ANNEX 2

TROPICAL SUGAR COMPANY LIMITED (TSCL)

AIR EMISSIONS INVENTORY REPORT

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1. INTRODUCTION

Tropical Sugar Company Limited (TSCL) was incorporated on June 23, 2023 and will be operated as a vertically integrated sugar cane cultivation and sugar production company that will be located on the Vere Plains within the constituencies of southeast and southwest Clarendon, Jamaica. TSCL intends to build a 2500 TCD Sugar Plant with 12.5 MW Co-Generation Plant at Lionel Town, Clarendon. The TSCL factory will be located next to the existing decommissioned Monymusk Sugar Factory at Vere Plains, Clarendon. Figure 1 shows the location of the facility.

In addition to sugar, TSCL expects to manufacture, distribute locally and export downstream products inclusive of molasses, cane liquor, water for retail consumption and pharmaceutical products, among others, when fully operational and equipped.

TSCL will install a power generating plant that provides steam and electric power for the sugar manufacturing process at the factory. This air emissions inventory (AEI) highlights the main air emissions sources at TSCL and outlines the average and maximum expected emissions at TSCL. This AEI will facilitate the:

- Determination of the classification of the facility
- Development of a new air dispersion model for the facility, if needed, and
- Completion of an application to the National Environment & Planning Agency (NEPA) for an Air Pollutant Discharge Licence, if needed.

Figure 1: Google Earth Image: Location of TSCL Factory

2. TSCL MANUFACTURING PROCESS OVERVIEW & FLOW CHART

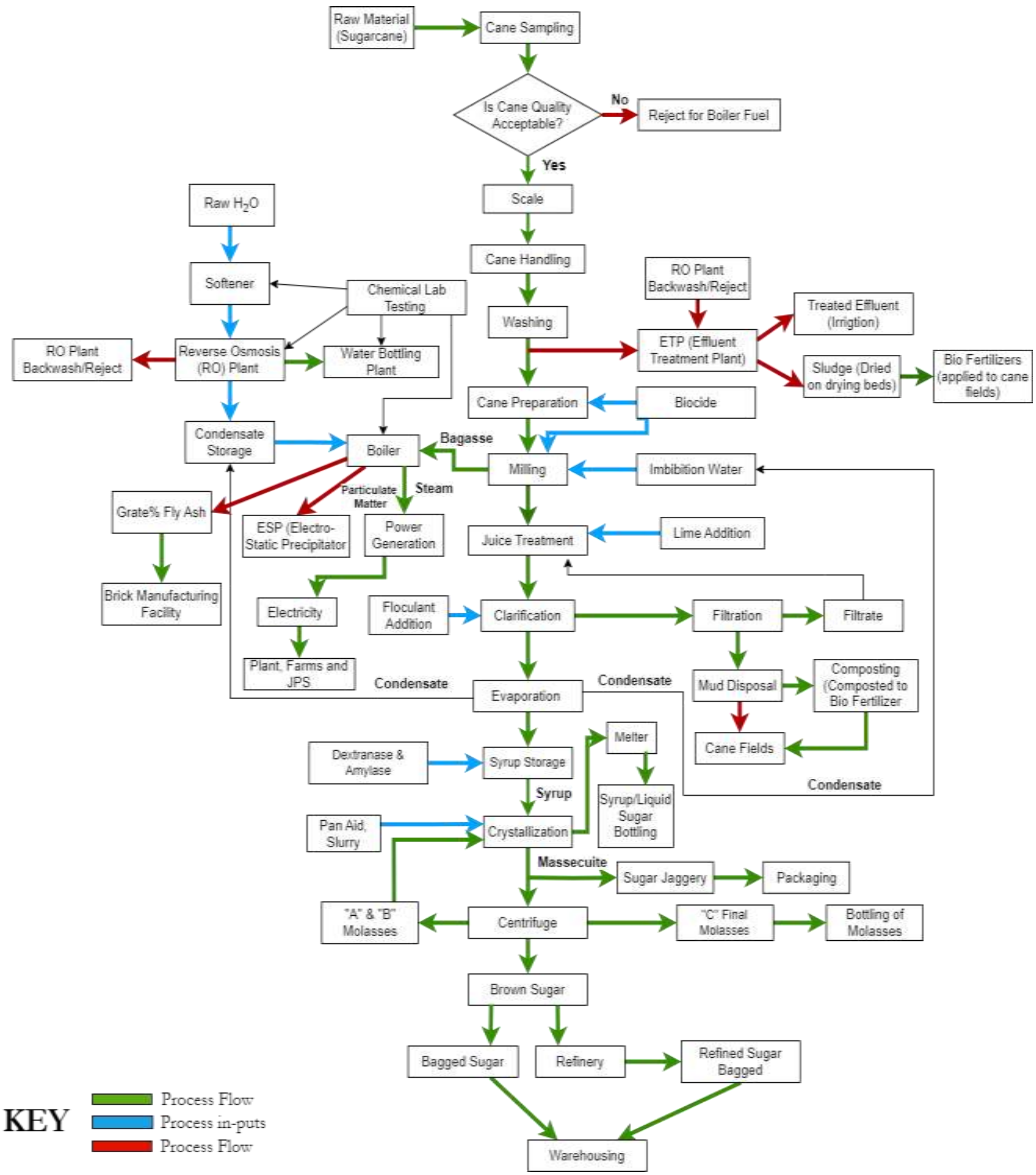
Figure 2 shows the detailed process flow chart for the manufacturing processes at TSCL. The main raw material, sugarcane, is sampled and tested for quality assessment. If the sugarcane quality is unacceptable, it will be repurposed for boiler fuel. When acceptable, the cane is weighed, washed and treated with biocide before it is milled. The effluent from the cane washing operation will be treated by an on-site Effluent Treatment plant and the treated effluent will be used for irrigation of the cane fields.

Imbibition water is added during the milling process and the cane juice is extracted for further processing while the fibrous residue from the milling process (bagasse) is stored for use as fuel for the boiler (BLR1) which will be used to produce steam for power generation. The cane juice is treated with lime before it is clarified and filtered. The clarified cane juice is then evaporated to form cane syrup and condensate. The condensate is re-used as imbibition water while the syrup is further processed by treating, crystallization and separation processes to create the desired products: sugar (raw, refined), sugar jaggery (massecuite), syrup (liquid sugar, sugar syrup) and molasses.

The residue from the clarification and filtration process will be composted to bio-fertilizer. The exhaust gases from the boiler will be passed through an electrostatic precipitator (ESP) which will use pneumatic means to collect and extract particulate matter from the exhaust gases before it is emitted from the boiler stack.

TSCL intends to produce 12.5 MW of power with bagasse as the primary fuel source for its co-generation facility. It is expected that 3.5 MW will be consumed by the Factory operations, 3.0 MW will be exported for use at the farms and the remaining +5.0 MW to 7.0 MW will be sent to the Jamaica Public Service Company Ltd. (JPSCo.) for the national grid.

Figure 2: TSCL Agro-processing Facility Process Flow Chart



3. SOURCES

TSCL has several sources of air emissions which are described in further detail in the sections 3.1 - 3.9 below.

The main air emissions sources include:

1. Bagasse Boiler
2. Diesel Generator

The significant fugitive air emissions sources include:

3. Bagasse Storage & Handling System

The insignificant fugitive air emissions sources include:

4. Sugar Production Process
5. Ash Storage & Handling System
6. Fuel Storage Tanks
7. Vehicle Engines
8. Paved & Unpaved Road Surfaces
9. Effluent Treatment Plant (ETP)
10. Sewage Treatment Plant

3.1 Bagasse & Wood Chips Fired Boiler

One (1) bagasse fired boiler will be used in the process to produce steam and electric power for use in the sugar manufacturing facility. The Terravista Solutions P. Ltd boiler (BLR1) will be rated for the generation of 75 MT/hr steam at 485±5°C, 6.6 MPa (66 kg/cm^2). This bi-drum, natural circulation watertube type boiler has a traveling grate combustor.

The boiler will typically use bagasse as the main fuel source. However, wood chips may be used during the off-peak season when the bagasse supply is low.

The exhaust from the boiler passes through an electrostatic precipitator (ESP) for particulate removal before being conveyed to the boiler stack (BLR1STCK).

The combustion of the bagasse and wood chips by the boilers and the emission of the exhaust from the stack will be the main source of stack air emissions at TSCL.

3.2 Diesel Generator

There will be one (1) main standby diesel generator (TSCLGEN1) which generates power for the process as necessary when there is no power supply from the boiler. The generator will be rated at 1,010 kVA. The generator emits its exhaust from its individual stack (GEN1STCK).

The combustion of diesel by the generator and the emission of the exhaust from the diesel generator stack is a source of stack air emissions at TSCL.

3.3 Bagasse Storage & Handling System

The bagasse storage and transportation system is mainly composed of 3 bagasse silos, a mechanized conveyor system, its supporting devices and an uncovered bagasse storage area (BAGASSE). The bagasse produced at the mills is either directly fed to the boiler via the bagasse silos or stored in stockpile(s) in the available space in the open yard (~ 10,000 m^2) before being fed to the boiler. The boiler will be fed from the bagasse silos using an overbed feeding system with a drum feeder below the bagasse silo and a bagasse extractor below the drum feeder.

The particulate matter generated by the crushing of the sugarcane and feeding the bagasse to the boiler occurs in enclosed areas. These activities are therefore insignificant sources of fugitive emissions at TSCL. However, the wind erosion of the particulate matter (PM) from the bagasse stockpile(s) is a significant source of fugitive air emissions at TSCL.

3.4 Sugar Production Process

Ethanol vapour is considered a Volatile Organic Compound (VOC) and it is produced during the sugar production process. This production of ethanol during the process operations will be an insignificant source of fugitive air emissions at TSCL.

3.5 Ash Storage & Handling System

The exhaust gases will contain ash from the combustion of the bagasse. The exhaust gases for the boiler will pass through the dust collecting plates in the two fields of the Electrostatic Precipitators (ESPs) to remove the ash particles before the exhaust gases are emitted from the stack. The ash that is collected by the ESP dust collecting plates will be collected in the ESP Ash hoppers. TSCL will install a Pneumatic Fly Ash Conveying system with vibrators on the hoppers to ensure the movement of the ash.

A horizontal belt conveyor will transport the ash from the discharge hoppers for the Economiser, Air heater and ESPs to an incline belt conveyor that transfers the ash to the 50 m^3 Ash Storage Silo. The silo will have a conditioned fly ash extraction system equipped to facilitate unloading of the ash into an open truck. The ash may then be transported by trucks for use in brick manufacturing.

The storage, handling and transportation of the ash will be a source of insignificant fugitive air emissions at TSCL.

3.6 Fuel Storage Tank

TSCL has one above ground diesel oil fuel storage tank with an operating capacity of 990 Liters and dimensions of 1m x 1m x 1.2m height.

The evaporative and standing emission losses of Volatile Organic Compounds (VOCs) from the above ground fuel storage tank will be an insignificant source of fugitive air emissions at TSCL. This fugitive air emissions source is considered insignificant for reporting purposes.

3.7 Vehicle Engines

The operations at TSCL will involve the use of several vehicles for the transportation and handling of sugarcane. For manual harvesting of sugarcane, Tractors, Grabbers, Cane Carts and manual loading may be used. For mechanical harvesting of sugarcane, Harvesters, Cane Carts and Tractors may be used.

The combustion of fuel by these vehicles will be a source of fugitive air emissions at TSCL. These fugitive air emission sources are considered insignificant for reporting purposes.

3.8 Paved & Unpaved Road Surfaces

The operations at TSCL involve the transportation of cane from the fields to the Factory for processing, and transportation of the ash from the ESPs to the brick manufacturing site. These roads are typically unpaved roads in the cane fields and paved public and private roads which are accessed by the vehicles when loaded and when empty.

Particulate matter (PM) generated from the use of the paved and unpaved surfaces will be a source of insignificant fugitive air emissions associated with the operations at TSCL.

3.9 Effluent Treatment Plant

The Effluent Treatment plant at TSCL includes the treatment of wastewater from the cane washing process and other sugar manufacturing processes and reject from the Boiler feed water Reverse Osmosis (RO) plant. The treated effluent will be used for irrigation of the sugarcane fields. The sludge residue from the treatment plant will be dried on drying beds and applied to the sugar cane fields as bio fertilizer.

Fugitive emissions result from volatilisation of compounds at the liquid surface of storage tanks during the various treatment phases in the overall collection, treatment and storage system. This will be a source of insignificant fugitive air emissions at TSCL.

3.10 Sewage Treatment Plant

The Sewage Treatment plant at TSCL will treat the wastewater derived from the operation of bathroom facilities at the sugar factory. The treated effluent will be used for the irrigation of the sugarcane fields. The sludge residue from the treatment plant will be dried on sludge drying beds and applied to the sugar cane fields as bio fertilizer.

Fugitive emissions result from volatilisation of compounds at the liquid surface of storage tanks during the various treatment phases in the overall collection, treatment and storage system. This will be a source of insignificant fugitive air emissions at TSCL.

4. INVENTORY ASSUMPTIONS

4.1 General

1. The assumptions about the maximum and average operating conditions were based on the information provided by TSCL, some of which was incorporated into the TSCL Factory Operations Project Brief (Environmental & Engineering Managers Limited (EEM), 2025).

2. The relevant emission factors were taken from the 'US EPA AP-42 Compilation of Air Pollutant Emission Factors' (US EPA AP-42) (United States Environmental Protection Agency (US EPA), n.d.) and the Australian National Pollutant inventory (NPi) Emission Estimation Technique (EET) Manuals (Australian Government, Department of Sustainability, Environment, Water, Population & Communities, n.d.). The following chemical formulae and terms were used for the pollutants:

    a. CH_4 – Methane
    b. CO – Carbon Monoxide
    c. NO_x – Nitrogen Oxides
    d. PM – Particulate Matter of all sizes
    e. PM_{10} – Particulate Matter with an aerodynamic diameter less than or equal to 10µm
    f. SO_2 – Sulphur Dioxide
    g. VOC – Volatile Organic Compounds
    h. TOC – Total Organic Compounds

4.2 Boiler

The overall emission rates for the boiler is calculated as the sum of the emission rates for the boiler while burning bagasse and the emission rates for the boiler while burning wood chips.

4.2.1 Bagasse Firing

1. The emission rates for the bagasse boiler were taken from US EPA AP-42 Chapter 1, Section 1.8 Bagasse Combustion in Sugar Mills, Table 1.8-1 (United States Environmental Protection Agency (US EPA)). The US EPA source classification code (SCC) 1-02-011-01 is applicable.

2. The expected bagasse composition is shown in Table 1.

Table 1: Expected Bagasse Composition

Fuel (Bagasse) Composition	% by weight as fired basis
Moisture	50
Ash	1.5
Carbon	23.5
Hydrogen	3.3
Nitrogen	0
Sulphur	0
Oxygen	21.8
Gross Calorific Value (GCV) (Kcal/kg)	2,272

(TERRAVISTA Solutions P. Ltd., 2025)

3. The average bagasse feed rate for the Boiler is 31 MT/hr per the boiler manufacturer.

4. The average annual bagasse operating hours is estimated to be 7,200 hours (~10 month operation).

5. The average annual bagasse consumption was estimated to be 223,200 MT/yr based on the average annual bagasse operating hours and average annual bagasse feed rate.

6. The maximum bagasse feed rate is reported as 35 MT/hr. This aligns with the ~33.2 MT/hr theoretically calculated based on its heating value and the 71.5% boiler efficiency reported by the manufacturer.
7. The maximum annual operating hours is estimated to be 8,000 hours (~11 month operation).
8. The maximum annual bagasse consumption is estimated to be 280,000 MT/yr based on the maximum annual operating hours and maximum annual bagasse feed rate.
9. The ESPs are designed to reduce the particulate matter from 2,200 mg/Nm^3 to 100 mg/Nm^3 (TERRAVISTA Solutions P. Ltd., 2025) and therefore has a 95.5% removal efficiency for PM/TSP which was used to adjust the AP-42 emission factor for the uncontrolled PM from 15.6 lb PM/MT bagasse to 0.71 lb PM/MT bagasse.
10. The emission factor for Polycyclic Organic Matter (POM) in bagasse was used to estimate the Volatile Organic Compounds (VOCs) in bagasse.

4.2.2 Wood Chips Firing

1. The wood residue is assumed to be dry wood which will be used in this industrial boiler. The US EPA source classification code (SCC) 1-02-009-08 is therefore applicable.
2. The emission factors for the combustion of wood chips in the boiler were taken from US EPA AP-42 Chapter 1, Section 1.6 – Wood Residue Combustion in Boilers, Table 1.6-1/2/3/4 (United States Environmental Protection Agency (US EPA)).
   a. The PM emission factor used is associated with the use of the ESP as a PM control device.
3. The dry wood chips are assumed to have a heating value of 8,000 MTU/lb per the US EPA AP-42 Section 1.6.1.
4. The maximum wood chip feed rate is estimated to be ~15 MT/hr based on its heating value and the 71.5% boiler efficiency reported by the manufacturer (TERRAVISTA Solutions P. Ltd., 2025).
5. The maximum annual wood chips consumption is reported to be 25,000 MT/yr.
6. The maximum annual operating hours for the boiler while using wood chips is estimated to be 1,667 hours (~69.5 days operation).
7. The average wood chips feed rate for the Boiler is assumed to be 80% of the maximum feed rate and is estimated to be 12 MT/hr.
8. The average annual wood chips operating hours is estimated to be 1,080 hours (~1.5 month operation).
9. The average annual wood chips consumption is estimated to be 12,960 MT/yr based on the average annual wood chips operating hours and average annual wood chips feed rate.

4.3 Diesel Generator

1. The diesel generator is classified to be a large stationary industrial diesel engine (>600 hp) and therefore the US EPA source classification code (SCC) 2-02-004-01 is applicable.

2. The emission factors for the combustion of diesel oil in the diesel generator were taken from US EPA AP-42 Chapter 3, Section 3.4 – Stationary Internal Combustion Sources, Table 3.4-1/2/3 (United States Environmental Protection Agency (US EPA)).
3. The diesel fuel quality is expected to meet the current standards of local supply and was assumed to be an average of diesel fuel quality provided to similar local industrial facilities.
    a. % Sulphur = 0.137%, Heat Content = 45,640 kJ/kg, Ash = 0.0003%, Density = 0.8485 kg/L
4. The average annual operating hours for the diesel generator is expected to be 500 hours as reported by TSCL.
5. The estimated maximum annual operating hours of the diesel generator is estimated to be 750 hours. This is estimated based on a 50% increase of the average annual operating hours.
6. The maximum hourly fuel consumption rate is estimated to be 117.37 L/hr for the generator based on the 1,010 kVA rating and an assumed 80% efficiency.
7. The maximum hourly fuel consumption rate and maximum annual operating hours result in a maximum annual fuel consumption of 88,028 L/yr for the generator.
8. The average hourly fuel consumption is estimated to be 82.16 L/hr for the generator, based on the assumption that the average fuel consumption rate is ~70% of the maximum fuel consumption rate.
9. The average hourly fuel consumption rate and average annual operating hours result in an average annual fuel consumption of 41,080 L/yr for the generator.

4.4 Bagasse Handling & Storage

1. The emissions of particulate matter from the bagasse stockpile (BAGASSE) due to wind erosion was taken from the Australian NPi EET Manual for Mining Version 3.1, January 2012 (A.1.1.18)
    a. 0.4 kg/ha/h TSP and 0.2 kg/ha/h PM_{10} due to wind erosion of active stockpile
2. The average annual bagasse storage area is ~ 0.75 ha (75% of the maximum area) and operates during the average annual boiler operating period.
3. The average annual operating hours is estimated to be 7,200 hours which is the operating hours for the boilers while burning bagasse.
4. The maximum annual bagasse storage area is 1.00 ha and operates during the maximum annual boiler operating period.
5. The maximum annual operating hours is 8,000 hours which is the maximum operating hours for the boilers while burning bagasse.

5. FINDINGS & RECOMMENDATIONS

The boiler and generator will be the main air emission sources at TSCL. The PM stack emission rates for the boiler due to the combustion of bagasse results in 354.5 g PM/MT bagasse input and therefore meets the 4,200 g PM/MT bagasse input emission standard for new sources. The boiler stack emission PM rates are well within compliance due to the use of the ESP to control the stack PM emissions. The facility has not yet received fuel certificates for the diesel oil, however, it is expected to meet the NRCA standard of 0.5% maximum sulphur content.

Table 2 and

Table 3 summarize the average annual and maximum annual emissions inventory results respectively. The detailed emissions inventory results in g/s and kg/hr are shown in Appendix 1.

The data shows that TSCL is classified as a major facility as defined in the 2006 NRCA Air Quality Regulations. The Natural Resources Conservation Authority (NRCA) Air Quality Regulations, 2006 defines a "major facility" as any facility having any air pollutant emitting activity or source with the potential to emit:

i. >100 MT/yr of one or more of the following parameters: SO_2, PM, CO and NO_x
ii. >5 MT/yr lead
iii. >10 MT/yr of any single priority air pollutant (PAP)
iv. >25 MT/yr of any combination of priority air pollutants (PAPs)

In the case of TSCL,

Table 3 shows that the maximum annual PM, NO_x and CO emissions are each greater than 100 MT/yr and this results in its classification as a major facility.

As a major facility, TSCL should complete a detailed air dispersion model to predict the ambient concentrations due to these emissions and determine their compliance with Jamaica National Ambient Air Quality Standards (JNAAQS). An application should subsequently be completed and submitted to the National Environment and Planning Agency (NEPA) for a new Air Pollutant Discharge licence for the facility.

Table 2: Summary of TSCL Annual Average Air Emissions

Pollutant	Generator 1	Boiler 1-Bagasse & Wood Chips	Bagasse Storage	TOTAL
	GEN1STCK	BLR1STCK	BAGASSE	
	MT/yr	**MT/yr**	**MT/yr**	**MT/yr**
SO_2	0.095	2.592		**2.69**
PM	0.048	84.73	2.16	**86.94**
PM_{10}	0.039	4.15	1.08	**5.27**
NO_X	2.19	184.72		**186.91**
CO	0.58	62.21		**62.79**
VOC (as TOC)		1.874		**1.87**
Pb		4.98E-03		**4.98E-03**
CO_2	112.86	194,313.6		**194,426**
CH_4	6.16E-02			**0.062**
Benzene	5.31E-04			**5.31E-04**
Xylenes	1.32E-04			**1.32E-04**
Formaldehyde	5.40E-05			**5.40E-05**
Acetaldehyde	1.72E-05			**1.72E-05**
Acrolein	5.39E-06			**5.39E-06**

Table 3: Summary of TSCL Annual Maximum Air Emissions

Pollutant	Generator 1	Boiler 1-Bagasse & Wood Chips	Bagasse Storage	TOTAL
	GEN1STCK	BLR1STCK	BAGASSE	
	MT/yr	MT/yr	MT/yr	MT/yr
SO_2	0.203	5.00		5.20
PM	0.102	110.07	2.88	113.05
PM_{10}	0.084	8.00	1.44	9.52
NO_X	4.69	266.00		270.69
CO	1.246	120.000		121.25
VOC (as TOC)		3.54000		3.540
Pb		9.60E-03		9.60E-03
CO_2	241.85	257,400		257,642
CH_4	0.13192			0.132
Benzene	1.14E-03			1.14E-03
Xylenes	2.83E-04			2.83E-04
Formaldehyde	1.16E-04			1.16E-04
Acetaldehyde	3.69E-05			3.69E-05
Acrolein	1.16E-05			1.16E-05

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Appendix 1: Detailed Emission Rates for TSCL

Table 4: Average and Maximum Emission Rates for TSCL in g/s and kg/hr

AVERAGE

Pollutant	Generator 1	Boiler 1- Bagasse & Wood Chips	Bagasse Storage	TOTAL	Generator 1	Boiler 1- Bagasse & Wood Chips	Bagasse Storage	TOTAL
	GEN1STCK	BLR1STCK	BAGASSE		GEN1STCK	BLR1STCK	BAGASSE	
	g/s	g/s	g/s	g/s	kg/hr	kg/hr	kg/hr	kg/hr
SO_2	0.053	0.667		0.719	0.19	2.40		2.59
PM	0.026	4.493	0.083	4.603	0.095	16.17	0.30	16.57
PM_{10}	0.022	1.067	0.042	1.130	0.078	3.84	0.15	4.07
NO_X	1.22	18.23		19.45	4.38	65.64		70.02
CO	0.323	16.00		16.32	1.16	57.60		58.763
VOC (as TOC)		0.458		0.458		1.648		1.648
Pb		1.28E-03		1.28E-03		4.61E-03		4.61E-03
CO_2	62.7	11,916.7		11,979.4	225.7	42,900.0		43,125.7
CH_4	0.0342			0.034	0.123			0.123
Benzene	2.95E-04			2.95E-04	1.06E-03			1.06E-03
Xylenes	7.33E-05			7.33E-05	2.64E-04			2.64E-04
Formaldehyde	3.00E-05			3.00E-05	1.08E-04			1.08E-04
Acetaldehyde	9.58E-06			9.58E-06	3.45E-05			3.45E-05
Acrolein	2.99E-06			2.99E-06	1.08E-05			1.08E-05

MAXIMUM

Pollutant	Generator 1	Boiler 1- Bagasse & Wood Chips	Bagasse Storage	TOTAL	Generator 1	Boiler 1- Bagasse & Wood Chips	Bagasse Storage	TOTAL
	GEN1STCK	BLR1STCK	BAGASSE		GEN1STCK	BLR1STCK	BAGASSE	
	g/s	g/s	g/s	g/s	kg/hr	kg/hr	kg/hr	kg/hr
SO_2	0.075	0.84		0.92	0.27	3.03		3.30
PM	0.038	18.36	0.100	18.50	0.136	66.10	0.36	66.59
PM_{10}	0.031	1.34	0.050	1.43	0.112	4.84	0.18	5.13
NO_X	1.74	44.47		46.21	6.25	160.09		166.34
CO	0.46	20.17		20.63	1.66	72.60		74.26
VOC (as TOC)		0.595		0.595		2.141		2.141
Pb		1.61E-03		1.61E-03		5.81E-03		5.81E-03
CO_2	89.6	42,954		43,043.7	322.5	154,635		154,957.5
CH_4	0.049			0.049	1.76E-01			0.176
Benzene	4.21E-04			4.21E-04	1.52E-03			1.52E-03
Xylenes	1.05E-04			1.05E-04	3.77E-04			3.77E-04
Formaldehyde	4.28E-05			4.28E-05	1.54E-04			1.54E-04
Acetaldehyde	1.37E-05			1.37E-05	4.92E-05			4.92E-05
Acrolein	4.28E-06			4.28E-06	1.54E-05			1.54E-05