AN ECONOMIC ANALYSIS OF LANDFILL GAS TO ENERGY PROJECTS IN THE ISLAND STATE OF TRINIDAD AND TOBAGO

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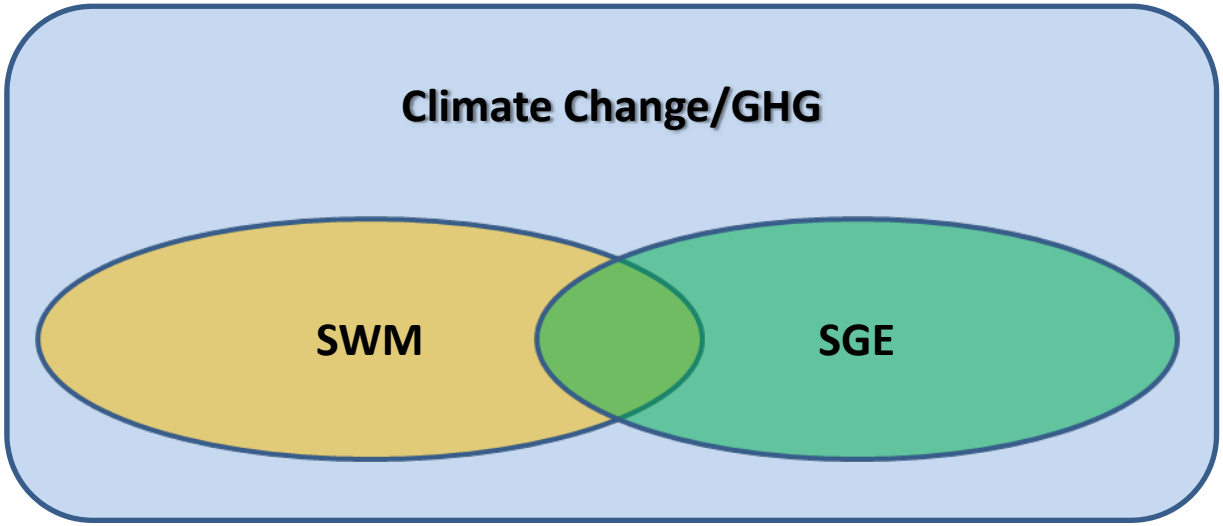
OUTLINE

- Overview (Introduction, Motivation, Research Question, Objectives)
- Profile of Trinidad and Tobago (Landfills and Waste)
- Landfill Gas to Energy Projects (LGEP)
- Structure of Research
- Methodology and Results
- Conclusion

INTRODUCTION

- Context of Research:
  - General:
    - Climate Change
  - Specific:
    - Sustainable Waste Management (SWM)
    - Sustainable Green Energy (SGE)/Renewable Energy (RE)

Diagram 1. Research Context



INTRODUCTION

- Majority of municipal solid waste in (MSW) Trinidad and Tobago (T&T) are disposed off in landfills
- T&T landfills are either close to capacity or are at capacity and still collecting waste
- 99 percent of electricity is generated from Natural Gas
- Drive for Renewable Energy is at its initial stage
- Trinidad and Tobago – lack of proper SWM programs and RE Initiatives

MOTIVATION

- T&T is seen as a relatively high emitter of GHGs as a Small Island Developing State (SIDS) in the Caribbean.

- Potential Impacts of GHGs– Humans and Environment in T&T.

- Need for projects and programs in T&T to mitigate GHG emission (Methane) and promote sustainable waste management and renewable energy.

PROBLÉMATIQUE/RESEARCH QUESTION

- Is it economically and environmentally feasible to manage municipal solid waste as an energy resource via the use of landfill gas to energy projects for electricity generation in the island state of Trinidad and Tobago?

OBJECTIVES

- Determine the quantities of methane emitted, per year basis;
- Determine the potential amount of electricity that can be generated from captured methane from landfills, per year basis;
- Identify the costs and the benefits of adopting and implementing landfill gas to energy projects in Trinidad and Tobago at the three main landfills
- Determine whether landfill gas to energy projects should be implemented at the three major landfills of Trinidad.

Summary of Literature Review

Table 1. Summary of Literature

Literature	Subject
Mets et al. (2007)	Solid Waste and Management
Midilli et al (2006)	Sustainable Green Energy
Hogland and Marques (2007)	Sustainable Waste Management
Afroz et al. (2010)	Determinants of Waste Generation
Singh et al. (2009)	Solid Waste and Methane Emissions in Trinidad and Tobago (CBA)
Jaramillo and Matthews (2005)	Cost and Benefits of LGEP
International Council for Local Environmental Initiatives (2009)	Landfill gas to energy projects
Pierpaoli and Diotallevi (2007)	Landfill gas to energy projects
Chiemchaisri, Ayuwat, and Putthamilinprateep (2007)	Landfill gas to energy projects

Profile of T&T in context of Solid Waste Management

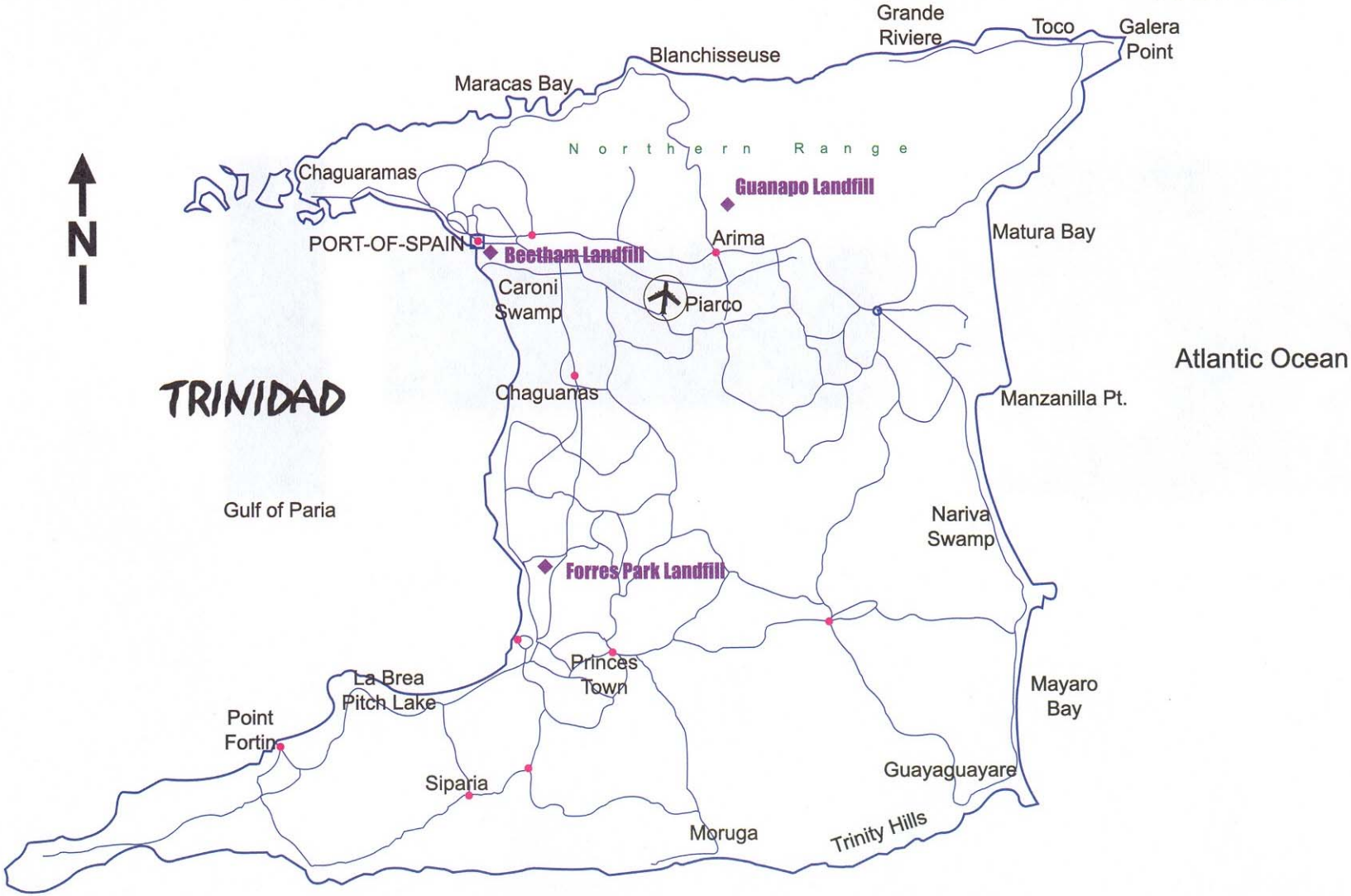
- The three main landfills in T&T are either close to capacity or are at capacity and still collecting waste
  - Beetham Landfill
  - Forres Park Landfill
  - Guanapo Landfill

- Majority of waste in T&T are disposed off in these landfills (Municipal Solid Waste)

- Came under management of SWMCOL in 1983, before they were open dumps

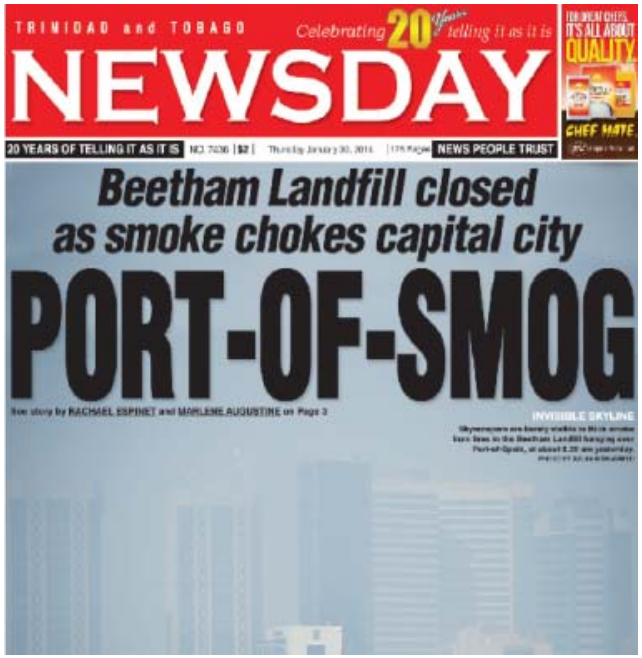
SWMCOL

Map showing locations of 3 Landfills in Trinidad managed by SWMCOL And 1 Landfill in Tobago managed by THA



Health and Environmental Impact of Emissions from Landfills

- Landfill gases can be carried into communities by surface level winds
- Toxic chemicals and compounds emitted from landfills (Respiratory Problems)
- Landfill gas can migrate via the soil underground
- Landfill gas poses explosion hazard

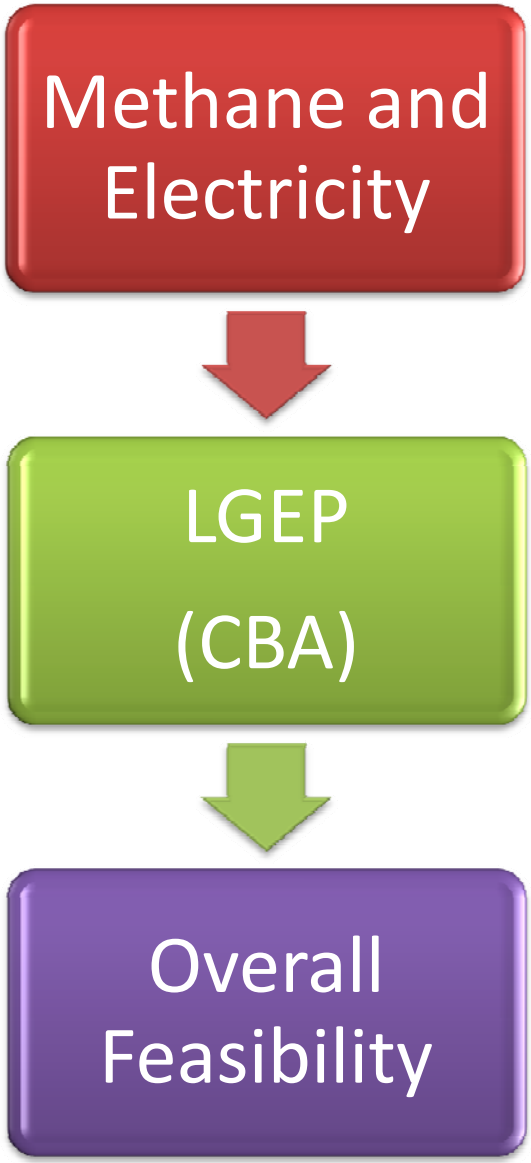


Solution - Landfill Gas to Energy Project (LGEP)

- LGEP came into being in the 1970's
- Significant implementation began in late 1990's
- LGEP through Implementation showed efficiency, dependability, and cost-savings
- Climate Change and Renewable Energy help spurred growth
- LGEP – Electricity Generation or Direct Use

Structure of Research

Diagram 2. Research Structure



Estimating Methane Emissions and Electricity Generation Potential

- **Methodology – Methane Emissions**
  - *The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*
  - Steps:
    - Estimate the total municipal solid waste generated and disposed of in solid waste disposal sites
    - Determine the CH_4 correction factors
    - Estimate the CH_4 production rate per unit of waste
    - Estimate the total net annual CH_4 emissions

- **Methodology - Electricity Generation**
  - Utilize the USEPA Conversion Factors
  - Steps:
    - Converted into standard cubic feet of methane
    - Methane to Electricity Ratio: 150 scf per minute = 0.778 megawatt
  - Account for Net Capacity Factor – 85% of electricity generated

Results from the Beetham Landfill

- **3.1554 Gigagram** of methane emitted annually
  - per year 149,190,467.4 scf of methane
  - per minute is 287.8 scf
  - 95% Collection Efficiency - 273.401 scf per minute

- **1.418 Megawatts** of electricity per minute
  - 85.08 MWh; 2,041.92 MW per day; 61,257.6 MW per month; 735,091.2 MW per year.

- Accounting for Net Capacity Factor (85%) of a LGEP - **1.2053 MW** per minute or
  - 72.318 MWh; 1,735.632 MW per day; 52,068.96 MW per month; 624,827.52 MW per year.

Results from the Forres Park Landfill

- **1.84012 Gg** of methane emitted annually
  - per year 87,002,713.72 scf of methane
  - per minute is 167.83 scf
  - 95% Collection Efficiency - 159.438 scf per minute

- **0.83 MW** of electricity per minute
  - 49.8 MWh; 1,195.2 MW per day; 35,856 MW per month; 430,272 MW per year.

- Accounting for Net Capacity Factor (85%) of a LGEP – **0.7055 MW** per minute or
  - 42.33 MWh; 1,015.92 MW per day; 30,477.6 MW per month; 365,731.2 MW per year.

Results from the Guanapo Landfill

- **0.9685 Gg** of methane emitted annually
  - per year 45,791,648.5 scf of methane
  - per minute is 88.333 scf
  - 95% Collection Efficiency - 83.916 scf per minute

- **0.435 MW** of electricity per minute
  - 26.1 MWh; 626.4 MW per day; 18,792 MW per month; 225,504 MW per year.

- Accounting for Net Capacity Factor (85%) of a LGEP **0.37 MW** per minute or
  - 22.2 MWh; 532.8 MW per day; 15,984 MW per month; 191,808 MW per year.

The Cost and Benefit Analysis

- **METHODOLOGY** (Cost)
  - The cost analysis for each of the LFGEP will be done via the use of the **Landfill Gas Energy Cost Model** (LFGcost-Web Model)
    - Economic Feasibility Assessment
    - Default inputs
    - Grounded on particular characteristics of the landfill under study as well as additional user input data
    - Estimated based on conventional electricity generating technologies
    - Construction and operation, project finance parameters, and economic outputs

- **METHODOLOGY** (Benefits)
  - Estimate the amount of methane mitigate if the LGEP is implemented (tons CO_2e per year)
  - Use the USEPA conversion displacement factor ratio for fossil fuel to determine mitigated CO_2 emissions (tons CO_2 per year)
  - Amount of electricity available for distribution (MWh)

The Cost and Benefit Analysis

Table 2. Cost Output

	Beetham Landfill			Forest Park Landfill			Guanapo Landfill		
	Internal Combustion Engines (15 year lifespan)	Gas Turbines (15 year lifespan)	Microturbines (10 year lifespan)	Internal Combustion Engines (15 year lifespan)	Gas Turbines (15 year lifespan)	Microturbines (10 year lifespan)	Internal Combustion Engines (15 year lifespan)	Gas Turbines (15 year lifespan)	Microturbines (10 year lifespan)
Total installed capital cost for year of construction (US$)	$7,713,027	$8,231,482	$6,518,119	$3,150,420	$3,502,243	$2,577,428	$1,615,012	$1,817,443	$1,370,420
Internal rate of return (%)	Negative	Negative	Negative	Negative	Negative	Negative	Very High	Very High	Negative
Net present value at year of construction (US$)	($3,309,808)	($3,163,825)	($2,108,875)	($264,081)	($178,948)	($186,364)	$75,149	$119,957	($88,276)
Net present value payback (years after operation begins)	None	None	None	None	None	None	1	1	None

The Cost and Benefit Analysis

Table 3. Benefit Output	Beetham Landfill	Forres Park Landfill	Guanapo Landfill	Total
Methane Mitigated (tons CO_2e per year)	62,950.23	36,710.394	19,321.575	**118,982.199**
Carbon Dioxide Mitigated from Fossil Fuels (tons CO_2 per year)	385,599.759	231,093.189	118,319.926	**735,012.874**
Electricity for Distribution (MWh)	72.318	42.33	22.2	**136.848**

CONCLUSION

- T&T can reduce methane emissions from landfill sites via landfill gas to energy projects for electricity generation. Also reduce carbon dioxide emissions from the burning of fossil fuels.

- Economically feasible to implement landfill gas to energy projects at the Guanapo Landfill.

- Not Economically Feasible at the Beetham Landfill Forres and Park Landfill Site.

- Overall, these projects provide a solution for sustainable green energy and sustainable waste management for the island of Trinidad and Tobago.