash fusion complications may create a significant risk to the integrity of current boiler steaming components. Additional potential for wild cane is presented in section 5.7.

# Final Feasibility Study Arundo Donax

---

## 3.1.4 Current Processing and Logistics

Bagasse is currently transferred during the crushing season from BSI's mill to the power station by conveyor belt. Reclaimed bagasse can be added from the storage stockpile to the bagasse line prior to the first boiler take off conveyor. Both boilers are fed from this conveyor with the surplus bagasse being sent to the bagasse store and stockpiled for long term storage.

While the mill is crushing at 310TC/H during the season, 88.5T/H bagasse is produced with 67T/H being burnt as fuel to produce 145T/H steam. By the end of the crushing season, the mill would have stored 54 800 T of bagasse. During the off-crop period, the stockpiled bagasse is recovered as fuel and consumed at 28T/H generating 61T/H HP steam for 12 weeks.

The bagasse in the stockpile is moved and reclaimed by means of a Front-End Loader (FEL). Reclaimed bagasse is feed into a bagasse hopper which in turn rateably feeds the reclaim conveyor to the boiler feed conveyor.

## 3.1.5 Outputs

The output from the Base Case EMB model burning only bagasse is included in Appendix C and summarized as follows.

### Processing

- 36 weeks crushing session
- 310 tons cane per hour
- An Operational Time Efficiency (OTE) of 94.5%
- Final mill Bagasse moisture 47%
- Process steam on cane 45%
- 65 Bar Ab
- 485 C



## Final Feasibility Study Arundo Donax

---

### Biomass Outputs

- |                          |              |
|--------------------------|--------------|
| ▪ Total Bagasse produced | 382,300 Tons |
| ▪ Bagasse Stock piled    | 54,800 Tons  |
| ▪ Total Bagasse/ year    | 437,100 Tons |
| ▪ Wild Cane/year         | 0 Tons       |

### Energy Outputs

- |                               |        |
|-------------------------------|--------|
| ▪ Power generation in crop    | 23 MW  |
| ▪ Power generation off crop   | 14 MW  |
| ▪ Potential On crop energy    | 68 GWh |
| ▪ Potential Off crop energy   | 23 GWh |
| ▪ Total Energy Potential/year | 91 GWh |

### **3.2 Assumptions:**

In compiling this conceptual design, the following general assumptions were made.

- The topography of the Wild Cane fields allows for mechanized slashing and harvesting. Lands as far as 40 Km from BELCOGEN may be considered.
- The shredder and daily stockpile of shredded biomass will be placed in the existing stockpile area near the bagasse
- A new shredder is located on BELCOGEN's property but not owned by them. An electrical shredder is selected instead of a diesel one. See justification in Appendix D.
- The 150kW AC electrical shredder is powered from the internal boiler main control centre (MCC)
- Once compressed the stockpile is reasonably waterproof
- The bagasse circulation conveyors will circulate bagasse continuously
- Burning the blend is in line with information provided by the mill at the site visit
- The wild cane bagasse blending ratio does not exceed 10%
- The cut wild cane will be left in the field to dry off to 55% moisture

## Final Feasibility Study Arundo Donax

---

- Wild cane biomass is only delivered during the 8-hour daytime shift at 20T/H
- The ESP and supporting kit are installed but not included in our costing

### **3.3 Proposed Changes with Costs**


The following section describes and quantifies the new operational condition and potential performance while fuelling BELCOGEN on bagasse together with additional wild cane using a 10% blend. In compiling a new conceptual design, consideration is given to the following salient features.

- Utilising existing plant and machinery
- Optimizing the existing plant to limit the requirement for additional capital
- Enhancing the power generation period
- Utilising the maximum additional wild cane fuel potential

#### **3.3.1 Capacity Changes**

There is enough existing plant capacity installed to explore the additional cogenerating potential of the additional biomass. The planned increase in annual generation energy output will come from the additional wild cane biomass blended into the bagasse stream. Bagasse will continue to be stored at the end of the crushing season to be blended to produce additional power during the off-crop period. The combine capacity is summarised below in table 3.1.

# Final Feasibility Study Arundo Donax



Base Case Crop	68.24 GWh
Off Crop Base Case	22.85 GWh
<b>Total</b>	<b>91.09 GWh</b>

Wild cane Crop	79.18 GWh
Wild cane Offcrop	23.68 GWh
<b>Total</b>	<b>102.87 GWh</b>

Wild Cane difference	11.78 GWh
<b>Total Wild Cane / year</b>	<b>42533 t/y</b>

Additional fuel generating potential

Table 3.1: Energy output from blended biomass

## 3.3.2 Technology Changes

The BELCOGEN plant will remain sized and configured to match both the process steam and power requirements of BSI during the crushing season, and to maximize the stored biomass generating potential during the extended off crop period. The new steaming and power generation operating conditions for both the season and off crop has been simulated in an EMB simulation. The output from the EMB model is used to establish the new model and has been included in Appendix C.

## 3.3.3 Operating Environment/Configuration Changes

To achieving the required emission standards, it is also recommended that the ESPs are replaced with a wet fuel gas scrubber and smuts handling system as

## Final Feasibility Study Arundo Donax

---

shown in Appendix B. This is a no regret decision for BELCOGEN and should be considered even if the proposed project does not proceed.

### **3.3.4 Process and Logistics Changes**

#### Processing of Wild Cane

Receiving and blending the wild cane fuel will be an area of focus under the enhanced operating conditions.

- Sun dried biomass will be delivered to a new electrical trash shredder located in the fuel stockpile area behind the boilers
- Biomass is discharged from the shredder onto a small stockpile near the existing bagasse stockpile
- Biomass is fed onto the existing boiler feed conveyor for blending at the correct fuel to bagasse ratio which will vary between the sugar cane on and off season
- After the boilers have taken their required amount of fuel, the surplus blend flows via the bagasse store onto the bagasse stockpile

One (1) additional BELCOGEN resource may be required to work with the blending and loading of biomass onto the conveyer belts.

One (1) additional resource will be required to assist in operation of the shredder at the BELCOGEN plant.

#### Harvesting and Delivery of Wild Cane

A new entity will be setup to handle the wild cane. It will be responsible for cutting, drying, loading and transporting the biomass fuel to BELCOGEN for shredding with its own electrical shredder located there. This facility is described further in the next chapter.

## Final Feasibility Study Arundo Donax

---

Ideally, the wild cane will require lands located with 40km of BELCOGEN. Harvesting and transport will take place 10 months of the year out of the heavy rainfall period at an average rate of 20 T/H during the daytime.

- The wild cane is to be cut with a standard tractor slasher rig and left in the field to dry until the moisture drops to 55%
- After drying the biomass is windrowed and collected by means of a tractor rake/blower rig into one of three small 3-ton infield trailer tractor rigs and driven out of the field. Each trailer doing 7 trips per day on average
- The biomass is loaded into one of two 20-ton high volume road hauling truck trailer rigs and driven to the BELCOGEN plant. Each truck taking 2 hours per trip and does 4 trips per day
- Biomass is delivered to BELCOGEN over their weighbridge, where the mass and moisture are measured before finally offloading onto the shredder infeed table

### Equipment Costs

The harvesting conceptual design envisages the following equipment and manpower required to process the wild cane from the field to the fuel stockpile in addition to an overall facility coordinator (estimated 9 staff in total).

Qty	Equipment	Cost	Staff
1	90kW Tractor and Slasher combination	\$65,000	1
1	90KW Tractor rake and loading blower	\$65,000	1
3	In-field 90kW Hauling Tractor and 5 ton self-tipping trailer	\$220,000	3
2	High volume 20 ton truck trailer sets	\$300,000	2
1	Beast Bandit Heavy Duty shredder 2680XP 150KW model	\$350,000	1*

\* 1 WC-CHD staff located at BELCOGEN

Table 3.2: Equipment cost and staffing needs

## Final Feasibility Study Arundo Donax

---

Tests conducted on a standard heavy-duty trailer-based biomass and tree shredder have confirmed this design is able to prepare the wild cane for suitable blending and combustion with bagasse.

### 3.3.5 Output Changes

The annual output from the new EMB model now burning bagasse and wild cane biomass is included in Appendix C and summarized as follows.

▪ Total Bagasse produced	383,000 Tons
▪ Bagasse Stock piled	55,400 Tons
▪ Wild cane during the crop	34,000 Tons
▪ Wild cane during the Off crop	8,300 Tons
▪ Total Wild cane per annum	42 533 Tons
▪ Power generation in crop	23 MW
▪ Power off crop (17 weeks)	11 MW
▪ Potential in-crop energy for sale	79 GWh
▪ Off crop energy for sale	24 GWh
▪ Total annual energy for sale	103 GWh
▪ Energy used by the new shredder	260 MWh

# Final Feasibility Study Arundo Donax

---

## 4.0 Financial Feasibility

### 4.1 Current Situation

#### 4.1.1 BEL Electricity Financials

BEL supplies the country of Belize with all its electricity. The current revenue for the past 5 years is shown below in Table 4.1 and Figure 4.1 (BEL, 2018).

Year	Revenue (Millions USD)
2014	\$110.85
2015	\$103.01
2016	\$98.50
2017	\$103.61
2018	\$107.57

Table 4.1: BEL Revenues

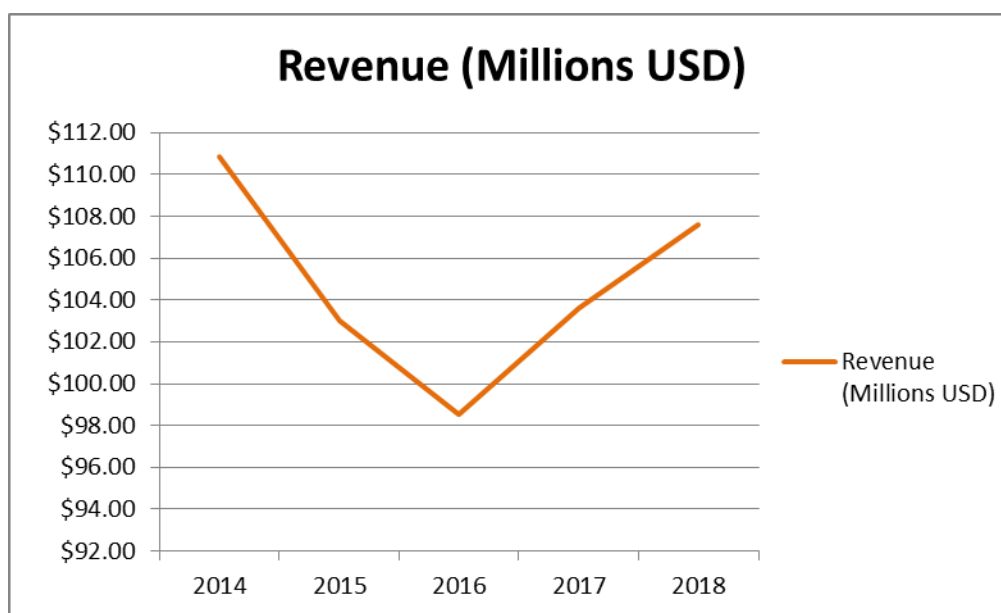


Figure 4.1: BEL Revenues

## Final Feasibility Study Arundo Donax

The fluctuation in the effective selling and purchasing cost per KWh has led to unpredictable gross profits by BEL. Figures 4.2 and 4.3 show the impact.

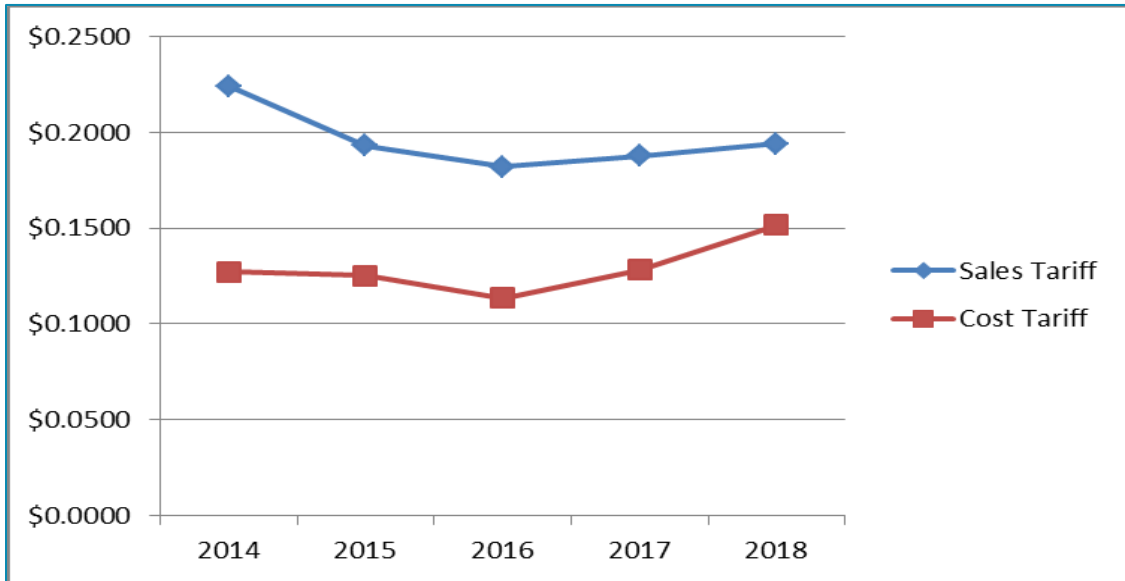
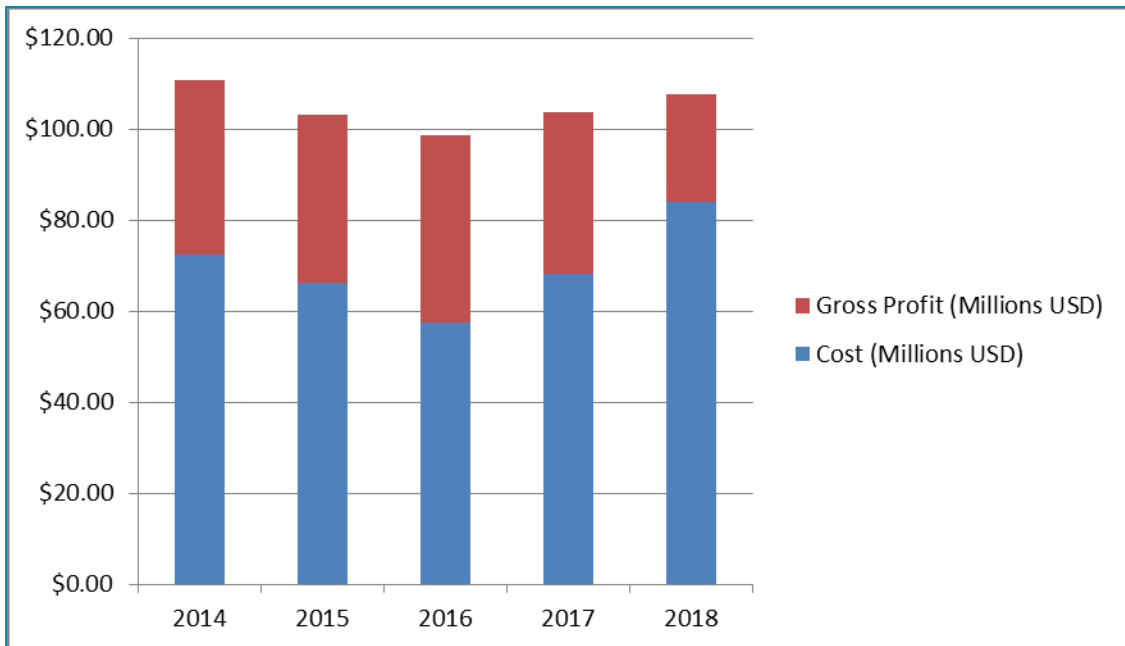


Figure 4.2: Purchase and Sales Tariffs





# Final Feasibility Study Arundo Donax

---

Figure 4.3: BEL Gross Profits

BEL realized a net loss in 2018 due partly to its lowest gross margin in the last 5 years which was led by a 37.7% increase in the per KWh cost of electricity from Mexico in 2018. 17.1% of BEL's energy is purchased from BELCOGEN.

## 4.1.2 BELCOGEN Electricity Financials

BELCOGEN supplies electricity to BEL under a PPA, initially using a composite tariff considering the cost of energy from biomass and fossil fuel. As explained in section 2.2.3 #4, the PPA set a tariff based on the combined use of Fossil fuel and Biomass. Since the fossil fuel generators at BELCOGEN are not functional, the tariff was adjusted by the regulator to be based on biomass only. The tariff has therefore varied unpredictably over the life of BELCOGEN and with some disagreement since BELCOGEN did not report the malfunctions to the regulator at the time. This would have caused an automatic adjustment in the tariff. The current tariff is \$0.1034 effective January 2018. Table 4.2 and Figure 4.4 show the revenues from electricity supplied by BELCOGEN to BEL during 2018.

Month	Revenue (USD)
January	\$439,660
February	\$659,790
March	\$684,650
April	\$790,220
May	\$788,330
June	\$666,680
July	\$717,310
August	\$594,820
September	\$313,200
October	-*
November	-*
December	\$420,630

## Final Feasibility Study Arundo Donax

<b>Annual</b>	<b>\$6,075,290</b>
---------------	--------------------

\* Plant closed for maintenance

Table 4.2: BELCOGEN 2018 Revenues

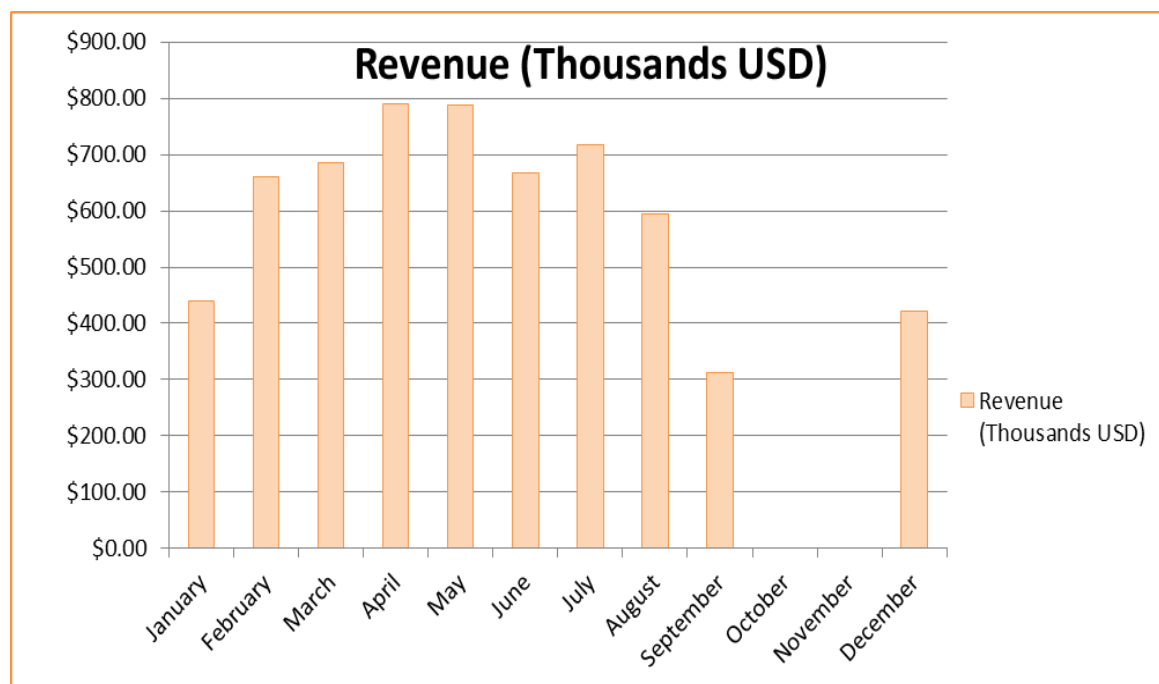


Figure 4.4: BELCOGEN Annual Revenues

The 2018 sugar cane crop provided 887,000 tons of Bagasse which was used by BELCOGEN to generate electricity. The cost of the Bagasse at \$0.50 per ton totalled \$443,500. For the purposes of the calculations, the cost is prorated over the year using the KWh generated. E.g.

Total MWh in 2018 = 71,897

MWh in January = 52.03

January Cost =  $52.03 / 71,897 * \$443,500 = \$32,100$

The gross profit during the 2018 period is shown in Figure 4.5.

## Final Feasibility Study Arundo Donax

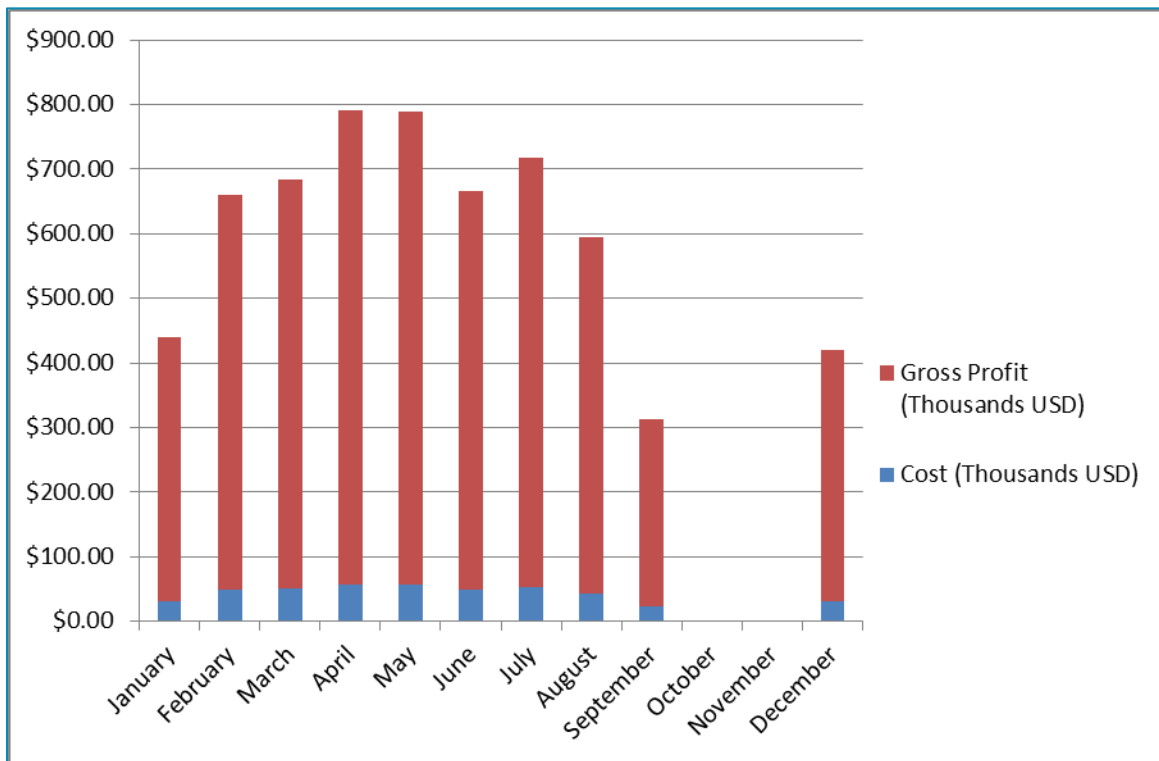


Figure 4.5: BELCOGEN Gross Profits

### 4.1.3 Bagasse Biomass Cost

The cane farmers currently supply BELCOGEN indirectly through ASR-BSI with the bagasse used to fuel their generation. Additional revenues are paid to the farmers for this bi-product which ASR-BSI supplies to BELCOGEN<sup>2</sup>.

## 4.2 Assumptions

The following assumptions were used in generating the financials of this business plan.

<sup>2</sup> Sugarcane farmers are paid \$0.05 per ton of bagasse generated from the processing of their sugarcane crop

# Final Feasibility Study Arundo Donax

---

## 4.2.1 General Assumptions

- Funding will be available from potential investors
- Land will be leased from Government under a long-term lease at no ongoing cost
- Corporate tax rate is 0% (for non-profit institution)
- Social Security and Payroll Tax burden is 5.5%
- Inflation is projected at 1.2% based on the average annual inflation rate as determined by the Central Bank of Belize:
- Capital depreciation expense is based on a 15-year straight line depreciation
- High fibre fuel cane will be available in commercial quantities within two years

## 4.2.2 Specific Assumptions

- A minimum of 1600 acres of marginal land will be available for wild cane production but a total of 2,000 acres is recommended.
- Wild cane yield is expected to be between 20 and 28 tons per acre
- Shredding will be done at 30 ton/hour
- 4,253 tons of wild cane will be harvested and shredded per month for 10 months
- WC-CHD Shredder's energy (260 MWh) cost is billed at the current tariff of \$0.1034
- WC-CHD has an administrative estimated cost of \$850.00 per month for rent & office costs
- Belize average monthly labour rates are as follows:
  - Production Manager US\$ 3,750
  - Operations Supervisor US\$ 1,700
  - Harvester Operator US\$ 1,300
  - Office Assistant/Receptionist US\$ 1,100
  - Labour Grade-1 to 5 US\$ 667 to \$ 1,100
- The project will be managed by 5Cs. As a market maker, over a 2-year period it is expected to engage the services of specialists in the form of consultancies

## Final Feasibility Study Arundo Donax

---

at a cost of US\$250,000 which is included in the required investment total for the overall project and the financial indicators presented in subsequent tables.

### **4.3 Proposed Changes**

All the key stakeholders will experience a measure of change financially due to the proposed project over a 20-year period. In addition to the existing key stakeholders, it is proposed that the operation to cultivate, harvesting, shredding and delivering the wild cane to BELCOGEN, be established as a non-profit entity. This entity (WC-CHD) may be similar to those non-profit organizations governed by the Non-Governmental Organisations Act, Chapter 315 of The Laws of Belize and may be a part of the 5Cs business development section.

The WC-CHD's day-to-day business operations would be handled by 9 new employees. As a non-profit operation, the WC-CHD will be exempt from all income taxes and may apply to the Minister of Finance to also be exempted from other business taxes and duties, including any import duties on the equipment needed for the project. The WC-CHD will keep accounts and other records of its operations to ensure that it conforms to commercial and accounting standards. It is expected that these accounts will be audited annually by an independent auditor selected through a competitive process.

WC-CHD will be furnished with all the required resources and technical support, allowing it to procure the most appropriate technology and make use of the latest advancements in order to provide economic stability and viability to an increasingly complex business. This will also allow for improvements in harvesting efficiency and better management. WC-CHD's small administrative office may be located at a suitable office location, but its operations will be executed in the wild cane fields in the northern region. Transportation of the biomass fuel will be outsourced to a 3<sup>rd</sup> party transportation agency via open tender. Net profits will be used to foster greater adaptation to, and mitigation of, climate change.

# Final Feasibility Study Arundo Donax

---

An Excel model will be used to generate pro-forma financials and run various scenarios. The model is described in chapter 6.0 and sample detailed financials are included in Appendix E. For the 1<sup>st</sup> year of our base scenario, the financial impacts are detailed for each functional area below. The full 20-year statements may be viewed in the Excel model.

## 4.3.1 Distribution (BEL)

### Additional Investment

- None

### Additional Revenues

- None

### Additional Expenses

- Savings due to substituting Mexican energy  
11,520 MWh @ 0.0666 = \$767,232  
(Mexican rate – BELCOGEN rate = \$0.17 - \$0.1034 = \$0.0666)
- Savings on cost to purchase FX = \$34,272  
(0.0175 x \$ 1,958,400)

## 4.3.2 Generation (BELCOGEN)

Retain 44% of new revenues  
Wild Cane Purchasing price of \$15.90 per ton

### Additional Investment

- None

### Additional Revenues

- 11,780 MWh @ \$0.1034 = \$1,218,052

### Additional Expenses

## Final Feasibility Study Arundo Donax

---

- Wild cane fuel 42,533 tons @\$15.90 = \$676,275
- 1 Staff = \$12,000

### 4.3.3 Handling & Delivery (WC-CHD)

Retain 34.86% of energy revenues

Wild Cane Selling price of \$15.90 per ton

Wild Cane Purchasing price of \$6.00 per ton

#### Investment

- Machinery = \$1,000,000 (\$395,000 + \$395,000 + \$210,000)
- Access Road = \$150,000
- Office Furniture/Equipment = \$39,000
- Working Capital Support = \$150,000 (Year 1)
- Project Consultancies over 2 years = \$250,000

#### Revenues

- Wild cane fuel 42,533 tons @\$15.90 = \$676,275

#### Main Expenses

- Wild Cane fuel 42,533 tons @\$6 = \$255,198
- Depreciation = \$72,400
- Outsourced Transportation Services = \$100,440
- Total operating Expense = \$803,510

### 4.3.4 Cultivation (WC-CHD)

Wild Cane Selling price of \$6.00 per ton

Receives 21.14% of the energy revenues

#### Additional Investment

- Supply of 1<sup>st</sup> crop = \$1,469,667

#### Additional Revenues

- Wild Cane fuel 42,533 tons @\$6.00 = \$255,198

# Final Feasibility Study Arundo Donax

## Additional Expenses

- Wild Cane care 42,533 tons @\$1 = \$42,533

### 4.3.5 3<sup>rd</sup> Party Service Providers

RFPs are recommended for 3<sup>rd</sup> party contracts

- Road Works and supply and cultivation of wild cane 1<sup>st</sup> plants
- Transport contract for 10 months - Estimated budget of \$100,440

## 4.4 Financial Outputs

The initial indicators were generated using a base scenario as defined further in section 5.6.

### 4.4.1 Indicators

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	1.27%	14.22%	<b>49.52%</b>
Payback Period (Years)	1.00	1.00	>20	7.03	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	0.14	0.95	<b>3.47</b>
Net Present Value (\$1000)	\$5,281.93	\$3,491.24	(1,366.98)	(\$68.20)	<b>\$7,541.21</b>
Net Cash Flows (\$1000)	\$21,524.39	\$14,227.17	(\$357.51)	\$4,241.45	<b>\$38,885.50</b>

Table 4.3: Financial Indicators for 20-year period



## 4.4.2 Statements

Cultivation Operation – 1<sup>st</sup> Ten Years Income/Expense

<b>Cultivation (WC-CHD) - Income/Expense</b>										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
<b>Revenue:</b>										
Sale of Wild Cane	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198
<b>Total revenue</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>	<b>255,198</b>
<b>Expenses:</b>										
Cultivation Costs	42,533	42,533	42,533	42,533	42,533	42,533	42,533	42,533	42,533	42,533
<b>Total Operating Expenses</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>	<b>42,533</b>
<b>Profit/Loss Before Taxes</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>	<b>212,665</b>
<b>Pre-Tax (%)</b>	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%
<b>Taxation Provision</b>	3,722	3,722	3,722	3,722	3,722	3,722	3,722	3,722	3,722	3,722
<b>Net Profit/Loss</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>	<b>208,943</b>

Table 4.4: Income/Expense Statement – Cultivation Operation – 1<sup>st</sup> 10 years

Handling & Delivery Operation – 1<sup>st</sup> Ten Years Income/Expense

Harvesting & Delivery (WC-CHD) - Income/Expense										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
<b>Revenue:</b>										
Sale of Wild Cane	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275
<b>Total revenue</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>	<b>676,275</b>
<b>Expenses:</b>										
Personnel Cost	105,178	105,178	105,178	105,178	105,178	105,178	105,178	105,178	105,178	105,178
Purchase of Wild Cane (Farmers)	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198	255,198
Harvesting Costs	37,854	37,854	38,309	38,768	39,234	39,704	40,181	40,663	41,151	41,645
Repairs and Maintenance (Equipment)	32,200	32,460	32,850	32,850	32,850	32,850	32,850	32,850	32,850	32,850
Bank Charges	3,941	3,941	4,020	4,100	4,182	4,266	4,351	4,438	4,527	4,618
Utilities	28,666	28,666	28,688	28,709	28,731	28,754	28,776	28,799	28,822	28,845
Software	1,200	1,200	1,260	1,323	1,389	1,459	1,532	1,608	1,689	1,773
Office & Operating Expenses	3,502	3,514	3,556	3,599	3,642	3,686	3,730	3,775	3,820	3,866
Depreciation & Amortization	72,400	72,400	72,400	72,400	72,400	65,000	65,000	65,000	65,000	65,000
Consultancy Fees	125,000	125,000	-	-	-	-	-	-	-	-
Insurance	15,000	15,180	15,332	15,485	15,640	15,796	15,954	16,114	16,275	16,438
Legal Fees	5,500	2,000	2,500	3,083	3,022	2,693	2,910	2,901	2,882	3,029
Accounting, Audit & Professional Fees	6,000	6,000	6,072	6,145	6,219	6,293	6,369	6,445	6,523	6,601
Transportation Costs	100,440	100,440	100,440	101,645	101,645	101,645	102,865	102,865	102,865	104,099
Office Rental	9,350	9,350	9,350	9,350	9,818	9,818	9,818	9,818	10,308	10,308
Other	2,080	2,068	2,151	2,258	2,349	2,443	2,565	2,667	2,774	2,913
<b>Total Operating Expenses</b>	<b>803,510</b>	<b>800,450</b>	<b>677,302</b>	<b>680,092</b>	<b>681,496</b>	<b>674,781</b>	<b>677,275</b>	<b>678,318</b>	<b>679,860</b>	<b>682,359</b>
<b>Profit/Loss Before Taxes</b>	<b>- 127,235</b>	<b>- 124,175</b>	<b>- 1,028</b>	<b>- 3,817</b>	<b>- 5,221</b>	<b>1,493</b>	<b>- 1,000</b>	<b>- 2,043</b>	<b>- 3,586</b>	<b>- 6,084</b>
<b>Pre-Tax (%)</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>
<b>Taxation Provision</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>Net Profit/Loss</b>	<b>- 127,235</b>	<b>- 124,175</b>	<b>- 1,028</b>	<b>- 3,817</b>	<b>- 5,221</b>	<b>1,493</b>	<b>- 1,000</b>	<b>- 2,043</b>	<b>- 3,586</b>	<b>- 6,084</b>

Table 4.5: Income/Expense Statement for Handling & Delivery Operation – 1<sup>st</sup> 10 years

Generation – 1<sup>st</sup> Ten Years Income/Expense

<b>Generation (BELCOGEN) - Income/Expense</b>										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
<b>Revenue:</b>										
Electricity	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052	1,218,052
<b>Total revenue</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>	<b>1,218,052</b>
<b>Expenses:</b>										
Personnel Cost	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Purchase of Wild Cane (WCHC)	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275	676,275
<b>Total Operating Expenses</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>	<b>688,275</b>
<b>Profit/Loss Before Taxes</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>	<b>529,777</b>
<b>Pre-Tax (%)</b>	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%
<b>Taxation Provision</b>	9,271	9,271	9,271	9,271	9,271	9,271	9,271	9,271	9,271	9,271
<b>Net Profit/Loss</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>	<b>520,506</b>

Table 4.6: Income/Expense Statement for Generation – 1<sup>st</sup> 10 years

Distribution – 1<sup>st</sup> Ten Years Income/Expense

<b>Distribution (BEL) - Income/Expense</b>										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
<b>Revenue:</b>										
<b>Total revenue</b>	-	-	-	-	-	-	-	-	-	-
<b>Expenses:</b>										
Electricity Savings (BELCOGEN vs Mexico)	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232	- 767,232
Foreign Exchange savings	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272	- 34,272
<b>Total Operating Expenses</b>	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504	- 801,504
<b>Profit/Loss Before Taxes</b>	801,504	801,504	801,504	801,504	801,504	801,504	801,504	801,504	801,504	801,504
<b>Pre-Tax (%)</b>	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%
<b>Taxation Provision</b>	14,026	14,026	14,026	14,026	14,026	14,026	14,026	14,026	14,026	14,026
<b>Net Profit/Loss</b>	787,478	787,478	787,478	787,478	787,478	787,478	787,478	787,478	787,478	787,478

Table 4.7: Income/Expense Statement for Distribution – 1<sup>st</sup> 10 years

## **5.0 Economic Feasibility**

### **5.1 Stakeholders**

The stakeholders for the proposed project include several groups. Those identifies by the Stakeholder Analysis Report (CCCCC, 2018) are:

- Policymakers and Regulators
- Caribbean Community Climate Change Centre
- Ministry of Public Service, Energy and Public Utilities (MPSEPU)
- The Ministry of Forestry, Fisheries and Sustainable Development, Environment and Climate Change
- ASR -Belize Sugar Industries Group and BELCOGEN
- Belize Electricity Limited
- Sugar Industry Research and Development Institute
- Orange Walk Agricultural Station
- Ministry of Agriculture
- University of Belize
- Cane Farmers and Associations

These were considered and the most important ones selected, and additional stakeholder added to provide an adequate technical, financial and economic picture. Those specifically targeted in the feasibility include: -

- 1) Regulators
- 2) Central Bank of Belize
- 3) Ministry of Economic Development
- 4) Ministry of Public Service, Energy and Public Utilities (MPSEPU)
- 5) Ministry of Agriculture
- 6) Belize Chamber of Commerce
- 7) Beltraide
- 8) Financers/ Green Climate Fund
- 9) Caribbean Community Climate Change Centre

## Final Feasibility Study Arundo Donax

---

- 10) BELCOGEN
- 11) Belize Electricity Limited
- 12) Biomass Cultivators/Associations
- 13) New WC-CHD

Each group plays a specific role in the economic life of the proposed Biomass project. It is also recognized that 5Cs and the WC-CHD operations may be integrated.

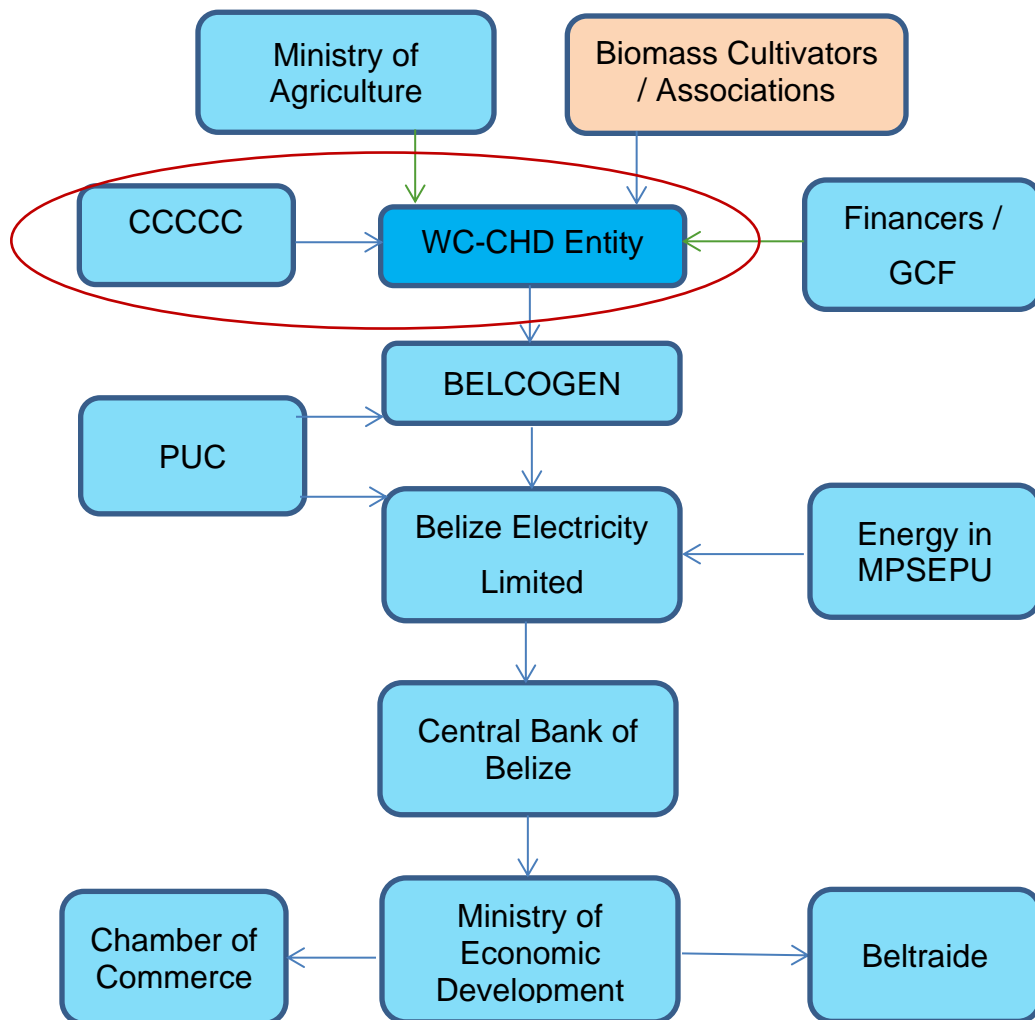


Figure 5.1: Stakeholder Mapping

## **5.1.1 Regulator**

Section 2.2 fully explains the role of the regulator. In summary this institution will enforce government's policy as it relates to the energy sector. As it relates to this project, the Regulator has indicated that subsequent to a request from BEL, a 3-year Research and Development grace period has been initiated and will expire in 2021. After this period, the applicable rates under the BEL-BELCOGEN PPA and the BEL public rates may be reviewed and adjusted if necessary. The tariffs are likely to drop if the cost of energy drops and the financial arrangements for the previous BELCOGEN investments improves.

However, it must be noted that the regulator may provide guidance for wild cane pricing between the stakeholders but is not required to make any recommendation.

## **5.1.2 Central Bank of Belize**

The Central Bank of Belize (CBoB) has amongst its many responsibilities, foreign exchange regulation. Since Belize imported over US\$64 Million in 2018, any potential reduction in this out payment as a result of this project would be of interest. Any other flows of US dollars within Belize between businesses would also attract their attention, including stakeholders.

The bank's outlook of the financial status of the cane farmer industry is one of constant gradual decline and they expect reduced productivity from the sector if the current trend continues.

## **5.1.3 Ministry of Economic Development**

The ministry is concerned with economic activity. Given the scope of the project this ministry is focused on business transactions ranging from consumer energy

## Final Feasibility Study Arundo Donax

---

rates and foreign investment. As a facilitator, the creation of an environment which is attractive to foreign investment is important. The cost of energy is a critical element of doing business in Belize depending on the energy intensity of the operation.

### **5.1.4 Ministry Responsible for Energy**

The Energy Unit is within the Ministry of Public Service, Energy and Public Utilities and has as its mission “To plan, promote and effectively manage the production, delivery and use of energy through Energy Efficiency, Renewable Energy, and Cleaner Production interventions for the sustainable development of Belize”. In its effort to address the energy concerns in Belize, it has plans to embark on some interventions including: -

- 1) Developing financial mechanisms to encourage energy efficiency
- 2) Developing minimum energy performance standards to prevent products with poor performance from being sold in Belize (Regional standards have been accepted for lights, air conditioners and refrigerators through CARICOM Regional Organisation for Standards and Quality (CROSQ) Energy Efficiency programme
- 3) Training and up-skilling energy professionals so that they can deliver energy efficient solutions
- 4) Running pilot and demonstration projects to show the effectiveness of Energy Efficiency
- 5) Implement minimum energy performance standards under the CARICOM Regional Organisation for Standards and Quality (CROSQ) Energy Efficiency programme

With these interventions and normal growth, it is expected that the net energy demand for the next few years will remain the same.

From as early as the 2012 energy plan, a focus was placed on indigenous energy supply and renewable energies (Tillett et al., 2012). Even though there is little



## Final Feasibility Study Arundo Donax

---

reference to Climate Change and its effects, there is clear support for projects of the type being proposed. No targets were set in 2012 but consideration was given in the 2018 NDC development.

### **5.1.5 Ministry of Agriculture**

The Ministry of Agriculture is the primary ministry responsible for the cane industry including farming and processing. ASR BSI is a private enterprise in the North which has the resources and expertise to execute its own operations, unlike the cane farmers, who due to their many challenges depend on this ministry a lot more. The proposed project might well require assistance from this ministry to the farmers, even though the wild cane does not represent a food crop. Farming practices will still be relevant for proper cultivation and harvesting as well as financial management skills.

Additionally, the sustainability of the wild cane business is directly linked to the sugar cane business since the wild cane fuel will be used as a 10% additive to the existing bagasse in order to extend the length of the BELCOGON generation cycle. Considering the Central Bank's outlook, and the 5C's plans for the sector, the ministry's role in ensuring the sustainability of the sector is a critical one. It is critical to at least maintain the current output of the sugar cane sector while seeking to improve productivity and exploring opportunities which support the farmers specifically and in general. The Ministry of Agriculture has also expressed its interest in working with SIRD I in supporting the monitoring of crop management and agronomy on the testing site.

### **5.1.6 Belize Chamber of Commerce**

The Chamber of Commerce is an NGO which represents a group of about 300 member businesses including energy generation companies. They have some

## Final Feasibility Study Arundo Donax

---

experience with private sector partnership investments and would be keen on facilitating any suitable partnerships within Belize. Their historically relationship with the cane farmer has been characterized as challenging but it is felt that the proposed project represents a good investment opportunity for Belize.

### **5.1.7 Beltraide**

Beltraide is Belize's quazi-governmental agency for trade and investment in Belize. They acknowledge the potential benefits of the proposed project but site further investment in the cane farming community as challenging, mostly because of their poor financial management and significant debt. They expect that an improvement in their operations would make it a more attractive investment opportunity. From an investment perspective, it is difficult to separate the historical position of these stakeholders from the proposal being considered.

### **5.1.8 Financers**

The Development Finance Corporation (DFC) is Belize's only Development Bank. They aim to support the strengthening and expansion of Belize's economy by providing financing to individuals, businesses and organizations. Sustainability and environmental acceptance are fundamental to their operations. They secure external financing from larger regional and international lending institutions for lending locally to parties.

Two of the sectors targeted by the bank are Renewable Energy and Agriculture. While the farmers need in the proposed project may touch on both sectors, they do not fit the traditional project profiles. For example, the production of wild cane is not for human consumption and the product does not produce energy directly. Some massaging of any financial request will be necessary.

## Final Feasibility Study Arundo Donax

---

It is felt by the corporation that special payment processes would have to be worked out to secure DFC repayments if they did invest. One credit union shared the same view as reported in the stakeholder analysis report (Mendoza, 2018). The Belize National Bank has indicated that they have no current business in that sector. They may still be invited to invest if private sector investment is pursued.

The GCF also plays a critical role in this sector and their role has already been previously mentioned in the background of this document.

### **5.1.9 Caribbean Community Climate Change Centre**

5Cs has been a champion of the proposed project and is the GCF's agency to bring the final request for funding to the GCF. Besides preparing a successful project, 5Cs hopes that this will be a spotlight project to motivate other companies in Belize and across the CARICOM region to embark on similar Biomass projects. Many of our territories still have relatively significant agricultural sectors and produce waste suitable for feedstock or other unexplored plant matter. They also see the project as one which can bridge the gap between sugar cane seasons thus prolonging the income streams to the farmers and increasing employment.

The Centre has been involved in developing projects which target current concerns like competitiveness of sugar rates, climate change issues and poor management and practices. These included: -

- 1) Financial Management
- 2) Climate proofing to assist over 5200 farmers to produce a more resilient cane against extreme high humidity, rain and high temperatures which facilitate the propagation of the "Frog Hopper" pest
- 3) Assisting cane farmers associations to achieving the Fair-Trade certification of farmers associations under the EU regulations. This serves to protect their status to supply the EU and guarantee a premium price.

## Final Feasibility Study Arundo Donax

---

- 4) Introduction of mechanism to improve harvesting efficiency and protect the land from fire damage
- 5) Education of farmers to address poor farming practices which lead to reduced soil organic carbons. Current yields are not expected to maintain livelihoods due to market prices. Training under this program is limited to production & productivity. Results are expected by year 2 after commencement
- 6) Diversification of product range from the sugar cane plant

5Cs believes that the SIRD I may be utilized to provide capacity building and training support for farmers to address productivity and financial management. Given its northern locale, there are clear synergies between a SIRD I based education program and the proposed cultivation of wild canes by the existing cane farmers in the north. These two independent plans (Wild Cane and Sugar Cane) support each other because the quantity of wild cane required by BELCOGEN will depend on the amount of Bagasse available from crushed sugar cane. As sugar cane production increases, so can wild cane production. If sugar cane production decreases so will the demand for wild cane based on this specific study. However, this relationship can change in the future.

### **5.1.10 BELCOGEN**

BELCOGEN is a fully owned subsidiary of the ASR Group and a sister company to the Belize Sugar Industries (BSI). They share adjoining factory space and operate quite closely. The BSI currently receives and processes canes from the farmers and provide the by-product Bagasse to BELCOGEN to produce energy. The latter has two boilers with the capacity to burn 90t/hr bagasse and Turbo Alternators; One 12.5MW Backpressure and one 15MW Extraction/ Condensing. Their two 2MW generators with medium speed HFO engines are not functional.

## Final Feasibility Study Arundo Donax

---

A portion of the steam produced by the boilers is used by BSI and a portion used to generate electricity for BEL under a PPA.

The proposed project seeks to expand the operations of BELCOGEN by supplying additional feedstock in the form of wild cane. More electricity will be supplied to BEL under the existing PPA at least until 2021 when the R&D grace period expires, and a review is initiated. Unlike the current feedstock which is provided indirectly through BSI arrangement with the cane farmers, the new wild cane feedstock will be provided directly to BELCOGEN by the WC-CHD. All these arrangements and logistics must be agreed.

Based on the technical recommendations, BELCOGEN is expected to receive an additional 10% of feedstock and have a longer generation cycle.

### 5.1.11 Belize Electricity Limited

BEL is one of eight local generators of electricity for the national grid and the only distributor since it owns the transmission network infrastructure. Excluding onsite usage, all generated electricity is sold to BEL for local consumption.

The proposed project would provide BEL with additional electricity and an opportunity to substitute an existing supply with this new supply. Potential substitution criteria would include: -

- Cost
- Source (Indigenous/Imported)
- Emissions

The current PPA tariffs at December 2018 are shown in Table 5.1 below.

Energy Suppliers	Tariff (Cost/KWh)
Belize Electricity Limited (BEL)	\$0.3679

## Final Feasibility Study Arundo Donax

---

Blair Athol Power Company Limited (BAPCOL)	\$0.2408
Belize Electric Company Limited (BECOL)	\$0.1090
Hydro Maya Limited (HML)	\$0.0778
Belize Co-generation Energy Limited (BELCOGEN)	\$0.1034
Santander Sugar Energy Limited (SSEL)	\$0.0870
Comision Federal de Electricidad (CFE)	\$0.1700

Table 5.1: PPA Tariffs

- The most expensive energy purchased is from BEL, BAPCOL and CFE.
- The only imported electricity is from CFE.
- The highest emissions levels are from BEL, BAPCOL and CFE.

Since the additional electricity would be subjected to the BEL-BELCOGEN PPA any change in terms and conditions of this instrument would cause an impact including the applicable tariff and the supplied amounts of energy. Consequently, the tariff to the consumers may also be amended.

### 5.1.12 Biomass Cultivators/Associations

While the project looks at biomass cultivation for future needs, the current cultivators of sugar cane ultimately supplies bagasse biomass to BELCOGEN for energy generation in Belize. This farming community comprise of 5200 farmers with lot sizes which vary from 5 to 10 acres. Farmers in the North supply BSI and those in the southern areas supply Santander Sugar Energy Limited (SSEL). The northern producers indirectly supply the feedstock used by BELCOGEN. Unfortunately, these farmers experience many operational and financial challenges which impact their viability. Besides failing to follow the best practices in the industry, they are also impacted by climate change and decreasing market prices for sugar. Collectively the farmers have accrued a debt of US\$3.65 million across 926 accounts with the DFC. Similar accounts also exist at the main credit union, but the specific details were not available.

# Final Feasibility Study Arundo Donax

---

The proposed project promises to provide labour opportunities for the cultivation community in the North and generate potential resources to fast track adaptation and mitigation in the sugar cane industry. How the project impact farmers will depend on: -

- 1) How profits are mobilized for climate change adaptation and mitigation
- 2) The level of cane farmers involvement in cultivation, harvesting and delivery of wild cane
- 3) The improved adaptive capacity of farmers and the agriculture sector in Belize

The WC-CHD established to cultivate, harvest and deliver the wild cane biomass will deal directly with BELCOGEN on one side and ensure benefits are pass through to the cultivation community/association and the Ministries of Agriculture and Energy on the other hand to support climate change mitigation and adaptation projects.

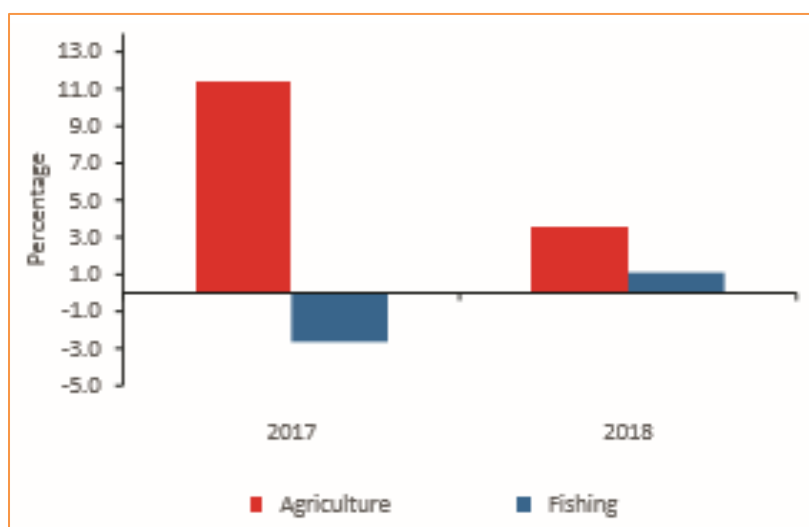
## **5.2 Economy**

### **5.2.1 General Outlook**

Belize has a gross Domestic Product (GDP) of US\$1,925 million in 2018 according to a World Bank report, its highest ever, up from 1,860 in 2017. It is the only Central American country in CARICOM and has proximity to large markets of Mexico and the US and historic trading ties to Europe. Its main economic sectors are tourism, agriculture, forestry, fishing and extraction. It emits 1.401 metric tonnes of CO<sub>2</sub> per capita. According to the CBoB's 2018 annual report, output was driven by higher growth in secondary and tertiary activities, as primary production was slowed by unfavourable weather and crop diseases (CBoB, 2019). Primary production (Agriculture & Fishing) rose by 3.4% in 2018 compared to a 9.8% increase in 2017.

## Final Feasibility Study Arundo Donax

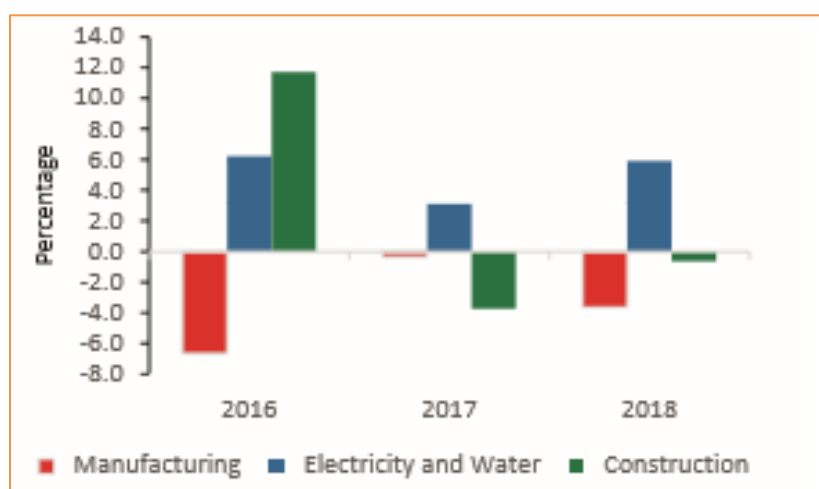
The sectoral growth slowed because of Agriculture which fell to 3.6% from 11.4% in 2017 (SIB, 2019).



Source : SIB

Figure 5.2 – Percentage changes in Primary Industries

Secondary industries had a mere 0.5% expansion. Service industries grew by 3.6% due to a 12.6% growth in stay-over arrivals and 19.1% in cruise ship disembarkations.



Source : SIB

Figure 5.3 – Percentage changes in Secondary Industries



# Final Feasibility Study Arundo Donax

---

# Final Feasibility Study Arundo Donax

## 5.2.2 Employment

Belize experienced an unemployment rate of 9.4% as of April 2018 (SIB, 2019).

Table 5.2 below shows the distribution across the country.

	2016		2017		2018
	April	September	April	September	April
<b>Country Total</b>	<b>8.0</b>	<b>11.1</b>	<b>9.0</b>	<b>9.7</b>	<b>9.4</b>
Male	4.3	6.9	4.8	7.1	5.6
Female	13.6	17.6	15.6	13.6	14.9
<b>Corozal</b>	<b>4.6</b>	<b>10.3</b>	<b>7.6</b>	<b>7.8</b>	<b>5.6</b>
Male	3.5	8.7	3.3	4.3	1.6
Female	6.8	12.9	15.5	13.3	12.0
<b>Orange Walk</b>	<b>7.2</b>	<b>8.4</b>	<b>8.4</b>	<b>12.4</b>	<b>6.8</b>
Male	4.6	3.2	4.6	7.2	3.3
Female	11.9	18.5	15.5	21.9	14.0
<b>Belize</b>	<b>9.6</b>	<b>12.8</b>	<b>10.9</b>	<b>8.0</b>	<b>8.5</b>
Male	3.6	9.2	6.0	7.6	6.6
Female	16.8	17.1	16.8	8.6	10.8
<b>Cayo</b>	<b>8.0</b>	<b>9.9</b>	<b>7.0</b>	<b>13.0</b>	<b>13.6</b>
Male	5.3	5.2	2.8	9.7	7.2
Female	11.9	18.1	14.6	18.2	22.4
<b>Stann Creek</b>	<b>10.6</b>	<b>17.7</b>	<b>13.1</b>	<b>8.7</b>	<b>11.9</b>
Male	6.2	9.5	9.7	6.9	8.4
Female	17.9	29.9	18.8	11.8	18.7
<b>Toledo</b>	<b>3.9</b>	<b>3.4</b>	<b>3.9</b>	<b>6.5</b>	<b>6.8</b>
Male	1.9	2.8	2.3	2.2	4.0
Female	8.0	4.5	7.0	16.2	11.3

Source : SIB

Table 5.2 – Unemployment Rates by District and Gender

Considering that the project will be launched in the north, the two districts which may benefit are Orange Walk and Corozal which have unemployment rates of 6.8% and 5.6%, the two lowest in Belize. Table 5.3 shows the actual distribution.

District	Unemployment	Labour Force	Jobs
<i>Corozal</i>	6.8%	21,770	20,545
Male		13,341	13,124
Female		8,429	7,421
<i>Orange Walk</i>	5.6%	21,115	19,677
Male		14,172	13,709
Female		6,943	5,968
<b>Total</b>			<b>40,222</b>

# Final Feasibility Study Arundo Donax

---

Table 5.3 – Employment in Corozal and Orange Walk

## 5.2.3 Belize Sugarcane Industry

With a record high of 1.7 million long tons, sugarcane deliveries grew by 2.2% driven by a 13.7% expansion in Santander Group which now delivers 25.3%. Santander's sugarcane harvest rose to 0.43 million long tons, more than enough to compensate for the 1.2% decline at BSI which fell by 36,150 long tons to 1.25 million long tons partially due to excessive rains during the first few weeks of harvesting. Additionally, the end of the European Union (EU) sugar production quota system in September 2017 resulted in a 25.2% drop in the average price per long ton of sugarcane to a historic low of \$47.90 for the 2017/2018 crop year (CBoB, 2019).

## 5.3 Cost Benefit Approach Framework

- The required approach to assess the feasibility of the proposed project is the cost benefit approach (CBA). There are different types or methods of analyses conducted under this framework to determine the economic efficiency or feasibility of a project. It is important to note that there are four key operations which may be required to incur costs and accrue benefits and will be subject to this detailed analysis. These are: -Electricity Distribution
- Electricity Generation
- Wild Cane Cultivation
- Wild Cane Harvesting and Delivery

Key indicators will be examined for these operations.

### 5.3.1 Net Present Value (NPV)

The NPV is an indicator which accounts for the time value of money. It provides a method for evaluating and comparing projects with cash flows spread over time, as in loans, investments or another source. It depends on the interval of time between now and the cash flow and the discount rate.

## Final Feasibility Study Arundo Donax

---

$$PV = FV / (1+r)^n$$

Where    PV - Present Value  
            FV - Future Value  
            r    - Interest rate (as a decimal, so 0.10, not 10%)  
            n    - Number of years

The NPV is determined by calculating the costs (-ve cash flows) and benefits (+ve cash flows) for each year of an investment. After the cash flow for each year is calculated, the present value (PV) of each one is achieved by discounting its future value at a periodic rate of return. NPV is the sum of all the discounted future cash flows. This method is a useful tool to determine if a project or investment will result in a net profit or a loss. A positive NPV results in profit, while a negative NPV results in a loss.

In addition to a project NPV, 4 separate NPVs will be created for consideration

### 5.3.2 Cost Benefit Ratio (CBR)

The CBR is an indicator that summarizes the overall value for money of a project or proposal. It is the ratio of the project benefits relative to its costs, both expressed in monetary terms. All benefits and costs should be expressed in discounted present values. It can also be a profitability index in a for-profit context. The rule of thumb is that higher the CBR the better the investment.

$$CBR = B (1 + r)^n / C$$

Where    B - Benefit over project period  
            C - Project Cost over project period  
            n = Number of years for the project duration  
            d - Discount rate

## Final Feasibility Study Arundo Donax

---

CBR < 1	CBR = 1	CBR > 1
In economic terms, the costs exceed the benefits. Solely on this criterion, the project should not proceed. However, other financial and economic indicators will be considered in the final analysis	The benefit matches the cost and the project may be allowed to proceed, but with little viability. A higher value is desirable to achieve good sustainability,	The benefits exceed the costs, and the project should proceed. This could provide a false sense of security. The CBR must be used as a tool in conjunction with other indicators.

Table 5.4: CBR Interpretation

The CBR is relevant for the Handling Facility which is a new operation

### 5.3.3 Incremental Cost Benefit Ratio (ICBR)

The ICBR is an indicator which results from incremental analysis. The process identifies the relevant additional revenues and costs which would result from the project. This method helps to determine the margin by which a project is more beneficial or costly than another the project. It is often used to compare alternative options to help determine which is more feasible.

$$\text{ICBR} = \Delta B / \Delta C$$

Where  $\Delta B$  – Change in benefits for project

$\Delta C$  - Change in costs for project

The ICBR is relevant for existing operations; BEL, BELCOGEN & Farmers

### 5.3.4 Payback Period (PP)

## Final Feasibility Study Arundo Donax

---

The PP is the period elapsed before an investment is recouped. This method helps to determine when the net financial benefit becomes positive. This simple indicator does not consider the life of assets and it may not make provision for forecasted skewed cash flow.

$$PP = I / (B - C)$$

Where I – Project Investment

B – Discounted Benefits from project

C – Discounted Costs from project

### 5.3.5 Internal Rate of Return (IRR)

The Internal rate of return (IRR) is used to estimate the profitability of potential investments. It is a discount rate that makes the NPV of all cash flows from a particular project equal to zero. IRR calculations rely on the same formula as NPV does. It may be used to compare other investments and decide what capital projects should be funded.

$$PV = FV / (1+IRR)^n$$

Where PV - Present Value

FV - Future Value

IRR- Internal rate of return

n - Number of years

### 5.3.6 Other Economic Methodology

After consideration of the various methodologies, particularly for determining the cost and benefit of economic factors, the Benefit Transfer Methodology (BTM) was preferred. The CBA focuses on the monetary expression of costs and benefit. However, this is not always possible due to cost and time constraint. The BTM is

# Final Feasibility Study Arundo Donax

---

used to estimate economic values for ecosystem services by transferring available information from previous studies at other locations and/or contexts. In this case pre-existing information from a similar location or project will be used to value challenging economic factors. The study conducted by 5C's for a number of projects under the SPACC acknowledges the various difficulties and limitations with the CBA approach and other methodologies (Bynoe et. al., 2014).

## 5.4 Economic Impacts

### 5.4.1 Key Stakeholders

*The complexity of this project is such that while it may have an overall feasibility assessment, there are multiple key roles which impact on its successful implementation.*

These key roles are: -

#### Cultivation (WC-CHD)

Investment required for: -

- 1<sup>st</sup> Land Preparation
- 1<sup>st</sup> year planting materials
- 1<sup>st</sup> Cultivation

Reoccurring impacts include: -

- Additional cultivation expenses

#### Harvesting and Delivery (WC-CHD)

Investment required for: -

- Road Construction
- Equipment

Reoccurring impacts include: -

- Staff

## Final Feasibility Study Arundo Donax

---

- Harvesting
- Maintenance
- Shredding
- Operating expenses
- Transportation to BELCOGEN
- Wild cane purchases

### Generation (BELCOGEN)

- Increase in energy production
- Initial increase in revenues subject to PUC revision

Reoccurring impacts include: -

- Staff

### Distribution (BEL)

- Reduction in electricity purchase cost
- Reduction in foreign exchange transaction cost
- Fewer emissions

## **5.4.2 Outcomes**

The feasibility of the proposed project will be linked to the realization of the projected economic, environmental and sustainability outcomes for the different entities in addition to the usual financial indicators. Table 5.5 below presents these 10 potential additional outcomes followed by specific actions which are deemed necessary. Outcomes are not expected to be large but significant in terms of starting trends for future potentially larger projects and contributing to climate change related project implementation.



## Final Feasibility Study Arundo Donax

Type	Outcomes	Expectations
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Regulator to review BELCOGEN-BEL PPA tariff</li> <li>Regulator to review public tariff</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Lower public tariffs for businesses</li> <li>More foreign exchange available to service local requests &amp; repatriation</li> </ul>
Economic	3) Improved farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>Increase revenues for farmers in the northern districts</li> <li>Opportunity to service outstanding debt</li> <li>Capacity to remain viable</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>Additional employment for underemployed farming employees in the northern districts</li> <li>New employee opportunities in the farming industry</li> </ul>
Economic	5) Increased implementation of adaptation and mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors like energy and agriculture</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Training in cultivation best practices for sugarcane</li> <li>Financial trainings</li> <li>CW-CHD able to fulfil its mandate</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>More local biomass fuel</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>Adaptation of climate resilience technologies to crop cultivation</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>Substitution of fossil fuel generation with clean energy</li> </ul>

# Final Feasibility Study Arundo Donax

---

Table 5.5 – Projected Project Outcomes

a) Prices

Economic outcomes 1, 2 & 3 are linked to price setting.

**Biomass Fuel Prices**

The set price for each ton of wild cane sold to BELCOGEN will be critical to the sustainability of the proposed project. The fading commitment of many farmers to the sugar cane industry considering falling yields and prices, threatens the sustainability of the current industry and the proposed new crop. The farmers are already concerned because of the historical payment of US\$0.50 per ton for bagasse. The two products are different and so are the circumstances. BELCOGEN will also require a purchase price that allows them to continue to operate at a comfortable price point for their investors.

Given this business to business transaction and the current regulatory framework the PUC which is often involved in rate setting is not responsible for setting the price of wild cane fuel. This does not exclude them from the process. They may provide guidance and participate in the discussion but cannot propose a rate. The Ministry of Agriculture may also play a similar role.

As part of the necessary negotiations between the cane farmers/associations and BELCOGEN, there are a few pricing methodologies which may be considered; none of which are perfect. They must all consider the initial one-time start-up costs and the operating costs.

- 1) The sugar cane model. As done for the sugar cane, the seller may be paid for each unit of energy produced. However, this approach removes the production risks from BELCOGEN

## Final Feasibility Study Arundo Donax

---

- 2) The cost-based model. The cost for each ton of wild cane is used along with a profit margin to arrive at a selling price product. However, this approach places all the production risks on BELCOGEN.
- 3) The profit-sharing model. The effective unit cost for the 2 stakeholders must be covered by the revenues received under the PPA tariff and the remainder shared appropriately.

### **Electricity Tariffs**

Given that the project proposes to maximize the use of the BELCOGEN investment, no addition capital investment is expected. However, the quantity of energy produced is expected to increase. This could change the way the return on investment has been calculated and potentially lead to a reduced tariff under a revised PPA. It may also result in slightly lower tariffs for the consuming public if more expensive sources of energy are substituted. If the chosen source is imported (CFE) or supplied based on an imported product (fossil fuels), a foreign exchange saving will result, and this can improve the overall investment climate.

### ***b) Employment***

Economic outcome 4 is linked to employment. The WC-CHD will require an estimated 9 full time persons to run it. The entity is expected to outsource the transportation of the wild cane to the BELCOGEN plant to a 3<sup>rd</sup> party who must have at least 4 full-time drivers. 1 additional person may be required at BELCOGEN.

Harvesting & Delivery	Period	Execution
Cutting	10 months of the year	Performed by in-house employees
Loading	10 months of the year	Performed by in-house employees
Transportation	10 months of the year	Outsourced to a 3 <sup>rd</sup> party

## Final Feasibility Study Arundo Donax

---

---

Shredding	10 months of the year	Performed by in-house employee stationed at BELCOGEN
Equipment Maintenance	2 months after production	Performed by in-house employees

Table 5.6 – Wild Cane Harvesting Activities

The WC-CHD will have oversight for the proposed 2,000 acres of land and will work closely with the Ministry of Agriculture and other stakeholders to cultivate, harvest and deliver the wild cane.

c) Production

Sustainability outcomes 6 to 8 are linked to production of fuel and energy in Belize.

### **Farm Productivity**

While the Ministry of Agriculture has indicated their desire to see sugar cane farmers continue to produce at least at their current levels to support the 10:1 blend ratio proposed for BELCOGEN's current infrastructure, the general cultivation of wild cane amongst the wider farming community is a more fundamental issue. The most efficient methods of producing wild cane in the community is beneficial to the overall project aims and objectives.

The farming of wild cane is new to Belize. It is expected that since this is a species of cane, some current sugar cane practices may be applicable both to cultivation and harvesting. Lessons learnt by farmers and the Ministry of Agriculture over the years may be brought to bear in this new endeavour. It is expected that since the plant grows on marginal lands throughout Belize and appears to thrive in the wild without attention, it will perform well with minimum care. The work commenced with SIRD I is expected to provide more conclusive results about the optimal plant density for cultivating the wild cane. Initial results

## Final Feasibility Study Arundo Donax

---

from some work done by CERMES at the University of the West Indies suggests that we can expect a yield of around 28 tons of wild cane per acre.

### **Fuel Substitution**

Fuel substitution is linked to the decision-making process at BEL. It is expected that this process supports Belize's Energy policy which expresses a preference for indigenous energy. Belize being a land of rivers and agriculture has naturally turned to biomass given the limitations of its rivers. The project therefore has the potential for better energy security for Belize.

#### *d) Emissions*

Environmental outcomes 9 and 10 are linked to emissions. This project will result in tons of avoided CO<sub>2</sub> emissions which is a desirable outcome in the context of Belize's national objectives and their UNFCCC NDC international commitments. However, the level of impact on emissions depends on BEL's decision on substitution. BEL, BAPCOL and CFE have the greatest emission levels due to their fossil fuel nature and are candidates for substitution. CFE has the added disadvantage of being foreign. The onboarding of more environmentally friendly farming practices amongst the cultivation community will further support efforts to reduce harmful emissions.

# Final Feasibility Study Arundo Donax

---

## 5.5 Assumptions

### 5.5.1 Economic Assumptions

Within each stakeholder group there is the need to make certain assumptions because not all inputs are fixed or automatic. However, in order to perform the required analysis, inputs must be measured; quantitatively where possible. Some stakeholder roles are supportive and while these roles are important and expected to be forthcoming, they may only be described qualitatively and do not constitute a true quantifiable input for our purposes. The assumptions will therefore focus on the measurable inputs into the analysis process covering the technical, financial and economic assessment.

- 1) The wild cane cultivation process can utilise some employees that are underemployed in the sugar industry. During the off months they can support the cultivation of wild cane. This will be minimal beyond the 1<sup>st</sup> year since the plant does not require significant care.

*Unemployment and underemployment still exist in the northern district. While sugar cane industry employees have pursued other interest to enhance their income, opportunities to be involved in the cultivation of wild cane is likely to be more attractive than the hustle to make ends meet from unpredictable short-term ventures.*

- 2) The industry can find staff to manage and operate the WC-CHD at standard industry costs.

*The implementation of a public awareness and education program should address any stigma associated with farming in the North. This intervention along with others, aimed to address the mounting challenges including climate change, facing the farming community. The campaign should restore some of the appeal and confidence lost in the last decade. e.g.*

## Final Feasibility Study Arundo Donax

---

*different opportunities offered by the WC-CHD should attract the younger generation which has moved away from traditional farming.*

- 3) The Productivity and Financial training being considered by 5Cs and the Ministry of Agriculture should include all potential cultivators of wild cane and be implemented during the early stages of the wild cane project.

*These training opportunities aim to improve farm management overall. They are not yet fully developed and so the implementation dates are unknown. However, they should be implemented before any cultivation is commenced. This will allow for a positive impact to take root at the sugar cane farms and aid in building better resilience while improving the livelihood of the cultivation communities in the North of Belize.*

- 4) The required acres allocation to farmers is agreed with Ministry of Agriculture and farmers based on the total requirement

*In determining land allocation to farmers, the Ministry is expected to consider the current sugar cane production levels along with each farmer's commitment to sustainable cultivation. This latter may be gauged by the potential cultivator's participation in the planned training and progress made towards implementing change.*

- 5) The project has a life cycle of 20 years

# Final Feasibility Study Arundo Donax

## 5.5.2 Fixed Inputs

<b>Cultivation (WC-CHD)</b>	<b>Data</b>
Wild cane blend ratio on bagasse	10%
Wild Cane required	42,533 tons
Field yield based on results from Middlesex (North Stann Creek River)	20-28 tons per Acre (Based on CERMES research-Appendix A)
Investment -Land (Provided by GoB)	2126 Hectares / 1519 Acres (1,600-2,000 Acres recommended)
Investment -Preparation of 1 <sup>st</sup> Crop	US\$1,619,667
<b>Handling and Delivery (WC-CHD)</b>	<b>Data</b>
Employees	Nine (9) employees required for WC-CHD
Investment (Equipment & Roads)	US\$1,589,000
Transportations/Diesel emissions intensity	0.0028 tons CO <sub>2</sub> /Litre of Diesel
<b>Generation (BELCOGEN)</b>	<b>Data</b>
Employees	One (1) employees required for BELCOGEN
Emissions from additional biomass	Emissions neutral
<b>Distribution (BEL)</b>	<b>Data</b>
CFE Imported power emissions intensity	0.889 tons CO <sub>2</sub> /MWh
BEL fuel substitution	CFE
PPA Tariff	US\$0.1034 per KWh

Table 5.7: Fixed Inputs

## 5.5.3 Key Sensitivities

<b>Input Parameter</b>	<b>Range</b>
Discount Rate	5.9% to 15%
Selling Price to BELCOGEN	\$12 to \$18
Purchase Price from Farmers	\$4 to \$8

Table 5.8: Sensitivities

In addition to the base scenario presented below, the model will run additional scenarios based on the sensitivities provided above.



# Final Feasibility Study Arundo Donax

---

## 5.6 Base Scenario

### 5.6.1 Base Scenario Input

The base scenario is one in which the benefits to the key stakeholders must be balance with the benefits and potential benefits to Belize as a whole.

- 1) The cultivation, harvesting and delivery activities of the WC-CHD must be feasible since its excess proceeds will be used to reinvested into various sectors of the Belize economy to promote the implementation of climate change mitigation and adaptation project amongst other beneficial activities. Ideally, its two major functional areas should also show feasibility separately.
  - a) Cultivators must be able to make a good enough profit to allow them to have a better life
  - b) Harvesters and delivery service providers must be able to generate a profit
- 2) The energy generator (BELCOGEN) must be able to make a good enough profit to allow for the acceleration of their payback on previous investment and ultimately a reduced tariff to BEL
- 3) The energy distributor (BEL) must be able to save money with cheaper, cleaner local electricity to accelerate progress towards Belize's NDC targets and offer lower electricity rates to the public
- 4) CBoB must be able to save foreign exchange and create a better investment environment for Ministry of Economic Affairs, Belize Chamber of Commerce and Beltraide to promote

All electricity rate changes are subject to the PUC processes.

Input Parameter	Base Scenario Values
Discount Rate	15%
Selling Price to BELCOGEN	\$15.90
Purchasing Price from Farmers	\$6.00
BELCOGEN PPA Tariff	\$0.1034

Table 5.9: Base Scenario Inputs

# Final Feasibility Study Arundo Donax

## 5.6.2 Base Scenario Outputs

Categories	Annual Result
<b>Cultivation (WC-CHD)</b>	
Additional (Wild Cane) Revenues	42,533 @ \$6 = \$255,198
Additional Cultivation cost	42,533 @ \$1 = \$42,533
Additional Gross Profit	\$ 212,665
<b>Handling and Delivery (WC-CHD)</b>	
Shredded Cane Revenues	42,533 @ \$15.90 = \$676,275
Wild Cane Cost	42,533 @ \$6.0 = \$255,198
Total Operating Expense	\$ 803,510
Gross Profit	(\$127,235)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80
Emissions from Transport – tons of CO <sub>2</sub>	68.43
<b>Generation (BELCOGEN)</b>	
Additional Energy Revenue	11,780MWh @ \$0.1034=\$1,218,052
Additional Shredded Cane Cost	42,533 @ \$15.90 = \$676,275
Total Operating Expense	\$688,275
Additional Gross Profit	\$529,777
Emissions from biomass – tons of CO <sub>2</sub>	0
<b>Distribution (BEL)</b>	
Purchase saving benefit from substitution	11,520 MWh @ (\$0.0666) = \$767,232
Savings on purchasing Foreign Exchange	\$1,958,400 @ 0.0175 =\$34,272
Additional Gross Profit	\$ 801,504
Emissions avoided - tons of CO <sub>2</sub>	11,520 MWh @ 0.889 = 10,241

Table 5.10: Base Scenario Summary Data

## Final Feasibility Study Arundo Donax

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC review</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Improved farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>US\$ \$4,132,598 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) Increased implementation of adaptation and mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors. E.g. energy and agriculture</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD can continue to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>More climate resilience technologies being used in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$ 7.5 Million</li> </ul>
Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	<ul style="list-style-type: none"> <li>3.47</li> </ul>
Financial	13) Payback Period	<ul style="list-style-type: none"> <li>1.93</li> </ul>
Financial	14) Internal Rate of Return	<ul style="list-style-type: none"> <li>49.52%</li> </ul>

## Final Feasibility Study Arundo Donax

Financial	15) Net Cash Flow		• \$39.9 Million		
Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	1.27%	14.22%	<b>49.52%</b>
Payback Period (Years)	1.00	1.00	>20	7.03	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	0.14	0.95	<b>3.47</b>
Net Present Value (\$1000)	\$5,281.93	\$3,491.24	(\$1,366.98)	(\$68.20)	<b>\$7,541.21</b>
Net Cash Flows (\$1000)	\$21,524.39	\$14,227.17	(\$357.51)	\$4,241.45	<b>\$39,885.50</b>

Table 5.11: Base Scenario Outputs

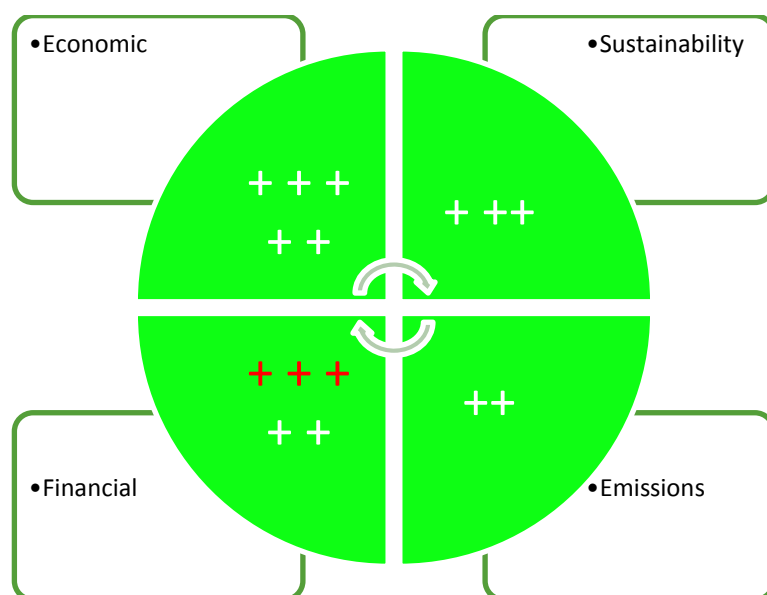


Figure 5.4 – Base Scenario Feasibility Performance

All four areas being green suggest the project is feasible if funded. However, 3 of the 5 financial indicators in section 4.4.1 for WC-CHD (Cultivation and “Harvesting & Delivery”) suggests that this is not a good financial investment for the private sector given the current investment climate in Belize; NPV of -\$1,367K and -\$68.20K, CBR of 0.14 and 0.95 and IRR 1.27% and 14.22% respectively. See financial indicators in table 4.3 for base scenario. This is partly because all the investment occurs at the WC-CHD since BELCOGEN and BEL already has all the

## Final Feasibility Study Arundo Donax

---

required infrastructure and resources necessary to execute the project. The WC-CHD is intentionally fashioned as a non-profit allowing it to channel excess proceeds to a fund established to implement other mitigation and adaptation projects. The independent suppliers from the broader economy who provide services to the CW-CHD will benefit financially.

### **5.7 Future Benefits**

A successful wild cane project would encourage the installation and expansion of biomass fuel production for energy generation in Belize and the wider Caribbean region.

- 1) The SSEL plant in the south could be quite confident in any such future expansion. This would of course further extend the proposed benefits to the electricity consuming public in Belize, BEL and the farmers in the south. This would be a very welcomed project with minimal risk to investors.
- 2) Industrial operations which utilize large volumes of steam in their procession could also be encouraged to make a similar investment given the favourable financial indicators for operators.
- 3) Caribbean territories which already produce some type of biomass product or have an abundance of marginal or unused lands could also see this project as a green light to pursue biomass target to contribute to their NDCs. E.g. Guyana and Suriname
- 4) Notwithstanding the challenges related to the wet season in Belize, and the 10% limiting factor of the BELCOGEN type boilers, there is certainly the possibility of expanding wild cane production. In the current environment this would require a matching increase in the production of sugar cane which provides the 90% bagasse required. Beyond this 10% blend there is the option to install an additional boiler which can withstand the burning conditions of wild cane biomass alone. This would positively impact the current limitation on the amount of wild cane that may be cultivated for biomass fuel in Belize. New

## Final Feasibility Study Arundo Donax

---

investment would be required, but any feasibility study would most likely prove its sustainability given the former investment in BELCOGN and SSEL and this proposed supplemental project.

- 5) This project would support the expanded use of wild cane in energy generation by way of an investment in an additional boiler that can handle up to 100% of that biomass. The capital costs at the energy plant would be about US\$20M and the other stakeholder costs would be about 2\$M.
- 6) The continuous support of mitigation and adaptation projects will allow Belize to accelerate its goals related to sustainability and climate change resilience.

# Final Feasibility Study Arundo Donax

---

## 6.0 Model

### 6.1 Setting up Assumptions

The first sheet in the model allows the user to setup the required inputs including the identified sensitivities. The default values will be what we consider to be the base case scenario.

### 6.2 Interpreting Results

Once values are entered, all the sheets will be automatically recalculated including the individual sheets for the four commercial entities and the final 2 output pages which present summaries. The results will present individual indicators and an overall project indicator. Inputs are varied for the 4 sensitivities and results generated and presented below.

### 6.3 Discount Rate Sensitivity

#### 6.3.1 Discount Rate Scenario Inputs

Based on the justification for the selected discount rate, two other scenarios are relevant and therefore of interest to the study.

Input Parameter - Scenario 1	Selection
Discount Rate	6%
Selling Price to BELCOGEN	\$15.90
Purchasing Price from Farmers	\$6.00
BELCOGEN PPA Tariff	\$0.1034
Input Parameter - Scenario 2	Selection
Discount Rate	10%
Selling Price to BELCOGEN	\$15.90
Purchasing Price from Farmers	\$6.00
BELCOGEN PPA Tariff	\$0.1034

Table 6.1: Discount Rate Scenario Inputs

# Final Feasibility Study Arundo Donax

## 6.3.2 Discount Rate Scenario 1 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC review</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Improved farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>US\$ \$4,132,598 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) Increased implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors. E.g. energy</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD can continue to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>More climate resilience technologies being used in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$ 25,299K</li> </ul>
Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	<ul style="list-style-type: none"> <li>9.27</li> </ul>
Financial	13) Payback Period	<ul style="list-style-type: none"> <li>1.93</li> </ul>



## Final Feasibility Study Arundo Donax

Financial	14) Internal Rate of Return	• 49.53%
Financial	15) Net Cash Flow	• \$ 61,334K

Table 6.2: Discount Rate Scenario 1 Outputs

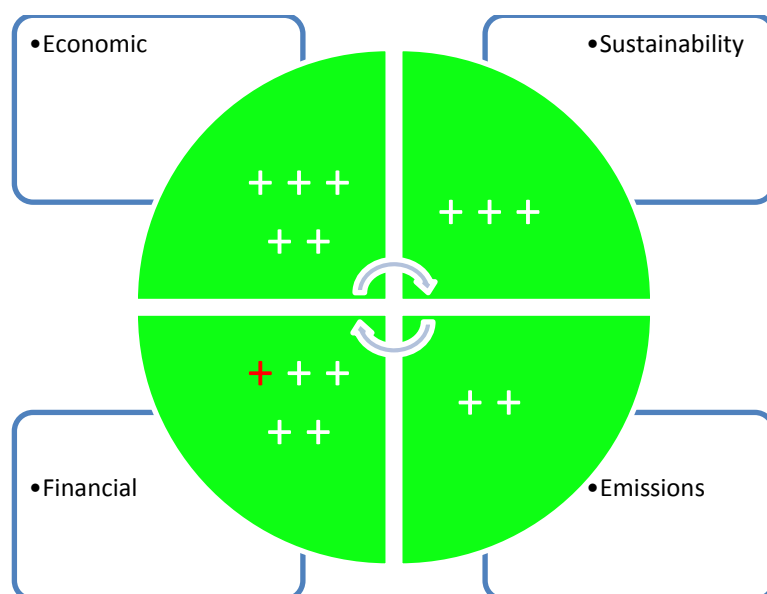


Figure 6.1 – Discount Rate Scenario 1 Feasibility Performance

Under Scenario 1 (6% discount rate), all four areas remain green suggesting that the project is still feasible if funded. Only the unaffected IRRs (1.27% and 14.22%) remain a concern for the 2 operational areas in the WC-CHD. The individual NPVs rise to -\$832K and \$2,300K respectively and the CBRs rise to 0.48 and 2.57. This would be a more conducive investment environment. See table 6.3 below.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	1.27%	14.22%	<b>49.52%</b>
Payback Period (Years)	1.00	1.00	19.75	7.03	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	0.48	2.57	<b>9.27</b>
Net Present Value (000)	\$14,209	\$9,392	(\$832)	\$2,300	<b>\$25,299</b>
Net Cash Flows (000)	\$32,352	\$21,384	\$233	\$7,114	<b>\$61,334</b>

# Final Feasibility Study Arundo Donax

Table 6.3: Financial Indicators for Discount Rate Scenario 1

## 6.3.3 Discount Rate Scenario 2 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC review</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Improved farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>US\$ \$4,132,598 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) Increased implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors. E.g. energy</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD can continue to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>More climate resilience technologies being used in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$ 13,059K</li> </ul>

## Final Feasibility Study Arundo Donax

Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	• 5.27
Financial	13) Payback Period	• 1.93
Financial	14) Internal Rate of Return	• 49.53%
Financial	15) Net Cash Flow	• \$ 46,385K

Table 6.4: Discount Rate Scenario 2 Outputs

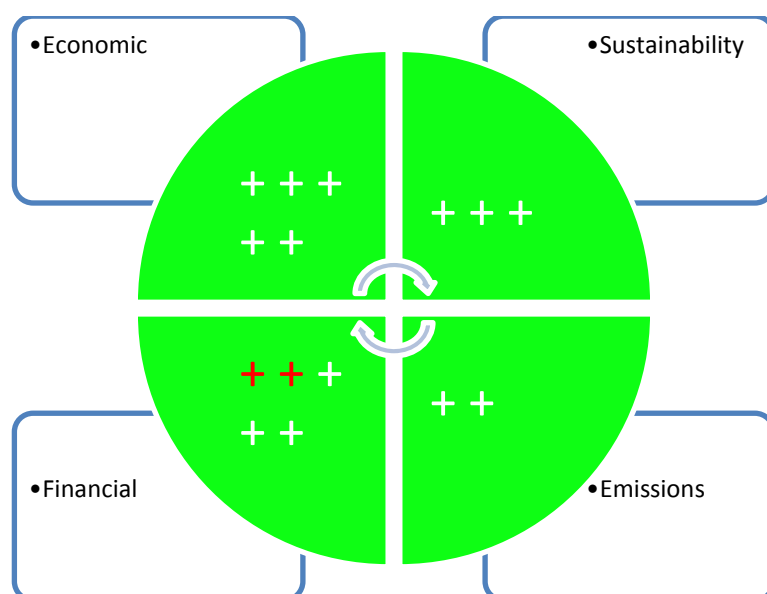


Figure 6.2 – Discount Rate Scenario 2 Feasibility Performance

Under Scenario 2 (10% discount rate), all four areas remain green suggesting that the project is still feasible if funded. The WC-CHD remains an investment concern in this scenario with its 2 operating areas having NPVs of -\$1,195K and \$666 and CBRs of 0.25 and 1.45.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	1.27%	14.22%	<b>49.52%</b>
Payback Period (Years)	1.00	1.00	>20	7.03	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	0.25	1.45	<b>5.27</b>
Net Present Value (000)	\$8,050	\$5,321	(\$1,195)	\$666	<b>\$13,059</b>

## Final Feasibility Study Arundo Donax

Net Cash Flows (000)	\$24,806	\$16,396	(\$178)	\$5,112	<b>\$46,385</b>
----------------------	----------	----------	---------	---------	-----------------

Table 6.5: Financial Indicators for Discount Rate Scenario 2

### 6.4 Selling Price Sensitivity

#### 6.4.1 Selling Price Scenario Inputs

Based on the modelling done for the wild cane selling price (from Cultivators) variations are of interest to the study.

<b>Input Parameter - Scenario 3</b>	<b>Selection</b>
Discount Rate	15%
Selling Price to BELCOGEN	<b>\$12</b>
Purchasing Price from Cultivators	\$6.00
BELCOGEN PPA Tariff	\$0.1034
<b>Input Parameter - Scenario 4</b>	<b>Selection</b>
Discount Rate	15%
Wild Cane Selling Price	<b>\$18</b>
Wild Cane Purchase Price	\$6.00
BELCOGEN PPA Tariff	\$0.1034

Table 6.6: Selling Price Scenario Inputs

# Final Feasibility Study Arundo Donax

## 6.4.2 Selling Price Scenario 3 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>• Even cheaper public tariff depending on PUC review</li> <li>• Even cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>• Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>• Improved investment environment</li> </ul>
Economic	3) Improved farming community circumstances in short & long term but unstable WC-CHD operations	<ul style="list-style-type: none"> <li>• Only US\$ \$815,024 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>• 10 new employees</li> <li>• Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) No implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>• No surplus of funds will be available to finance any projects</li> </ul>
Sustainability	6) Limited national engagement on climate change interventions	<ul style="list-style-type: none"> <li>• Little Interest in biomass projects</li> <li>• Model would not adequately support the leveraging of local resources for further climate action</li> <li>• Capacity across sectors. E.g. energy</li> <li>• A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>• Farmer training should be completed</li> <li>• WC-CHD is unable to fulfil its mandate</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>• Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>• Limited encouragement to implement climate resilience technologies in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>• 202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>• \$ 7,521K</li> </ul>
Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	<ul style="list-style-type: none"> <li>• 3.46</li> </ul>
Financial	13) Payback Period	<ul style="list-style-type: none"> <li>• 1.93</li> </ul>
Financial	14) Internal Rate of Return	<ul style="list-style-type: none"> <li>• 49.42%</li> </ul>

# Final Feasibility Study Arundo Donax

Financial	15) Net Cash Flow	• \$ 39,806K
-----------	-------------------	--------------

Table 6.7: Selling Price Scenario 3 Outputs

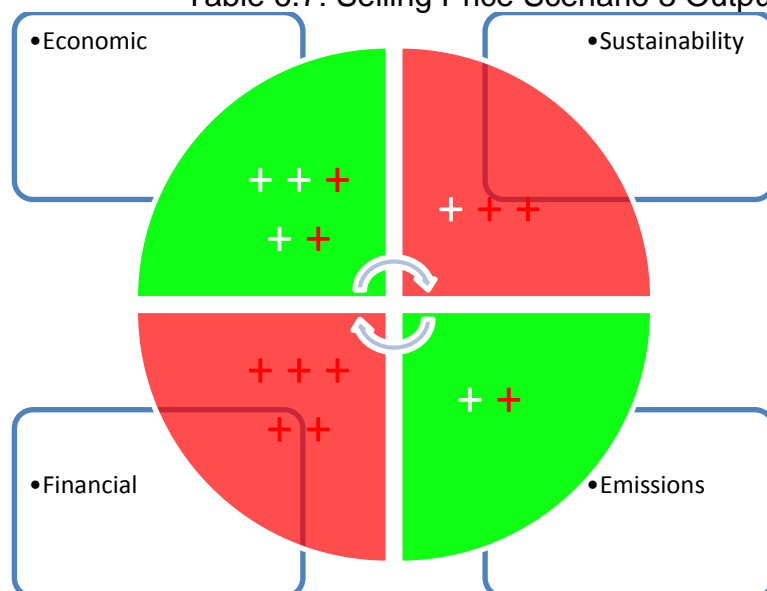


Figure 6.3 – Selling Price Scenario 3 Feasibility Performance

Under Scenario 3 (\$12 per ton), the overall project financial looks feasible but not for the WC-CHD. Most of the indicators for the WC-CHD suggest a failure of that entity which is expected to play a key role in the overall operation. Payback for that entity would not occur within the life of the project and all other indicators are unfavourable. See table 6.8 below.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	-9.17%	14.22%	<b>49.42%</b>
Payback Period (Years)	1.00	1.00	>20	7.03	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	-0.56	0.95	<b>3.46</b>
Net Present Value (000)	\$5,282	\$4,584	(\$2,480)	(\$68.20)	<b>\$7,521</b>
Net Cash Flows (000)	\$21,524	\$18,682	(\$4,892)	\$4,241	<b>\$39,806</b>

Table 6.8: Financial Indicators for Selling Price Scenario 3

The lower selling price effectively lowers the revenue to the WC-CHD and increased the revenue to BELOGEN. This would allow BELCOGEN to recoup its previous investment quicker and trigger the Regulator to drop the PPA tariff to BEL

## Final Feasibility Study Arundo Donax

and potentially result in cheaper public rates. Unfortunately, it places the WC-CHD in a very precarious position economically and this is unsustainable. The project cannot succeed if WC-CHD fails.

### 6.4.3 Selling Price Scenario 4 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC review</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Improved farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>US\$ \$5,918,984 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) Increased implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors. E.g. energy</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD can continue to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>More climate resilience technologies being used in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$7,552K</li> </ul>

## Final Feasibility Study Arundo Donax

Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	• 3.47
Financial	13) Payback Period	• 1.92
Financial	14) Internal Rate of Return	• 49.57%
Financial	15) Net Cash Flow	• \$ 39,928K

Table 6.9: Selling Price Scenario 4 Outputs

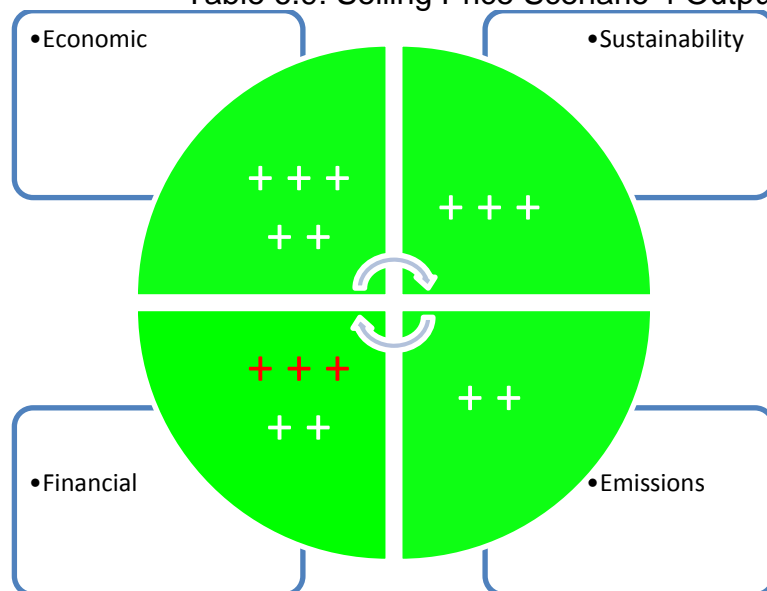


Figure 6.4 – Selling Price Scenario 4 Feasibility Performance

Under Scenario 4 (\$18 per ton), the overall project financials look feasible. However, the IRR, CBR and NPV for the WC-CHD suggesting that it is still not a great financial investment for the private sector given the current investment climate in Belize. See table 6.10 below.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	6.89%	14.22%	<b>49.57%</b>
Payback Period (Years)	1.00	1.00	11.97	7.03	<b>1.92</b>
Benefit/Cost Ratio	>100	>100	0.52	0.95	<b>3.47</b>
Net Present Value (000)	\$5,282	\$2,903	(\$768)	(\$68)	<b>\$7,552</b>
Net Cash Flows (000)	\$21,524	\$11,828	\$2,084	\$4,241	<b>\$39,928</b>

Table 6.10: Financial Indicators for Selling Price Scenario 4

The higher selling price effectively increases the revenue to the WC-CHD and reduces the revenue to BELOGEN. This would still allow BELCOGEN to recoup



## Final Feasibility Study Arundo Donax

---

its previous investment quicker than it does today but not as fast as the base scenario. It may still trigger the Regulator to drop the PPA tariff to BEL and potentially result in cheaper public rates. It could potentially create some push back from BELCOGEN. The WC-CHD would yield a better profit than anticipated, allowing for a greater contribution towards other climate change projects.

### 6.5 Purchasing Price Sensitivity

#### 6.5.1 Purchasing Price Scenario Inputs

Based on the justification for the selected wild cane purchase price, two other scenarios are of interest to the study.

<b>Input Parameter - Scenario 5</b>	<b>Selection</b>
Discount Rate	15%
Wild Cane Selling Price	\$15.90
Wild Cane Purchase Price	\$4.00
BELCOGEN PPA Tariff	\$0.1034
<b>Input Parameter - Scenario 6</b>	<b>Selection</b>
Discount Rate	15%
Wild Cane Selling Price	\$15.90
Wild Cane Purchase Price	\$8.00
BELCOGEN PPA Tariff	\$0.1034

Table 6.11: Discount Rate Scenario Inputs

# Final Feasibility Study Arundo Donax

## 6.5.2 Purchasing Price Scenario 5 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC review</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Smaller improvement in farming community circumstances in short and long term and stable WC-CHD operations	<ul style="list-style-type: none"> <li>US\$ \$4,132,598 in gross profits over 20 years to support the WC-CHD and its cultivation, harvesting and delivery activities</li> </ul>
Economic	4) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	5) Increased implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>Surplus of funds to finance adaptation and mitigation projects</li> </ul>
Sustainability	6) Continuous national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>A model that can leverage local resources for further climate action</li> <li>Capacity across sectors. E.g. energy</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD can continue to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>More climate resilience technologies being used in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20 years</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$ 7,552K</li> </ul>
Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	<ul style="list-style-type: none"> <li>3.476</li> </ul>
Financial	13) Payback Period	<ul style="list-style-type: none"> <li>1.92</li> </ul>
Financial	14) Internal Rate of Return	<ul style="list-style-type: none"> <li>54.57%</li> </ul>

# Final Feasibility Study Arundo Donax

Financial	15) Net Cash Flow	• \$ 39,926K
-----------	-------------------	--------------

Table 6.12: Purchasing Price Scenario 5 Outputs

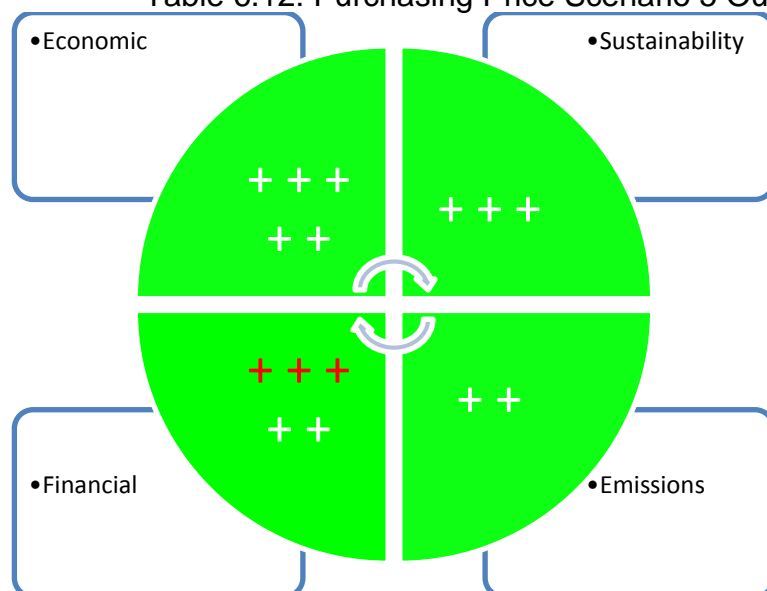


Figure 6.5 – Purchasing Price Scenario 5 Feasibility Performance

Under Scenario 5 (\$4 per ton), the overall project financials look feasible but 3 of the 5 financial indicators for the 2 operating areas in the WC-CHD suggest that this is not a good financial investment for the private sector given the current investment climate in Belize; NPVs of -\$795K and -\$629K, CBRs of 0.50 and 0.57 and IRRs 6.62% and 8.53% respectively. See financial indicators in table 6.13.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	6.62%	8.53%	<b>54.57%</b>
Payback Period (Years)	1.00	1.00	12.28	11.72	<b>1.92</b>
Benefit/Cost Ratio	>100	>100	0.50	0.57	<b>3.47</b>
Net Present Value (000)	\$5,282	\$3,491	(\$796)	(\$629)	<b>\$7,552</b>
Net Cash Flows (000)	\$21,524	\$14,227	\$1,968	\$1,957	<b>\$39,926</b>

Table 6.13: Financial Indicators for Purchasing Price Scenario 5

Again, the WC-CHD having been intentionally fashioned as a non-profit to minimize its benefits, allows a greater contribution to be made towards other

## Final Feasibility Study Arundo Donax

---

climate change projects. The impact on the economy would also encourage other private sector entities to invest in Belize.

### 6.5.3 Purchasing Price Scenario 6 Outputs

Type	Outcomes	Result over 20 years
Economic	1) Cheaper Electricity in medium and long term	<ul style="list-style-type: none"> <li>Cheaper public tariff depending on PUC</li> <li>Cheaper PPA tariff depending on PUC review</li> </ul>
Economic	2) Better Investment Climate in medium and long term	<ul style="list-style-type: none"> <li>Better USD foreign exchange availability over 20 years due to \$16,030,080 savings by BEL</li> <li>Improved investment environment</li> </ul>
Economic	3) Increase Employment in short and long term	<ul style="list-style-type: none"> <li>10 new employees</li> <li>Additional employment for a few underemployed cane farmers</li> </ul>
Economic	4) Greater improved farming community circumstances in short and long term but an unstable WC-CHD operation	<ul style="list-style-type: none"> <li>US \$4,132,598 in gross profits over 20 years to support the WC-CHD and its cultivation harvesting &amp; delivery activities</li> <li>Farmers benefit at the expense of the harvesting and delivery operation</li> </ul>
Economic	5) No implementation of adaptation & mitigation projects	<ul style="list-style-type: none"> <li>No significant surplus of funds will be available to finance projects</li> </ul>
Sustainability	6) Limited national engagement on climate change interventions	<ul style="list-style-type: none"> <li>Interest in biomass projects</li> <li>Model would not adequately support the leveraging of local resources for further climate action</li> <li>Capacity across sectors. E.g. energy</li> <li>A knowledge base for energy production and management</li> </ul>
Sustainability	7) Increased productivity in short and long term	<ul style="list-style-type: none"> <li>Farmer training should be completed</li> <li>WC-CHD is unable to fulfil its mandate to the sector</li> </ul>
Sustainability	8) Improved Energy Security in short and long term	<ul style="list-style-type: none"> <li>Additional biomass fuel provided</li> </ul>
Environment	9) Greater use of green technologies	<ul style="list-style-type: none"> <li>Limited encouragement to implement climate resilience technologies in crop cultivation across sub-sectors</li> </ul>
Environment	10) Reduced National Emissions in short and long term	<ul style="list-style-type: none"> <li>202,441 tons of CO<sub>2</sub> avoided over 20yrs</li> </ul>
Financial	11) Net Present Value	<ul style="list-style-type: none"> <li>\$ 7,531K</li> </ul>

## Final Feasibility Study Arundo Donax

Financial	12) Cost Benefit Ratio or Incremental Cost Benefit Ratio	• 3.46
Financial	13) Payback Period	• 1.93
Financial	14) Internal Rate of Return	• 49.47%
Financial	12) Net Cash Flow	• \$ 39,845K

Table 6.14: Selling Price Scenario 6 Outputs

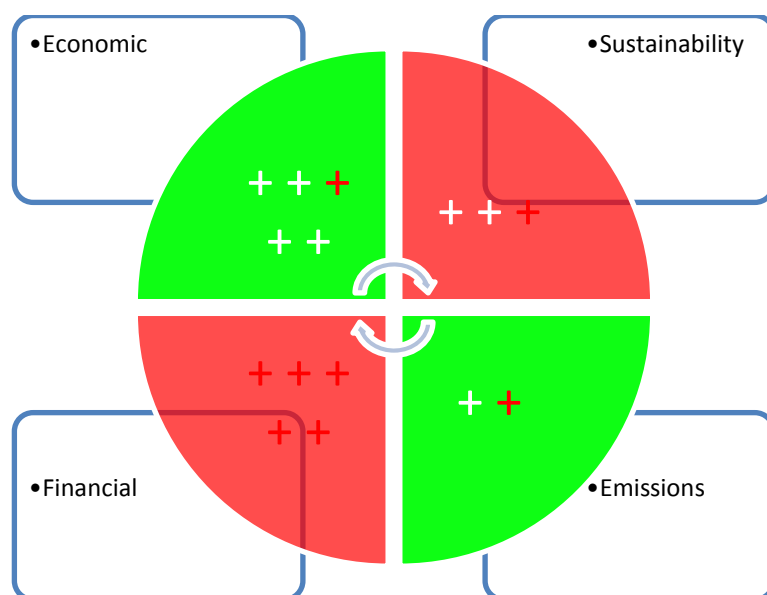


Figure 6.6 – Selling Price Scenario 6 Feasibility Performance

Under Scenario 6 (\$8 per ton), the overall project financials look feasible but all the indicators for WC-CHD suggest a failure of that entity which is expected to play a key role in the overall operation. Payback would not occur within the life of the project and all other financial indicators are unfavourable. See table 6.15 below.

Indicators	Distribution (BEL)	Generation (BELCOGEN)	Handling & Delivery (WC-CHD)	Cultivation (WC-CHD)	Overall Project
Return on Investment	100.00%	100.00%	-4.09%	19.90%	<b>49.47%</b>
Payback Period (Years)	1.00	1.00	>20	5.02	<b>1.93</b>
Benefit/Cost Ratio	>100	>100	-0.22	1.34	<b>3.46</b>
Net Present Value (000)	\$5,282	\$3,491	(\$1,938)	\$492	<b>\$7,532</b>
Net Cash Flows (000)	\$21,524	\$14,227	(\$2,683)	\$6,526	<b>\$39,845</b>

# Final Feasibility Study Arundo Donax

---

Table 6.15: Financial Indicators for Selling Price Scenario 6

The higher purchasing price effectively increases the revenue to the farmers and reduces the revenue to the WC-CHD. This places the WC-CHD in a very precarious position economically and makes its operations unsustainable. The project cannot succeed if the WC-CHD fails.

## **7.0 Investment**

The WC-CHD will function as a non-profit entity much like those governed by the Non-Governmental Organisations Act, Chapter 315 of The Laws of Belize. It could potentially develop a Private-Public-Partnership (PPP) “like” model, in the form of a private-non-profit partnership model of social enterprise providing a mutually beneficial business partnership between a for-profit company and the WC-CHD, a non-profit organization. It would be expected that the for-profit partner may be seeking an attractive rate of return for any investment made in the private-non-profit partnership. In addition to an attractive rate of return, the for-profit partner may also benefit from improved community relations or public image; be enabled to penetrate new markets or increases sales. The for-profit may also consider an investment in the partnership as being able to generate a social or environmental impact alongside a financial return. Partnership benefits for the WC-CHD are financial return, marketing and brand equity, and social impact. The private-non-profit relationship may be structured as a joint venture, a licensing agreement, or formal partnership.

It is worth noting that the private-non-profit partnership model will be based on active operational involvement in a social enterprise, not simply a business relationship. The two entities share the return, and it would be expected that the WC-CHD uses the proceeds to fund its mission while the profit partner either retaining or distributing their profit.

# Final Feasibility Study Arundo Donax

---

## **7.1 Areas of Investment**

As pointed out previously, BELCOGEN and BEL already have the resources and infrastructure to facilitate the new project. The only areas of investment required are therefore with the WC-CHD.

The WC-CHD requires US\$3.06 for equipment, starting capital, land acquisition and preparation for the first crop.

## **7.2 Type of Required Investments**

The areas of investment include capital purchases for Machinery and Equipment, cash investment for field preparation for the farmers and working capital support for the WC-CHD. As shown in the Financial Model, under the base scenario, the financial indicators (Return on Investment, Payback Period, Net Present Value and Benefit/Cost Ratio) are relatively low and may be unattractive to a traditional for-profit investor. Possible options are: -

- 1) Grant funding may be sought specifically for the WC-CHD non-profit entity from governments, international financial institutions, foundations and other entities that provide funding to NGOs, particularly if these funding agencies' focus is in climate change and the environment. This makes the GCF a prime target.
- 2) For-profit financing could technically also be sought from the private sector such as commercial businesses which may choose to exercise their social or moral conscience toward the greater good of Belize or the environment. Specific thought and legal advice may be necessary to establish whether BEL or BELCOGEN may participate given their upstream interests.

## **7.3 Potential Investors**

### **7.3.1 Local Investment**

## Final Feasibility Study Arundo Donax

---

### Belize Social Security Board

The Belize Social Security Board (SSB) is one of the largest institutional investors in Belize. According to the SSB, investments made by SSB play a major role in sustaining and developing Belize's economy. Contributions collected are used to meet operating expenses and to pay out benefits expenditure; any surplus is invested as per guidelines of the Social Security Act. Agriculture has been identified as one of those economic sectors in which the SSB can invest.

### Life Insurance Companies in Belize

The Insurance Act makes provision for the investment of assets of insurance companies. The Insurance Act requires domestic insurers to establish statutory funds for each class of insurance business in order to assure solvency and partial protection against investment losses. Financing provided to this project can be a suitable long-term investment for a life insurance company.

### Belize Electricity Limited

The Government of Belize is the largest shareholder in BEL, with direct ownership of approximately 32.6% interest in the Company with the Social Security Board owning an additional 31.2% interest in the Company. BEL will be one of the major beneficiaries of this project, mainly in the reduction of purchase of power from CFE in Mexico. They have already invested \$500,000 in the development process of this venture and further investment to see it come to fruition can be an attractive long-term investment with both financial and social benefits attached.

### Development Finance Corporation

The DFC is a Development Bank with the purpose of support the strengthening and expansion of the country's economy by providing developmental financing on an economically sustainable and environmentally acceptable basis to individuals,



## Final Feasibility Study Arundo Donax

---

businesses and organizations. While DFC owns much of the farmer's debt, they may see this opportunity as a means of potentially reducing that debt and retrieving their investment through a well-designed repayment plan.

### 7.3.2 International Investment

#### EU Funding

Belize as a member of the Caribbean Community (CARICOM), and the Forum of the African, Caribbean and Pacific states (CARIFORUM), benefits from EU regional programmes funded under the Caribbean Regional Indicative Programmes. Under the 11th EDF (2014-2020), there is a financial allocation for Belize, with the EU providing financial support to the national development strategy, built around three focal sectors, namely renewable and sustainable energy, health and public finance management. Much of the fund remain unused and may be channelled towards either entity requiring financing.

#### Inter-American Development Bank (IDB)

The IDB is the leading source of development financing for Latin America and the Caribbean, by providing loans, grants, and technical assistance. The 2013-2017 Country Strategy for Belize was designed to support the Government of Belize in improving public expenditure efficiency and effectiveness and promoting private sector development and sustainable export-led growth, by concentrating on four priority areas; education, tourism, transport and trade and tax policy. The Bank's current focus areas include three development challenges; social inclusion and equality, productivity and innovation, and economic integration. It also includes three cross-cutting issues; gender equality and diversity, institutional capacity and the rule of law and **climate change and environmental sustainability**. This project can benefit from this support.

#### Green Climate Fund

## Final Feasibility Study Arundo Donax

---

The Green Climate Fund is a fund established within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) has as its major focus projects which limit or reduce greenhouse gas emissions in developing countries and help adapt vulnerable societies to the already-felt impacts of climate change. Given their involvement so far, the potential challenges for for-profit investment and the emissions to be avoided, the project is considered ideal for the Green Climate Fund.

## 7.4 Investment Considerations

The previous section presents a baseline option which has been based on long-term sustainability. This is a core value for all the potential investment entities presented above. If other options are considered the same level of long-term sustainability would be desirable. For comparison purposes three options are compared.

### Option 1: Do nothing

This option maintains business as usual and does not incur any additional costs or benefits to any of the stakeholder; requiring no project and no investment.

### Option 2: Do 10% Wild Cane

This option requires the addition of 10% of shredded wild cane to the existing bagasse supply to BELCOGEN from ASR-BSI in order to create a biomass blend. It utilises the existing infrastructure of BEL and BELCOGEN and promoted the setting up of the WC-CHD to oversee the enhancement and operate between BELCOGEN and the Cultivation, harvesting and delivery service providers who are all asked to play a role. An investment of \$3.06 Million is required.

### Option 3: Do a separate Biomass Plant

This option does not seek to utilize the existing infrastructure of BELCOGEN. It seeks to establish a biomass power plant to supply BEL. Such a plant would be able to accommodate 100% wild cane biomass using new infrastructure. Not all the implications have been considered for this option since it was not the focus of the study. However, some comparisons are still possible based on the experiences of the consultants. An investment of approximately \$22 Million would be required.

Table 7:1 below compares the three possible options.

	<b>Option 1 - Do nothing</b>	<b>Option 2 - 10% Wild Cane</b>	<b>Option 3 - 100% Wild Cane</b>
The policy, regulatory, cooperation and operational environment	The established regulator would continue to grant small tariff increases to the of IPPs that supply BEL based on their PPAs.	The PUC has established a regulatory environment to address the supply of IPP using traditional or new technologies. Increasing the supply from BELCOGEN to BEL is within their PPA parameters and require no additional interventions.	This option requires a separate power plant and will require the establishment of a separate PPA between the IPP and BEL. The PUC policy and processes to develop the PPA are already established since PV, Hydro and Biomass are already in production.
Emissions	Local emissions would continue to rise since any additional demand would be met from diesel generation locally or imported expensive mixed generation from Mexico.	A net 202,441 tons of CO <sub>2</sub> would be avoided over 20 years	A net 2 Million tons of CO <sub>2</sub> would be avoided over 20 years
Farmer's Welfare	Farmer would have no additional revenues and the future of the sugar industry would be dependent on improvements in their own operations and the global market prices for sugar; the latter being unlikely to happen.	Existing farmers and other cultivators would earn revenues of \$4.3 Million over 20 years to support themselves.	Existing farmers and other cultivators would earn revenues \$40 Million over 20 years to support themselves.
Economic Environment	Further foreign exchange losses would occur.	\$685K saved by BEL in Foreign Exchange charges over 20 years	\$7 Million saved by BEL in Foreign Exchange charges over 20 years
	An opportunity for additional employment will be lost	An opportunity for additional employment will be realized	Much greater opportunities for additional employment will be realized from cultivating wild cane and running an electricity generation plant.

	Investment Climate may be negatively impacted	The investment climate may improve slightly	The investment climate may improve more significantly
The institutional and management environment	The institutional and management environment would not be affected	The institutional and management environment would not be affected	The institutional and management environment would not be affected
	There knowledge base for the use of biomass in energy generation would not be increased	The knowledge base for the new market would be significantly enhanced with the opportunities to learn in various areas including the commercial cultivation of biomass, harvesting, delivery and shredding.	In addition to the knowledge base enhancement gained from option 2, the industry would gain further knowledge in energy generation.
	Capacity building in the energy related institutions would continue to be slow.	This option would create capacity in several area of the energy cycle and better equip institutions to manage and advance the thrust to boost energy production using environmentally friendly sources.	In addition to the capacity built in option 2, institutions will add their capacity to deploy large scale biomass projects and manage the establishment of independent power producers in Belize.
The energy demand, supply and financial environment	While demand growth is currently low it may be expected that increased economic activity in the productive sectors would drive up demand. Beyond a 3-5 years period the supply would require some increase. Given the energy mix, this may come from an increase in	The additional electricity produced by the 10% increase in Biomass would exceeds any increase in demand. It will reduce the supply from Mexico by 11,520MWh; under	The additional electricity produced by a similar size plant as BELCOGEN using 100% wild cane Biomass could be used to substitute the produced amount from Mexico; 120 GWh;

	imports from Mexico which have also been increasing significantly in cost (37.7% increase in 2018). The only other option would be to ramp up production in their diesel plants and this is not desirable.	5%. BEL would save US\$15.3 Million over 20 years.	nearly 50%. BEL would save US\$153 Million over 20 years
	Increasing cost of electricity to BEL from BELCOGEN and other local IPPs coupled with increasing cost from Mexico would result in increasing electricity rate to commercial and residential BEL customers.	Producing more electricity from BELCOGEN's existing infrastructure will initially increase their revenues. However, the feed-in tariff will eventually be reviewed for a possible reduction along with BEL's electricity rate to commercial and residential customers.	An increase of 100% instead of the 10% in option 2 will significantly reduce the cost of energy purchased by BEL. After a PUC review, savings should be passed on through the BEL electricity rate to commercial and residential customers.
The physical and socio-cultural environment	This option does not impact the physical and socio-cultural environment	Given the need for 2000 acres of marginal land, some physical and minimal socio-cultural environmental impacts are expected. These are itemized in the ESIA document.	The impact of farming 20,000 acres of marginal land has not been determined.

Table 7:1

## 8.0 Project Implementation

The implementation period is estimated to be 3 years. Project management is however only expected to last for 24 months. This will ensure that all the necessary preliminary activities like procurement, public awareness, etc. are completed and progress is being monitored until harvesting of the first batch of wild cane and delivery to BELCOGEN has commenced. After three months of full production, daily management of the operation will become the full responsibility of the WC-CHD and other direct stakeholders.

Several stakeholders are expected to play a role in executing the project including:

-

- Project Manager
- 5Cs
- WC-CHD
- BELCOGEN
- BEL
- SIRD
- Ministry of Agriculture
- Ministry of Energy
- Cultivation Community/Association
- Contracted Suppliers

The plan below proposes an implementing schedule for the project.

	Year 1				Year 2				Year 3														
Tasks	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	PM	5Cs	WC-CHD	MoA	Cultivators	Contractors	BELCOGEN	MoE	Consultant	SIRD	BEL
<b>Project Management</b>													x										
<b>Component 1 - Preparation</b>																							
<b>Administration</b>																							
Establish Wild Cane Cultivation, Harvesting and Delivery functional entity (WC-CHD)													x	x	x	x	x			x			
Select Governance structure for WC-CHD													x	x									
Develop policies for WC-CHD													x			x				x	x		
Develop business processes and procedures for WC-CHD													x								x		
Establish MoU with BELCOGEN													x	x	x	x			x	x			
Complete plant cultivation research with SIRD													x	x	x	x						x	
Land Acquisition													x			x							
Develop cultivator selection criteria													x		x	x	x						
Select Cultivators and sign agreements													x		x	x	x						
Acquiring permits for harvesting naturally growing Arundo donax to plant													x			x							
Land Allocation to cultivators													x		x	x	x						
<b>Procurement</b>																							
Procure consultancies for market making, business processes, policies, etc													x	x	x								
Procure services to prepare and deliver plants													x	x	x	x	x						
Procure Farming Equipment & Install													x	x	x								
Procure services to transport wild cane from WCHC to Belcogen													x		x			x					
Negotiate price with BELCOGEN													x	x	x				x	x			
Negotiate price with cultivation community/association in the North													x		x	x	x						
Recruit Staff													x		x								
Procure Road construction services													x		x			x					
Procure Office space													x	x	x								
Procure Office Equipment													x		x								
<b>Training</b>																							
Documentation of processes and procedures													x		x	x	x						
Financial Training													x		x	x	x						
Farming Techniques training													x		x	x	x						
Cutting and harvesting training													x		x	x	x	x					
Transporting and delivery training													x		x								
Office Training													x		x								
<b>Component 2 - Cultivation</b>																							
Cut plants for sowing in 2,000 Acre area													x		x	x	x						
Plant wild cane plants													x				x						
Cultivate wild cane plants													x				x						
<b>Component 3 - Harvesting and Delivery</b>																							
Cutting /Slashing mature plants													x		x								
Picking up biomass													x		x								
Transportation biomass to Belcogen													x		x			x					
Scredding biomass to produce fuel at Belcogen													x		x			x					
Maintenance of all equipment													x		x								
<b>Component 4 - Knowledge Management and Public Awareness</b>																							
Public Campaign													x	x	x	x				x	x		
Publication of SIRD research data													x	x	x	x						x	
Data collection from active stakeholders													x	x	x	x	x		x				x
Quarterly Public project updates													x	x	x						x		
Emissions reporting; Project and National													x	x	x					x	x		x
<b>External Commercial Actions</b>																							
Generation using wild cane biomass fuel to supply electricity to BEL																			x				
Substitution of imported electricity with clean energy																							x

Figure 8.1: Project Schedule



## **8.1 Component 1 - Preparation**

Component 1 focuses on project preparation due to the complexities involved in delivering this project. It does have a measure of overlap with subsequent components and includes several supporting activities which are necessary or desirable for a successful project. The individual tasks are shown in the implementation schedule on the previous page. This component puts in place all the critical preparation and facilities necessary for subsequent components.

### **8.1.1 Administration**

The first steps must include the setup of the WC-CHD which is expected to play a central role in the project. Its governance structure must be agreed with consideration of the recommendations provided in section 4.3. Given the market-maker nature of the WC-CHD, it would be advisable to procure the services of expert consultants to assist in drafting the potential framework with policies which can provide the required guidance. This may be followed by the development of business procedures and processes which provide day-to-day direction for the management and employees.

Given the established commitments from BEL and the eagerness of the farming community in the Northern part of Belize, the next key stakeholder required to commit is BELCOGEN. This may be in the form of a MoU.

It is also critical to obtain approvals for the use of any government owned marginal lands required to cultivate the 2,000 acres of wild cane. The criteria to be used to select participating cultivators must also be agreed and those cultivators signed up and allocated plots. In preparation for procuring services to supply the wild cane cuttings for planting, the requisite permits to harvest existing plants must also be obtained.

## Final Feasibility Study Arundo Donax

---

In parallel with the activities mentioned, conclusive cultivation data should be acquired from SIRD. This must provide clear scientific guidance for the cultivation community.

### **8.1.2 Procurement**

Procurement will include the acquisition of farming equipment, services to transport wild cane from cultivation plots to BELCOGEN, staff, office space and equipment and road works. Negotiation of biomass prices must also commence with BELCOGEN and the cultivation community in the North.

Staff recruitment should consider the reports on employment statistics (SIB, 2019) which show that 2 to 3 times more females than males were unemployed nationally between 2016 and 2018 with unemployment at 9.4% in 2018. For the two key northern districts of Corozal and Orange Walk, unemployment was lower; averaging around 6%. However, the ratio of unemployed females to males is now over 5:1. This is rooted in the culture of the Northern districts in terms of the male-female role and the physical demands of the popular agricultural occupations. Since most of the WC-CHD employees may come from these districts and much of the tasks will be automated, females should be encouraged to apply for these jobs and receive the requisite training. This invitation should form part of the public campaign and engagement plan so that women feel empowered to pursue the new job opportunities. We already know from the stakeholder report that interest in related economic activity for this project is high among farmers and community residents consulted (Mendoza, 2018).

### **8.1.3 Training**

The WC-CHD will be required to execute different levels of training. There must be a wholistic approach to these sessions since there are many factors that will influence the outcomes of the project. It is proposed that the project manager have

## Final Feasibility Study Arundo Donax

---

some experience in business development and process engineering with an eye for details. The procedures to be followed by the WC-CHD should be developed and documented using text and diagrams which may be used during training sessions.

Some training sessions will focus on the business processes and office procedures to be followed by internal staff and external service providers/partners who are interested or required to play a role. These modules will be developed by the project manager and an external consultant. Financial Management must also be included since this represents a pressing need amongst farmers, some of whom may wish to participate in the project. It will also act as safeguard training for new cultivators of the wild cane plant.

Some training sessions will focus on farming techniques, cutting and harvesting the wild cane, transporting and delivery of the biomass to BELCOGEN. The shredding of the wild cane into ready-to-use fuel will also require special training from the supplier of the equipment.

Other supporting training may include 1) climate proofing to assist over 5200 farmers to produce a more resilient cane against extreme high humidity, rain and high temperatures which facilitate the propagation of the “Frog Hopper” pest and 2) assisting cane farmers associations to achieving the Fair-Trade certification of farmers associations under the EU regulations to protect their status to supply the EU and guarantee a premium price. This should be done to secure the 90% portion of the bagasse biomass blend proposed for the BELCOGEN boilers.

### **8.2 Component 2 - Cultivation**

This component focuses on the cultivation of the wild cane plant for commercial use.

### **8.2.1 Land Preparation**

The work of preparing the 2,000 acres of land for wild cane cultivation is a critical milestone in the project since harvesting and energy generation from the shredded wild cane will be just 15 months away from that point. Planting of the complete 1<sup>st</sup> crop seedlings may take multiple months, but the mature plants will be harvested on a first-plant first-cut basis. A cultivator must be contracted to supply the wild cane seedlings from the existing patches of wild cane across Belize and plant them. Planting must be executed based on guidance from the SIRD research. This will provide the best chance of achieving the expected tons of wild cane per acre of land. The selected marginal lands should be preferably within 40km of the BELCOGEN plant.

### **8.2.2 Plant Care**

The wild cane is a widely grown plant in Belize. Even though its land coverage in Belize has decreased in the last decade, its prevalence and capability to grow in marginal lands still makes it a good potential source. It is therefore not anticipated that this wild cane will require any significant attention or cost. However, until the lessons learnt from cultivating the wild grass have been recorded, it will be necessary to observe the growth of the plant. This 1<sup>st</sup> year will provide another an opportunity to record important data about cultivating the plant for commercial use. The data should be well recorded to support the capacity building and knowledge management objective of the project.

## **8.3 Component 3 – Harvesting and Delivery**

Component 3 focuses on the cycle of harvesting, delivery and shredding. Subsequent blending, burning and energy generation remains the responsibility of BELCOGEN. Once the cycle commences, it continues for 10-11 months of the year. 1-2 months are used to perform maintenance and allow for staff leave.

### **8.3.1 Harvesting**

The first plants are expected to be harvested 15 months after planting on a first-plant first-cut basis. The pace of harvesting is arranged to allow the cut wild cane to be sun-dried in the fields to a maximum of 55% moisture before removal. Data collected on the drying process would be very important for the learning process and could influence future changes.

### **8.3.2 Delivery**

Physically moving the wild cane biomass from the fields to BELCOGEN will be outsourced to a transportation firm which is experienced in moving materials. A simple process of picking up sun-dried biomass from the fields and loading into trailers will be used. The schedule will be arranged to match the harvesting rate so that a constant delivery rate to BELCOGEN is maintained for 11 months of the year.

Locating the shredder at BELCOGEN allows the project to benefit from cheaper wholesale electricity prices (US\$0.1034/KWh) and does not impact negatively on the environment since the energy produced in the BELCOGEN process is clean. If the shredder is in the field, we would need to use diesel to have a viable shredder solution which would still require relocation at times. We would lose the benefit of a single stationary unit in a central location using clean inexpensive energy.

The full logistics are presented in section 3.3.4. Like the previous processes, efforts should be made to closely observe and record data which could be used to re-engineering and improve processes. This is a new venture for Belize and all process or material flaws may be improved as time passes, with the support of actual data and new knowledge.

## **8.4 Component 4 - Knowledge Management and Public Education**

### **8.4.1 Knowledge Management**

Each component has well defined activities which when executed in the prescribed sequence is expected to result in a successful project. Additionally, they each provide an opportunity for data collection and learning from what is a new experience for Belize. The project must harness these opportunities and consider utilizing the public education campaign and other existing media and avenues to propagate the information beyond the project while also using that information to improve the internal processes of the WC-CHD and its suppliers.

This project has produced several documents (stakeholder engagement, gender involvement, feasibility, ESIA) so far, all of which address a range of issues which may be relevant to other similar projects. Making these documents available through the 5Cs' website and its various networks around CARICOM would certainly help the development and progress of similar projects.

The proposed implementation plan has specific phases which allow for effective monitoring and reporting on progress. This reporting should indicate any challenges experienced and eventually how they were overcome. This would provide further insight into the best practices and procedures to implement other mitigation and adaptation projects. Additionally, outputs from SIRD I would be of great scientific value and should form part of our knowledge base on biomass in Belize.

A key outcome is the reduction in emission over the next 20 years. While other initiatives will contribute to this, in collaboration with BEL we are able to monitor progress resulting from this project. Publishing this data quarterly would not only

## Final Feasibility Study Arundo Donax

---

contribute to the body of knowledge but also the level of interest and participation in Belize's implementation of mitigation and adaptation projects.

In recent years CARICOM has created different forums to facilitate the sharing of information, technologies and experiences. The use of Webinars, November as energy month in all its member states, coordinated regional meetings and the formation of the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE) as a coordinating agency, has made it easier to share information and lessons learnt. Beyond sharing, the project can serve as a catalyst for other countries to take actions in the biomass sector.

### **8.4.2 Public Education**

As recommended in the Stakeholder reports, there should be a public campaign designed to keep stakeholders updated on the status of the project, along with the circulation of information which could stimulate national responses as it relates to the implementation of mitigation and adaptation projects in Belize. Particular attention must be paid to the farming communities which are anticipated to participate. This campaign should be initiated by the WC-CHD at the start of the project.

The stakeholder report also indicated that there is not enough technology used in the farming industry to attract young people. The WC-CHD intends to automate its operation by utilizing better technologies that may make the sector appear more attractive. This should also be emphasized in the messaging to the younger persons in the community. The Management and Engagement plan identifies the key stakeholders and the best means to engage them. This plan should be activated as soon as possible since it is intended to address the ongoing progress of the overall Arundo Donax project and would support any public awareness exercises.

## Final Feasibility Study Arundo Donax

---

Additionally, the gender action plan promotes the use of social media, messaging in women's groups and gender-neutral job description as important in the engagement processes (Humes, 2018). This must be further supported by having suitable hygienic facilities and inclusion in technical training amongst other things detailed in the action plan.



# Final Feasibility Study Arundo Donax

---

## References

- 1) UN, 2015: *TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR USTAINABLE DEVELOPMENT*, A/RES/70/1, United Nations.
- 2) CCCCC, 2012: *Delivering Transformational Change 2011-21: Implementing the CARICOM Regional Framework for Achieving Development Resilient to Climate Change*. Belmopan, Belize: Caribbean Community Climate Change Centre.
- 3) Barnett, C., et. al., 2011: Final Report: Preparing Horizon 2030 - Long Term National Development Framework for Belize, Government of Belize
- 4) Mendoza, P., 2018: Final Report, Analysis of Stakeholder for Effective Use of Arundo Donax as Biomass Fuel in Belize, CCCCC Belize
- 5) Humes, D, 2018: GENDER ACTION PLAN FOR THE PROPOSED ARUNDO DONAX RENEWABLE BIO-MASS FUEL FOR BELIZE, CCCCC Belize
- 6) PUC, 2018: Rate-setting Methods and Process, Public Utility Commission, Belize
- 7) International Energy Agency, 2018: CO2 emissions from fuel combustion, IEA 2018
- 8) Belize Electricity Limited, 2019: Annual Report 2018– Financial and Operating Statistics, BEL 2019
- 9) GoB, 2016: Growth and Sustainable Development Strategy 2016-2019, Government of Belize, 2016
- 10)Tillett, Locke & Mencias 2011: National Energy Policy Framework, GoB 2011
- 11)SIB, 2019: Statistical Institute in Belize Annual Report, SIB, 2019
- 12)Bynoe, Cain, Perelta, 2014: The use of Benefit Cost Analysis to assess Adaptation and Mitigation Interventions in the Caribbean: Case Studies, CCCCC 2014
- 13)UNEP, 2013, Grid Emissions Factor of Belize 2009 – 2011, UNEP RISOE Centre 2013

# Final Feasibility Study Arundo Donax

## Appendix A – Assumption Data

<b>CERMES Data Test Locations</b>	<b>(Daniels) 2016 - tons/Hectare</b>	<b>(Smartt) 2019 - tons/Acre</b>	<b>(Smartt) 2019 - tons/Hectare</b>	<b>Average tons/Hectare</b>
Monkey River	2.83	3.45	1.40	2.11
Sittee River	7.08	4.76	1.93	4.50
Middlesex(North Stann Creek River)	29.97	15.18	6.14	18.06

<b>Costing Categories</b>	<b>International Costs USD</b>
Harvest per acre	\$10.00
Loading per acre	\$9.00
Transport per acre	\$6.00
Cost per acre	\$25.00
Cost per ton	<b>\$0.89</b>

Tons	42,533
Required Hectares	2,127
Required Acres	1,519
Recommended Acre	2,000

<b>Sugar Cane</b>	<b>USD</b>	<b>Description</b>
cane tons	\$1,254,000	Sales
sugar tons	150,000	Annual
price	\$42.45	Market price
Revenue	\$6,367,500	BSI
	\$4,610,000	farmers revenue - USD
	\$1,757,500	BSI profit and cost - USD
	\$3.68	Farmers revenue/ton of cane
	\$0.89	Farmers cost/ton of cane
	\$2.78	Farmers profit/ton of cane

<b>In-field Transport</b>	
Harvesting Cost per ton	\$0.68
Total Harvesting fuel cost	\$28,861.68
Equivalent Diesel	19,241
emissions intensity for diesel	0.00264
Emissions in tons of CO <sub>2</sub>	50.80
Emissions per ton of cane	0.001194286

## Final Feasibility Study Arundo Donax

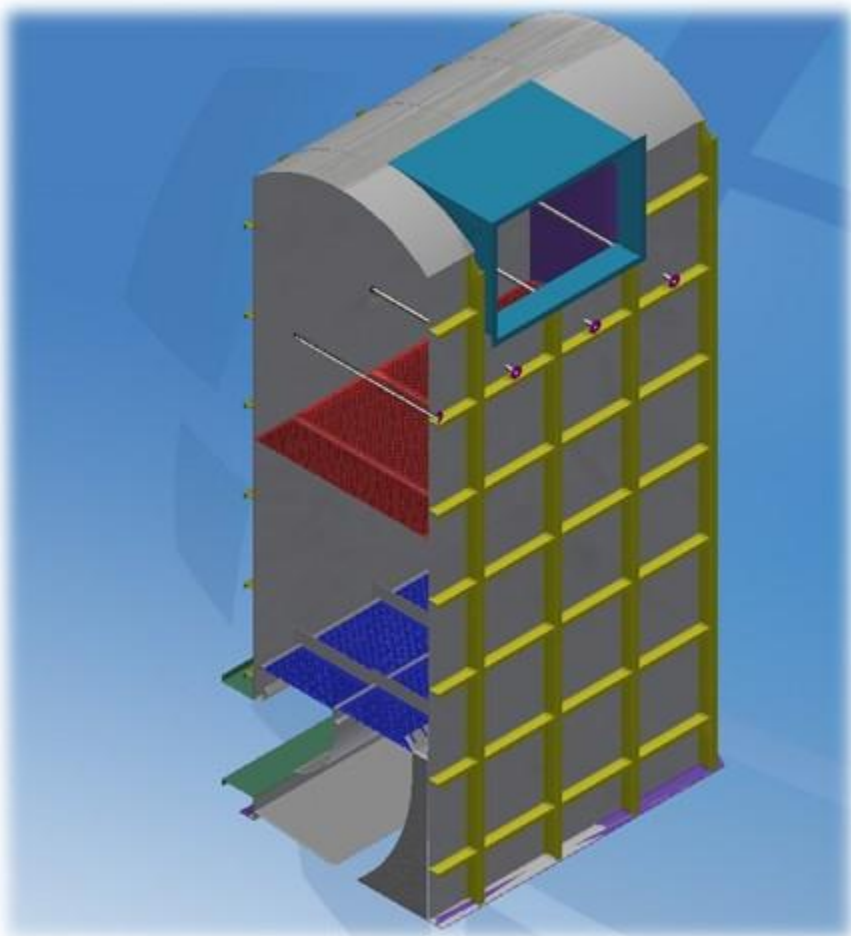
<b>Subcontracted Transportation</b>	
Tons per run	15
load runs	16
Trucks	4
Loads per day	4
Time to load	6 hours
Average Length of runs	30 km
Travel per day	480 km
Cost per litre of diesel	\$1.50
emissions intensity for diesel	0.00264
Diesel per KM	0.25
Emissions in tons of CO <sub>2</sub>	68.4288
Diesel	25,920
Cost of Diesel	\$38,880.00
Days	216
km per litre	4
Emissions per ton	0.00160884

<b>Cultivation Investment at WC-CHD</b>		
<b>Start-up Activity</b>	<b>Per Acre Cost \$US</b>	<b>Cost \$US</b>
Land Identification and surveys (Land & GIS)	\$100	\$151,904
Land Clearing	\$333	\$505,839
Sub-soiling	\$93	\$141,270
Ploughing	\$60	\$91,142
Liming	\$50	\$75,952
Planting material (4 tons per acre)	\$60	91,142
Planting	\$155	235,451
1st year Crop Maintenance	\$116.50	176,967
<b>Sub-total</b>		<b>\$1,469,667</b>

<b>Harvesting and Delivery Investment at WC-CHD</b>		
<b>Startup Activity</b>	<b>Per Acre Cost \$US</b>	<b>Cost \$US</b>
1 Tractor and Slasher combination	\$65,000	\$65,000
1 Tractor Rake and Loading Blower	\$65,000	\$65,000
3 Hauling Tractor and Self Tipping Trailer	\$73,333	\$220,000
3 High volume 20-ton truck trailer sets	\$100,000	\$300,000
1 Heavy Duty Shredder	\$350,000	\$350,000
Access Roads	\$150,000	\$150,000
Office Furniture & Equipment	\$39,000	\$39,000
Working Capital Support	\$150,000	\$150,000
Project Management	\$250,000	\$250,000
<b>Total</b>		<b>\$1,589,000</b>

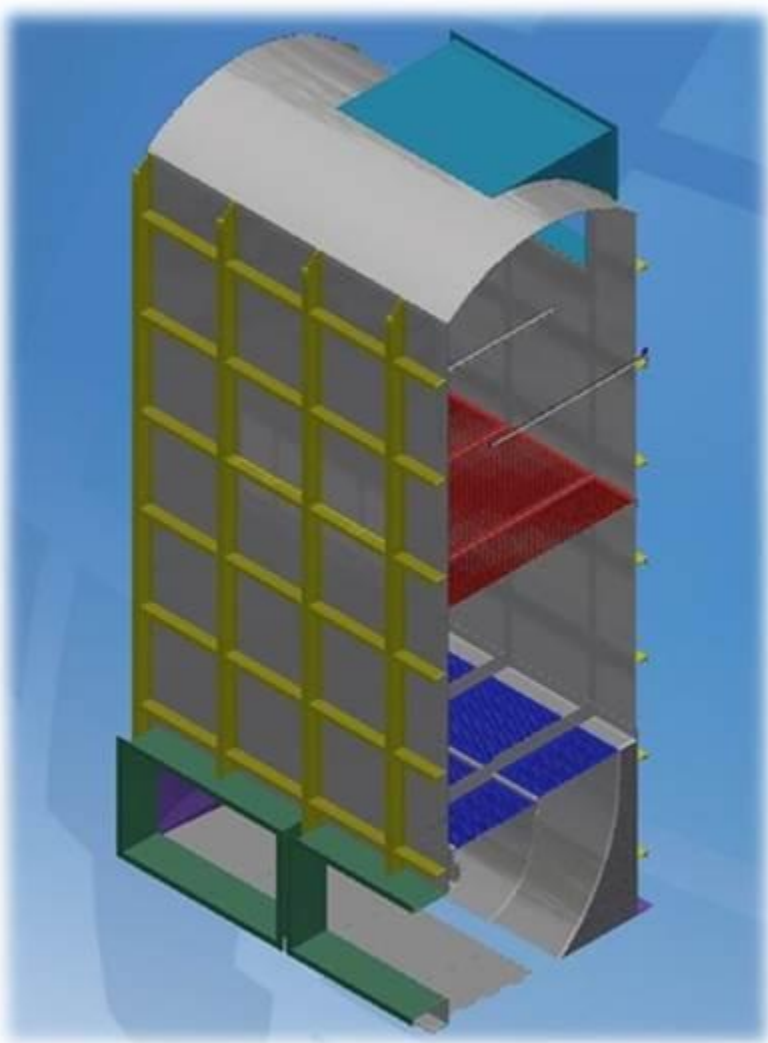
## Appendix B – Equipment

### Scrubber



## Final Feasibility Study Arundo Donax

---

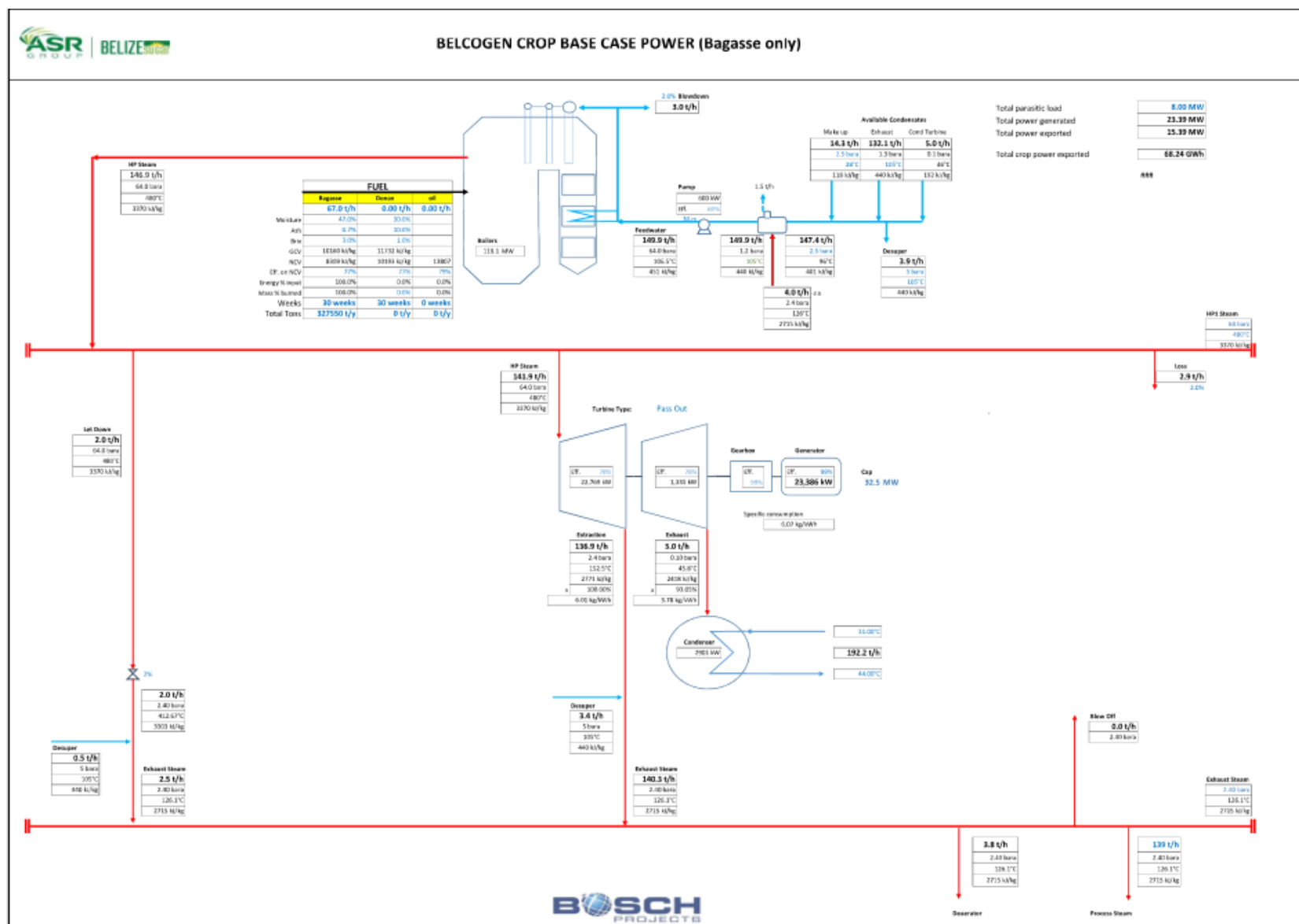


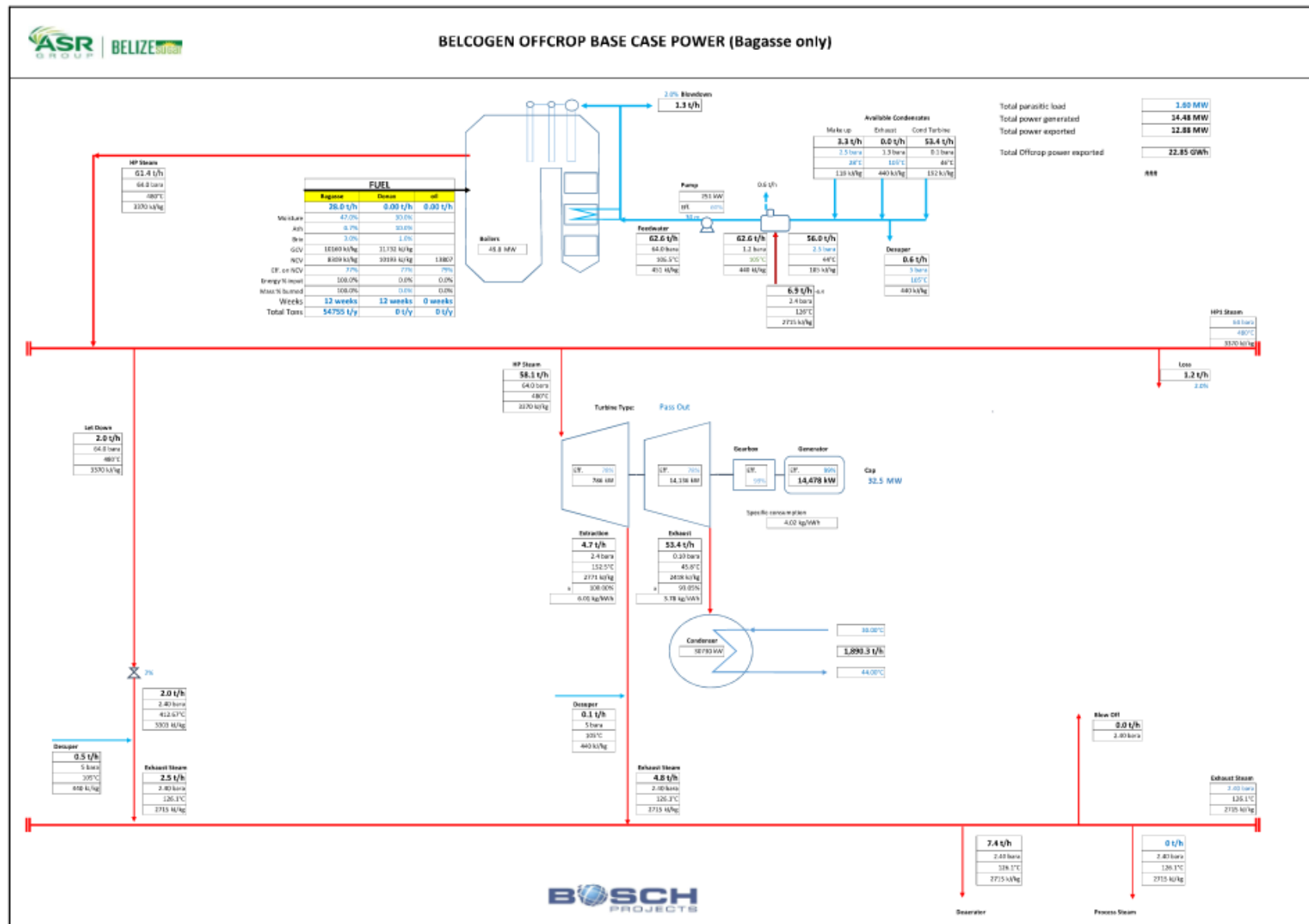
## Final Feasibility Study Arundo Donax

---

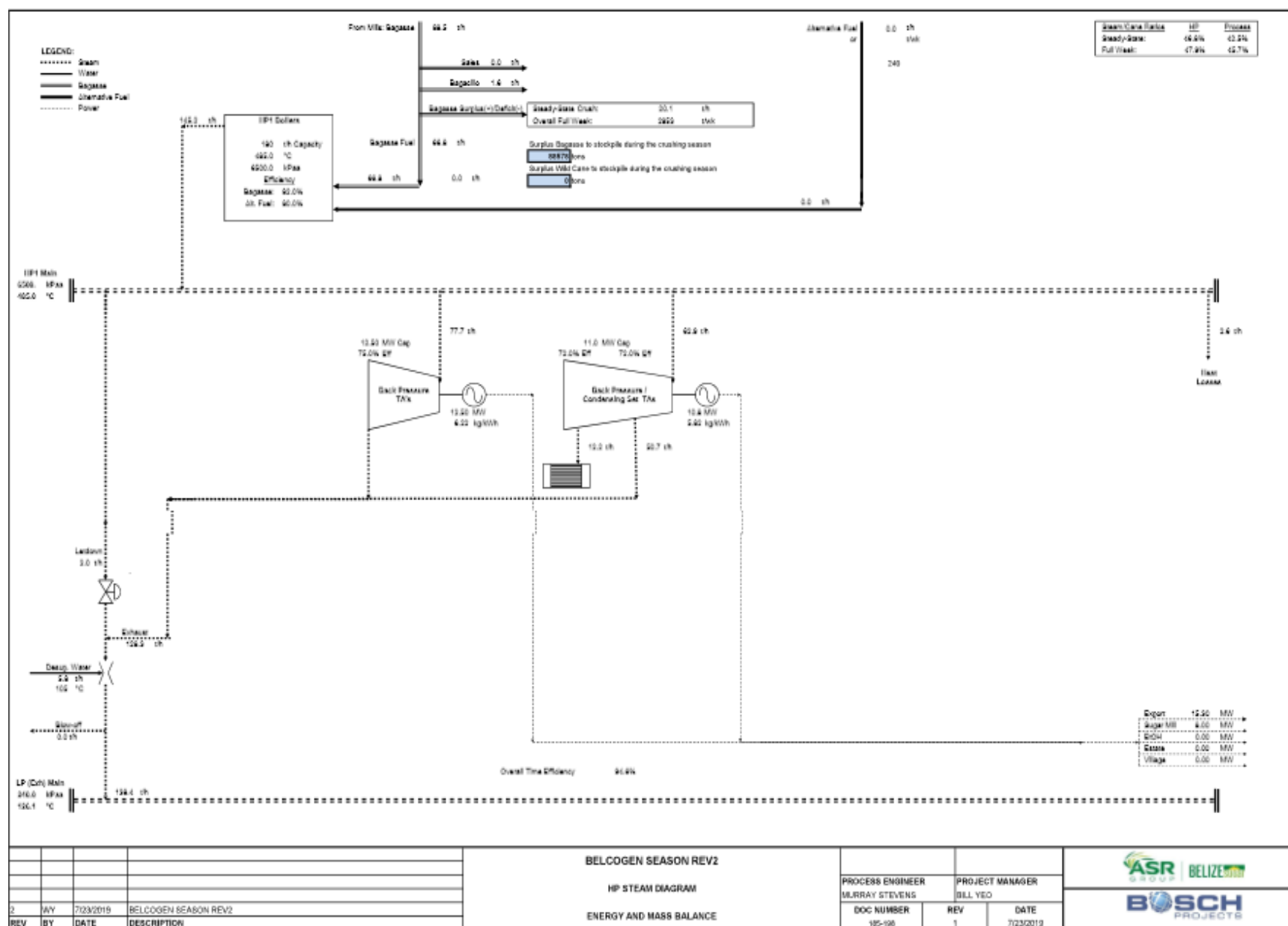


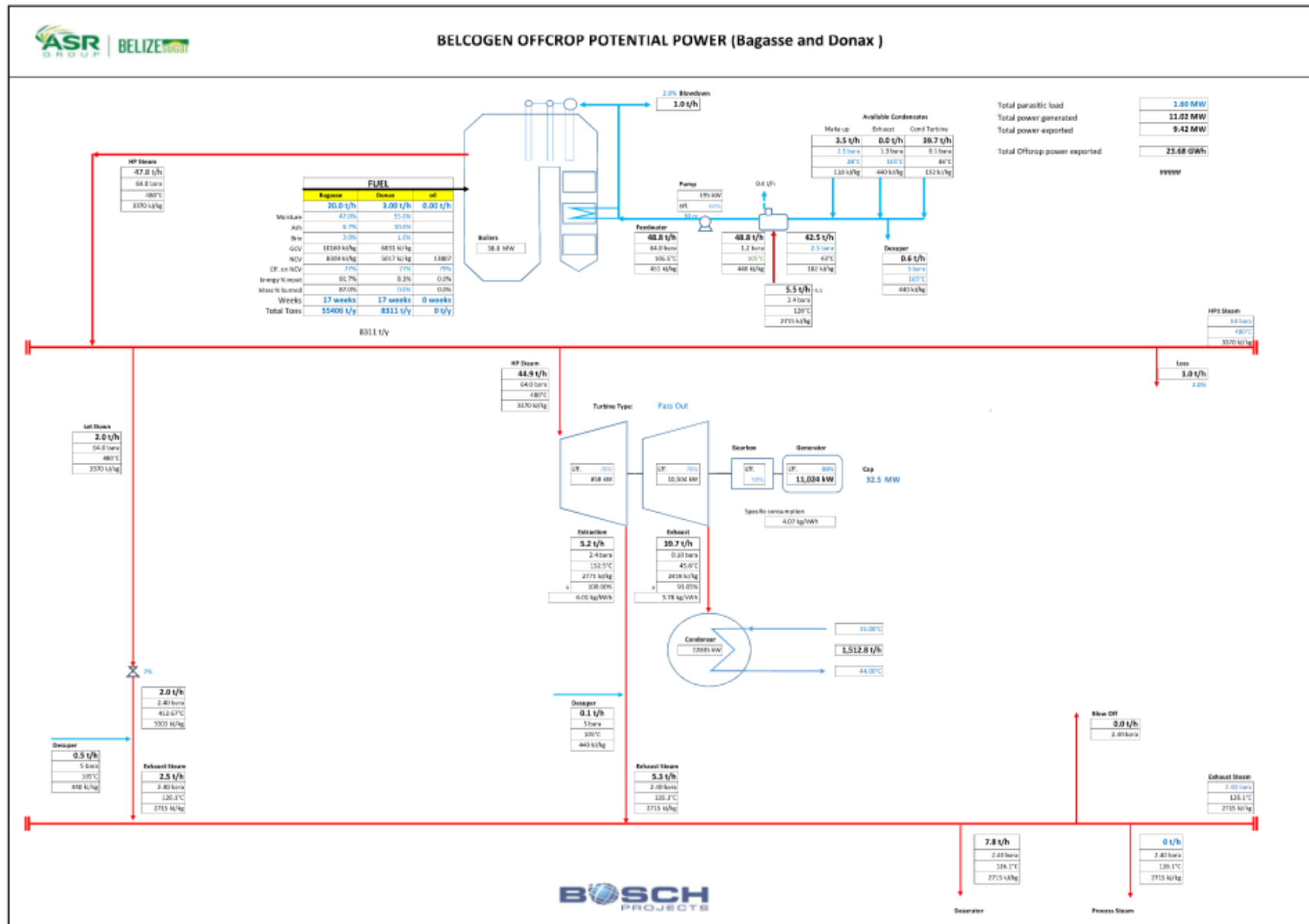
## Appendix C – Energy Balance

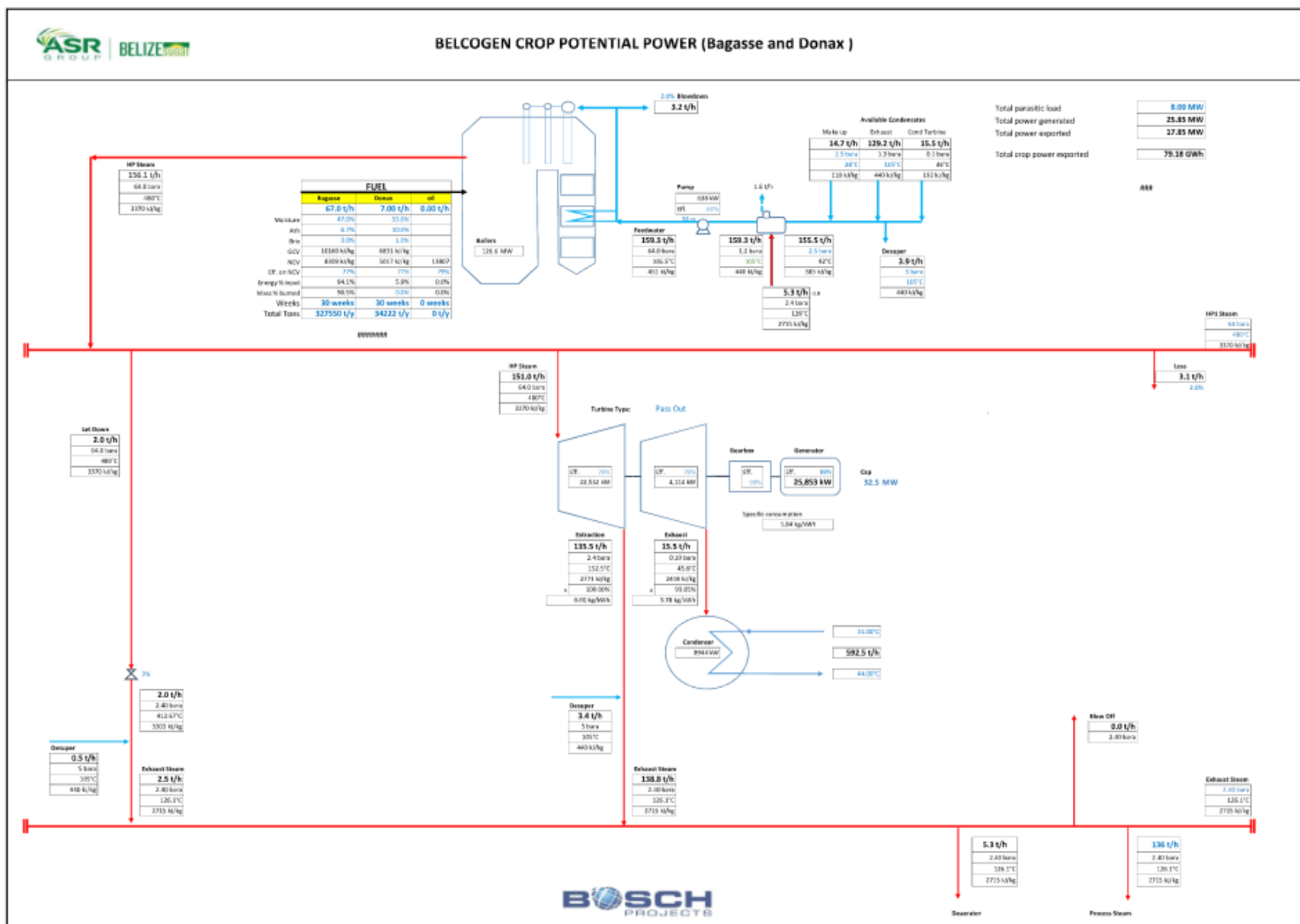












## Final Feasibility Study Arundo Donax

---



Base Case Crop	68.24 GWh
Off Crop Base Case	22.85 GWh
Total	91.09 GWh

Wild cane Crop	79.18 GWh
Wild cane Offcrop	23.68 GWh
Total	102.87 GWh

Wild Cane difference	11.78 GWh
Total Wild Cane / year	42533 t/y

Additional fuel generating potential

# Final Feasibility Study Arundo Donax

---

## **Appendix D – Justification**

### **Shredder**

The wild cane has been requested in a similar consistency to that of bagasse. A mobile shredder, the Bandit Beast 2680XP was successfully tested shredding whole stick cane and has been recommended for this project. Although the unit was powered by a diesel 275HP motor, it is possible to convert the unit and power the shredder with an electric motor. It's estimated the consumed power shredding Donax at 20T/H should be substantially lower than the full power of the diesel motor, and allowance should be made for a 150KW electric drive.

The benefit of using electric drive is the following:

- A reduction in fuel and maintenance operating cost.
- Lower power consumption.
- Increase in reliability from the electric motor.
- Noise reduction.
- Simplification of operations.
- A reduction the fire hazards associated with diesel in the bagasse stockpile area
- Avoidance of emissions from the machine

### **Discount Rate**

# Final Feasibility Study Arundo Donax

	No Debt (100 Equity Finance)	50% Debt /50 Percent Equity	100% Debt /No Equity	Notes
<b>Discount Rate</b>				
Tax Rate	28.21	28.21	28.21	Tax rate for BEL
Risk Free Rate	2.53	2.53	2.53	US Long Bond Rate - July 31, 2019
Country Risk Premium	7.34	7.34	7.34	Country Risk Premium - Professor Aswath Damodaran, Professor of Finance at the Stern School of Business at New York University
Market Risk Premium	5.50	5.50	5.50	Duff & Phelps Risk Premium Report
Specific Company Risk	4.00	4.00	4.00	Estimate of risk from investment in this project
Size Premium	3.99	3.99	3.99	The size premium is the extra return an investor expects to receive from an investment in small publicly companies versus a large company.
<b>Debt Ratio</b>	<b>0.00</b>	<b>0.50</b>	<b>1.00</b>	
Beta	0.60	0.60	0.60	Beta - Professor Aswath Damodaran, Professor of Finance at the Stern School of Business at New York University
Cost Of Equity	15.03	15.03	15.03	
Cost of Debt	9.19	9.19	9.19	Weighted Average Interest rate - Central Bank of Belize
After Tax Cost of Debt	6.60	6.60	6.60	
<b>Discount Rate</b>	<b>15.03</b>	<b>10.81</b>	<b>6.60</b>	

# Final Feasibility Study Arundo Donax

## Appendix E – Scenario Data

### Base Scenario

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 255,198	\$ 5,103,960
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 212,665	\$ 4,253,300
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 676,275	\$ 13,525,494
Wild Cane Cost	\$ 255,198	\$ 5,103,960
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (127,235)	\$ (120,702)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 676,275	\$ 13,525,494
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 529,777	\$ 10,595,546
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09

# Final Feasibility Study Arundo Donax

## Scenario 1 - Discount Rate 6%

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 255,198	\$ 5,103,960
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 212,665	\$ 4,253,300
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 676,275	\$ 13,525,494
Wild Cane Cost	\$ 255,198	\$ 5,103,960
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (127,235)	\$ (120,702)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 676,275	\$ 13,525,494
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 529,777	\$ 10,595,546
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09



# Final Feasibility Study Arundo Donax

## Scenario 2 - Discount Rate 10%

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 255,198	\$ 5,103,960
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 212,665	\$ 4,253,300
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 676,275	\$ 13,525,494
Wild Cane Cost	\$ 255,198	\$ 5,103,960
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (127,235)	\$ (120,702)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 676,275	\$ 13,525,494
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 529,777	\$ 10,595,546
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09

# Final Feasibility Study Arundo Donax

## Scenario 3 – Selling Price \$12

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 255,198	\$ 5,103,960
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 212,665	\$ 4,253,300
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 510,396	\$ 10,207,920
Wild Cane Cost	\$ 255,198	\$ 5,103,960
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (293,114)	\$ (3,438,276)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 510,396	\$ 10,207,920
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 695,656	\$ 13,913,120
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09

# Final Feasibility Study Arundo Donax

## Scenario 4 – Selling Price \$18

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 255,198	\$ 5,103,960
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 212,665	\$ 4,253,300
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 765,594	\$ 15,311,880
Wild Cane Cost	\$ 255,198	\$ 5,103,960
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (37,916)	\$ 1,665,684
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 765,594	\$ 15,311,880
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 440,458	\$ 8,809,160
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09

# Final Feasibility Study Arundo Donax

## Scenario 5 – Purchasing Price \$4

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 170,132	\$ 3,402,640
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 127,599	\$ 2,551,980
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 676,275	\$ 13,525,494
Wild Cane Cost	\$ 170,132	\$ 3,402,640
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (42,169)	\$ 1,580,618
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 676,275	\$ 13,525,494
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 529,777	\$ 10,595,546
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09

# Final Feasibility Study Arundo Donax

## Scenario 6 – Purchasing Price \$8

SUMMARY STATS		
Emissions per ton - Road Transport	0.0016	
Emissions per ton - Field Harvesting	0.0012	
Emissions per Imported MWh	0.8890	
Categories	Year 1	20 Years
Farmers		
Additional (Wild Cane) Revenues	\$ 340,264	\$ 6,805,280
Additional Cultivation cost	\$ 42,533	\$ 850,660
Additional Gross Profit	\$ 297,731	\$ 5,954,620
WCHC - Handling Facility		
Shredded Cane Revenues	\$ 676,275	\$ 13,525,494
Wild Cane Cost	\$ 340,264	\$ 6,805,280
Additional Operating Expense	\$ 548,312	\$ 8,542,236
Gross Profit	\$ (212,301)	\$ (1,822,022)
Emissions from Harvesting – tons of CO <sub>2</sub>	50.80	1,015.93
Emissions from Transport – tons of CO <sub>2</sub>	68.43	1,368.58
BELCOGEN		
Additional Energy Revenue	\$ 1,218,052	\$ 24,361,040
Additional Shredded Cane Cost	\$ 676,275	\$ 13,525,494
Additional Operating Expense	\$ 12,000	\$ 240,000
Additional Gross Profit	\$ 529,777	\$ 10,595,546
Emissions from biomass – tons of CO <sub>2</sub>	-	-
BEL		
Purchase saving benefit from substitution	\$ 767,232	\$ 15,344,640
Savings on purchasing Foreign Exchange	\$ 34,272	\$ 685,440
Additional Gross Profit	\$ 801,504	\$ 16,030,080
Emissions benefit - tons of CO <sub>2</sub>	10,241.28	204,825.60
Net CO2	10,122.05	202,441.09