2016 Reporting Year GHG Quantification
South American Conventional Oil & Gas Facilities
Gran Tierra Energy Inc.

Novus Reference No. 16-0389 FINAL REPORT August 11, 2017

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1.0 Introduction

Novus West Inc. (Novus) was retained by Gran Tierra Energy Inc. (GTE) to collect, summarize and quantify greenhouse gas (GHG) emissions for their assets located in Colombia and Brazil, based on the 2016 GHG calendar year emissions. While no local regulatory drivers exist for the region, GTE is acting as a responsible producer by committing to following international standards for voluntary reporting of GHG emissions. The 2016 Quantification report presented here is a continuation of the effort that began in 2015, and is intended to create a database of corporate GHG emissions related to South American assets as part of GTE's corporate sustainability initiatives.

2.0 Operations

GTE began its operations in Colombia in June 2006, as result of the acquisition of Argosy Energy. In 2007, GTE Colombia discovered the Juanambu (5 MM barrel gross) and Costayaco fields (50 MM barrel gross) in the Putumayo basin. The Costayaco facility started production in August, 2007. Moqueta was discovered in the Putumayo basin in 2010 and started production in June of 2011 after the pipeline was tied to Costayaco facilities. Currently GTE is the largest producer, reserve holder and exploration landholder in the Putumayo Basin of southern Colombia. In 2016, GTE acquired additional facilities in the Putumayo Basin and in the Middle Magdalena Valley (MMV) Basin, including Acordionero and its associated small facilities. In 2016, GTE also produced from the Tie field in Brazil.

Figure 1: GTE Assets in Colombia

Colombian assets include crude processing facilities in Sinu San Jacinto Basin, Llanos Basin, Putumayo Basin and Middle Magdalena Valley Basin. In addition to Colombian assets, GTE has Brazilian properties located in the Recôncavo Basin in the State of Bahia in Eastern Brazil. This report explicitly quantifies only GTE owned and operated assets and equipment, per the guidelines outlined by the International Petroleum Industry Environment Conservation Association (IPIECA). In 2016, average production had grown from approximately 24,000 in 2015 to 31,700 barrels of oil per day gross, due to the addition of Acordionero and other oil production facilities in the Middle Magdalena Valley.

3.0 Guidelines and Principles for Reporting

International guidance for greenhouse gas quantification and reporting is based on the Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions document (the Guideline), prepared by the IPIECA.

3.1 Reporting Guidance

The report was developed according to the following guidelines and standards:

- Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions, second edition, International Petroleum Industry Environment Conservation Association (IPIECA), the American Petroleum Institute (API) and International Association of Oil and Gas Producers (OGP), May 2011;
- Compendium of Greenhouse Gas Emission Estimation Methodologies for Oil and Gas Industry, API, August 2009 (the Compendium);
- AP-42, Fifth Edition Compilation of Air Pollutant Emission Factors, US Environmental Protection Agency (EPA), January 1995 (AP-42);
- Update of Fugitive Equipment Leak Emission Factors, Canadian Association of Petroleum Producer (CAPP), February 2014 (CAPP); and,
- Intergovernmental Panel on Climate Change (IPCC), 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

3.2 Reporting Principles

The reporting principles are described below (IPIECA, 2011):

Relevance: Define boundaries that appropriately reflect the GHG emissions of the organizations and the decision-making needs of users.

Completeness: Account for all GHG emission sources and activities which are material within the chosen organizational and operational boundaries. Any specific exclusions should be stated and justified.

Consistency: Use consistent methodologies and measurements to allow meaningful comparison of emissions over time. The consistent application of boundary definitions, accounting practices and calculation methodologies over time is essential for the production of comparable GHG emissions data. Transparently document any changes to the data, methods or any other factors in the time series.

Transparency: The degree of the information on the processes, procedures, assumptions and limitations of the GHG inventory are disclosed. Information should be reported in a clear, understandable, factual, neutral and coherent manner. Any changes to the data, methods or other factors affecting a time series of reported emissions should be transparently documented. The inventory process should be based on clear and complete documentation and archives.

Accuracy: Ensure that estimates of GHG emissions are systemically neither over nor under actual emission levels, as far as can be judged, and that uncertainties are quantified and reduced as far as practicable. Ensure that sufficient accuracy is achieved to enable users to make decisions with confidence as to the integrity of the reported GHG information.

4.0 Reporting Scope

4.1 Reporting Boundary

GTE's reporting boundary is intended to encompass the producing assets in both Colombia and Brazil. The boundary definition uses the control approach as outlined in the World Resources Institute WRI Greenhouse Gas Protocol, 2004. Under the control approach, a company accounts for 100 percent of the GHG emissions from operations over which it has control (WRI, 2004).

The Tie process plant and associated well pads in Brazil, and the Putomayo and Middle Magdalena Valley process facilities and well pads in Colombia constitute the 2016 GHG reporting boundary. Equipment located within the physical plant boundary but not operated by GTE are not included in the reporting boundary.

The emissions quantification has been performed in accordance with the reporting of Scope 1 emissions under the Guideline, which are defined as (IPIECA, 2011):

- combustion from stationary sources (e.g. fuel use in engines or turbines used to compress gases, pump liquids and generate electricity, and fuel use in heaters and boilers);
- combustion from flares and incinerators;
- combustion from company-owned mobile sources (e.g. transportation in motor vehicles and vessels, such as tank trucks and oil tankers);
- process emissions (e.g. glycol dehydration, acid gas removal/sulphur recovery, hydrogen production, fluid catalytic cracker (FCC) catalyst regeneration);
- venting emissions (e.g. vessel loading, tank storage and flashing, and venting of associated gas);
- fugitive emissions (e.g. leaks from equipment and piping components); and,
- non-routine events (e.g. gas releases during planned pipeline and equipment; and maintenance, releases from unplanned events).

4.2 Reporting Period

The reporting period for GHG emissions is defined as January 1st through December 31st, 2016.

4.3 Types of GHG Emissions

Six classes of greenhouse gases (GHGs) were identified as being of concern within the Kyoto Protocol (UNFCC, 2008):

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_2O),
- Sulfur hexafluoride (SF_6),
- Perfluorocarbons (PFCs); and,
- Hydrofluorocarbons (HFCs).

The most prevalent GHGs emitted from oil and natural gas industry operations are CO_2, CH_4, and N_2O, due to the number of combustion sources. HFC's are increasingly used in refrigeration systems, including virtually all motor vehicle air conditioners. Both HFC's and PFC's may be used as solvents, while PFC's are used in some fire extinguishing systems. Sulphur hexafluoride is found in high-voltage electrical equipment, and it is sometimes used as a tracer in pipelines (IPIECA, 2011).

The report will evaluate the potential emissions of the above six classes of GHGs within the reporting boundary.

4.4 GHG Reporting Unit

In order to account for direct and indirect varying effects of different types of GHGs, the concept of Global Warming Potential (GWP) has been introduced. The GWP of a greenhouse gas is defined as the ratio of the time-integrated radiative forcing (warming effect) from the instantaneous release of 1 kg of the GHG relative to that from the release of 1 kg of CO_2. Global warming potential is calculated over different time periods, typically ranging from 20 to 500 years. The most common time period for expressing GWPs is 100 years. The 100-year GWPs for the six GHGs covered by the Kyoto Protocol come from *Climate Change 1995: The Science of Climate Change* (IPCC, 1996), which is commonly referred to as the Second Assessment Report (SAR). In 2007, the IPCC published *Climate Change 2007: The Physical Science Basis* (IPCC, 2007), referred to as the Fourth Assessment Report (AR4), which contains revised GWPs (API, 2009).

In the report, the second set of GWP values (CO_2 GWP=1, CH_4 GWP=25 and N_2O GWP=298) from AR4 are applied. GHG emissions are reported as tonnes CO_2-equivalent basis (CO_2e) which is an aggregation of the mass of emissions of each GHG multiplied by its corresponding GWP.

4.5 Reforestation Initiative

GTE has implemented Reforestation and Conservation plans throughout Colombia. These long-term initiatives aid in absorbing carbon outputs from the industry. The reporting boundary is land owned in the Putumayo, Santander and Cesar regions. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories *Volume 4 – Agriculture, Forestry, and Other Land Use* was followed to determine the amount of greenhouse gas removed due to changes in biomass from the reforestation and conservation initiatives. Two chapters from the IPCC documents were followed: *Chapter 4 – Forest Land* and *Chapter 2 – Generic Methodologies Applicable to Multiple Land-Use Categories*. Within these chapters the methodologies for "Land Converted to Forest Land" was followed for the reforestation areas, and "Forest Land Remaining as Forest Land" was followed for the conservation areas.

5.0 Plant Process and Emission Sources

5.1 Description and Process Diagram

Crude oil extracted from GTE's wellpads are sent to the facility separators where oil and gas are separated. After the separated gases go through scrubbers, the gases are used at site for fuel for the heaters and electricity generators. Surplus gas is sent to the flare stack to burn.

Liquids are sent to vessels for separation of water and oil. The separated oil is then sent to tanks for storage and ultimately off-site transport through pipelines and tankers. Tank vapours at Costayaco are collected through a header and sent to the flare stack for destruction. The flare vapour collection efficiency from the tanks is 90%.

Figure 2 and **Figure 3** show the crude oil process at Costayaco and Moqueta respectively. There is an additional vessel located at Moqueta that is not shown in the figure. Process flow diagrams were not available for Tie or the MMV facilities, however a selection of aerial photographs for Acordionero, Colón and Santa Lucia facilities are presented in **Figure 4** through **Figure 6**, which illustrate the typical operations at these locations.

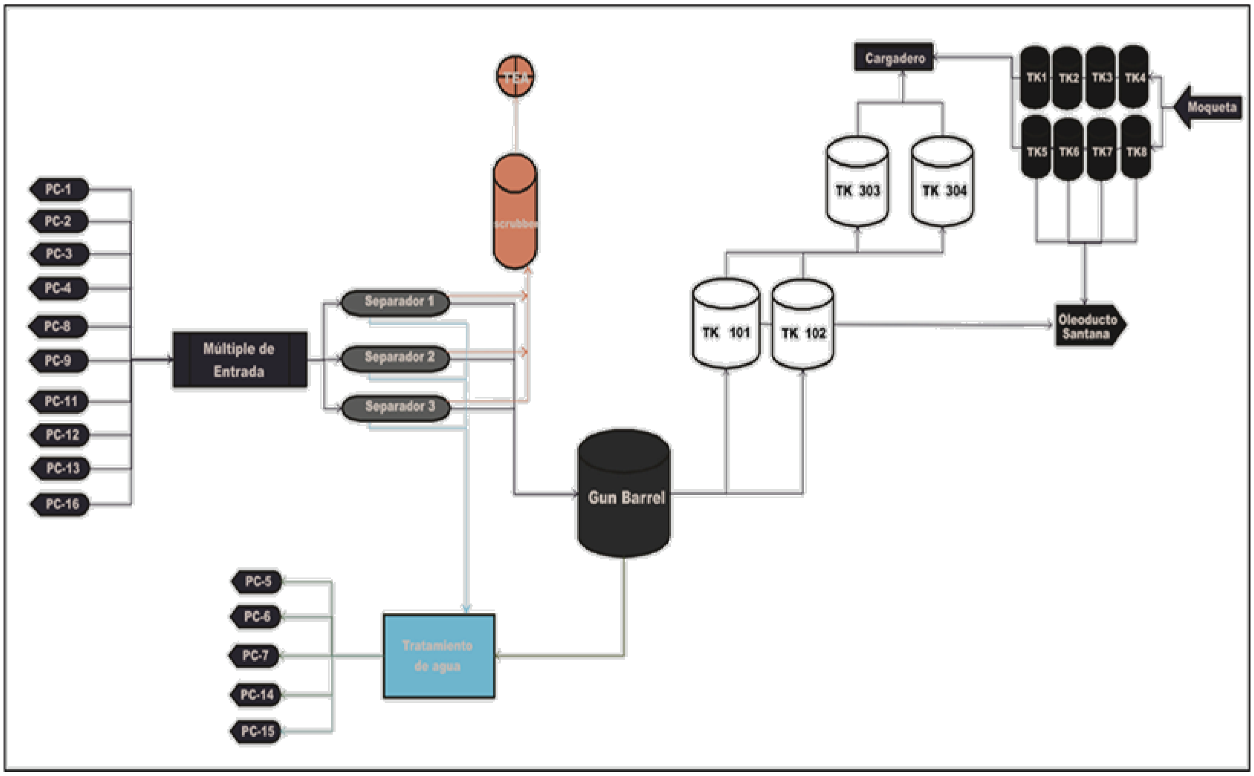

Figure 2: Costayaco Facility Process Flow Diagram

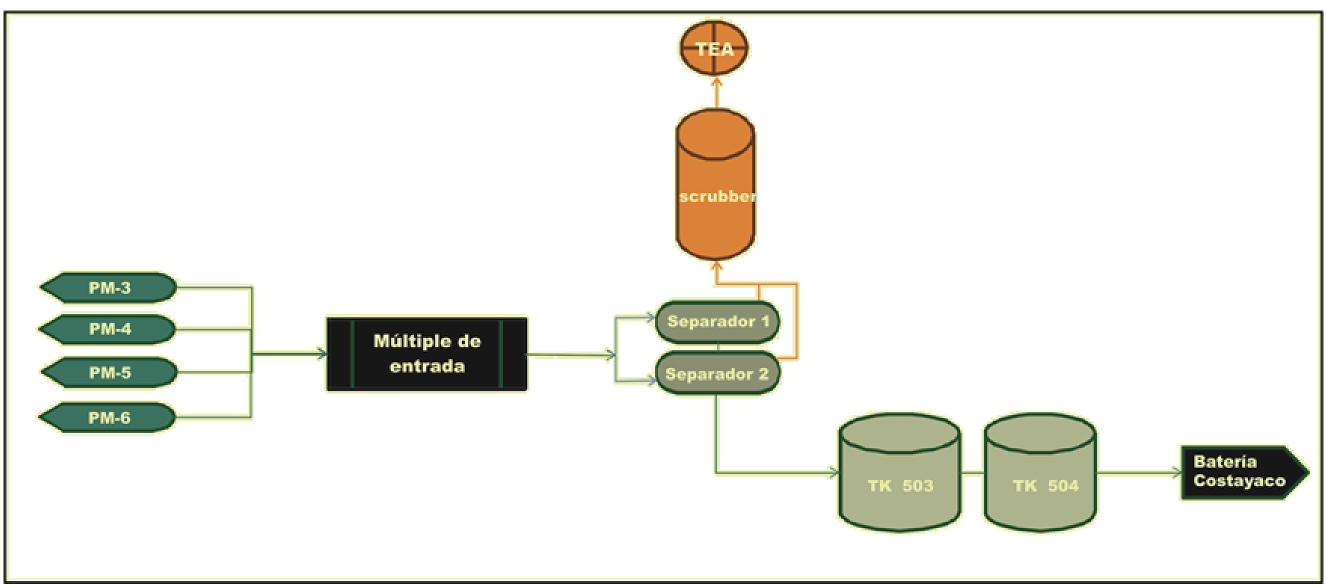

Figure 3: Moqueta Facility Process Flow Diagram

Figure 4: Aerial View of Acordionero Facility

Figure 5: Aerial View of Colón Facility

Figure 6: Aerial View of Santa Lucia Facility

5.2 Emission Sources and Relative Characteristic GHGs

5.2.1 Combustion Emission Sources

The combustion of carbon-containing fuels in stationary equipment such as engines, burners, heaters, boilers, flares, and incinerators results in the formation of CO_2 due to the oxidation of carbon. Very small quantities of N_2O may be formed during fuel combustion by reaction of nitrogen and oxygen. CH_4 may also be released in exhaust gases as a result of incomplete fuel combustion.

Emissions resulting from the combustion of fuel in transportation equipment that are included in the GTE owned and operated vehicle inventory only, are categorized as the mobile combustion sources included. Well exploration, drilling, testing and completions for all well pads were conducted by third-party companies; therefore, all combustion equipment used for these activities was excluded for reporting. Crude oil transportation from well pads to the processing plants and processed oil transportation out of the plants are via third-party owned pipelines and tank trucks; therefore, all emissions associated with operating these oil transfer methods have been excluded.

For both Costayaco and Moqueta, the gas-driven turbine generators are located within the facility's physical boundaries but are owned and operated by a separate company. As a result, their emissions were excluded from 2016 total emission calculations.

5.2.2 Process Emissions and Vented Sources

Vented sources occur as releases resulting from normal operations, maintenance and turnaround activities, and emergency and other non-routine events. These include sources such as crude oil, condensate, oil, and gas product storage tanks; blanket fuel gas from produced water or chemical storage tanks; loading/ballasting/transit sources, and loading racks. CH_4 is often released from the hydrocarbon storage tanks. Depending on the product composition, CO_2 may be a component of the products and potentially released through process and venting sources.

The following maintenance, turnover, and non-routine operations did not occur at the facilities in 2016:

- mud degassing;
- low pressure gas well casing;
- gathering pipeline blowdowns;
- vessel blowdowns;
- emergency shutdown/emergency safety blowdown;
- pressure relief valves (PRV's);
- well unloading and workovers; and,
- well blowouts (when not flared).

Only venting emissions due to tank flashing, storage and produced water occurred at the facilities during 2016 operations.

5.2.3 Fugitive Emission Sources

Fugitive emissions are characterized as unintentional releases, and can occur at piping components, equipment leaks near fittings, and from underground pipelines. Fugitive emissions are usually low volume leaks of process fluid (gas or liquid) resulting from the wear of mechanical joints, seals, and rotating surfaces over time. Specific fugitive emission source types include components and fittings such as valves, flanges, pump seals, compressor seals, pressure relief valves (PRV's), or sampling connections. Fugitive emissions also include non-point evaporative sources such as from wastewater ponds, pits, and impoundments. Similar to venting sources, CH_4 and CO_2 are potential GHGs depending on the composition of the product being released.

Table 1: Identified GHG Emission Sources at Gran Tierra Facilities

Facility	Emission Source	Emission Categories	GHGs
Tie Field (Brazil)	Heater/Treater	Combustion Source	CO_2, CH_4, N_2O
	Fire Pumps	Combustion Source	CO_2, CH_4, N_2O
	Internal Combustion Engines	Combustion Source	CO_2, CH_4, N_2O
	Flare	Combustion Source	CO_2, CH_4, N_2O
	Mobile	Combustion Source	CO_2, CH_4, N_2O
	Storage Tanks	Venting Source	CO_2, CH_4
	Leaks from Components and Process Lines	Fugitive Emission Source	CO_2, CH_4
Costayaco (Colombia)	Fire Pumps	Combustion Source	CO_2, CH_4, N_2O
	Internal Combustion Engines	Combustion Source	CO_2, CH_4, N_2O
	Turbine Generators	Combustion Source	CO_2, CH_4, N_2O
	Flares	Combustion Source	CO2, CH4, N_2O
	Crude Oil Storage Tanks	Venting Source	CO_2, CH_4
	Produced Water Tank	Venting Source	CH_4
	Leaks from Components and Process Lines	Fugitive Emission Source	CO_2, CH_4
Acordionero (Colombia)	Heater/Treater	Combustion Source	CO_2, CH_4, N_2O
	Fire Pumps	Combustion Source	CO_2, CH_4, N_2O
	Boiler	Combustion Source	CO_2, CH_4, N_2O
	Internal Combustion Engines	Combustion Source	CO_2, CH_4, N_2O
	Flare	Combustion Source	CO_2, CH_4, N_2O
	Storage Tanks	Venting Source	CO_2, CH_4
	Leaks from Components and Process Lines	Fugitive Emission Source	CO_2, CH_4
Los Ángeles, Santa Lucia (Colombia)	Heater/Treater	Combustion Source	CO_2, CH_4, N_2O
	Internal Combustion Engines	Combustion Source	CO_2, CH_4, N_2O
	Flare	Combustion Source	CO_2, CH_4, N_2O
	Storage Tanks	Venting Source	CO_2, CH_4
	Leaks from Components and Process Lines	Fugitive Emission Source	CO_2, CH_4
Moqueta, Colón, Chuira, Juglar, Juanambu, Guayuyaco (Colombia)	Internal Combustion Engines	Combustion Source	CO_2, CH_4, N_2O
	Flare	Combustion Source	CO_2, CH_4, N_2O
	Storage Tanks	Venting Source	CO_2, CH_4
	Leaks from Components and Process Lines	Fugitive Emission Source	CO_2, CH_4
Zoe, Gaitero, Tronos, Querbin (Colombia)	Storage Tanks	Venting Source	CO_2, CH_4

Potential emissions of the GHGs SF_6, PFC's and HFC's, from oil production have not been identified as being emitted from the reporting facilities. The emission sources and GHG's associated with GTE sources are summarized in **Table 1**.

6.0 Quantification Methodology

Greenhouse gas emission quantification methods were referenced from the Compendium. When necessary, AP-42 emission factors or CAPP guidance were applied when more appropriate emission quantification approaches were available versus those presented in the Compendium. Tank venting emissions were estimated using the US EPA software program TANKS 4.0.9d that uses meteorological and chemical data combined with AP-42 tank emission calculations.

A calculation spreadsheet was created to determine the emissions at the equipment level. The equipment emissions within the facility were summed according to the Guideline to determine facility level emissions. The corporate-level GHG emissions are an aggregate of all corporate owned facilities' emissions identified within the GHG quantification boundary. **Table 2** list the methodologies used for each emission source, including the relative fuel/gas properties and compositions. A methodology report documents equations, constants, assumptions and emission factors used for calculation is provided in **Appendix A**.

Table 2: Quantification Methodologies Used for Quantification

Emission Source	Emission Categories	Calculation Methodology			Emission Factor Reference	Fuel Property Reference
		CO_2	CH_4	N_2O		
Diesel Fire Pumps	Combustion Source	EF based on fuel type	EF based on fuel type	EF based on fuel type	Compendium Tables 4-3 and 4-5	Compendium Table 3-8
Diesel Internal Combustion Engines	Combustion Source	EF based on fuel type	EF based on fuel type	EF based on fuel type	Compendium Tables 4-3 and 4-5	Compendium Table 3-8
Heater/Treater	Combustion Source	Mass balance and fuel carbon content	Equipment Specific EF	Equipment Specific EF	Compendium Tables 4-7	Monthly gas analyses in pdf files
Turbine Generators	Combustion Source	Mass balance and fuel carbon content	Equipment Specific EF	Equipment Specific EF	Compendium Tables 4-9	Monthly gas analyses in pdf files
Storage Tanks	Venting Source	US EPA, AP-42	US EPA, AP-42	N/A	TANKS 4.0.9d	Monthly gas analyses in pdf files
Leaks from Components and Process Lines	Fugitive Emission Source	Fugitive components and EFs	Fugitive components and EFs	N/A	CAPP Fugitive EF, February 2014	CAPP UOG Volume 3 Table 5

7.0 Fuel Data and Meter System

Gas analyses were provided via populated spreadsheets for samples taken between 2007 and 2017, depending on the facility. Multiple samples were collected at Costayaco, Moqueta, Acordionero, Querbin, Juglar, Chuira, Los Ángeles, Santa Lucia, and Colón in Colombia, and eight samples were collected for Tie in Brazil.

7.1 Tie Field

At Tie, flare gas volumes are metered continuously using Flow Boss meters. The heater burns the same gas as the flare stack and is not metered since it is a relatively small volume compared to the flared gas volumes. Therefore, heater fuel consumption was estimated. Diesel volumes for fire pumps and engines were not directly available, so fuel consumption was estimated using output ratings and running hours of equipment. Mobile gasoline consumption was recorded using fuel purchase receipts.

The above fuel consumption, flared gas volumes and operational parameters for diesel equipment were manually input into the information collection spreadsheet tool for summarizing.

Flare gas was sampled on a monthly basis and monthly flare gas component analyses were provided. All gas analysis was used for calculating average mole carbon content, mass carbon content, high heating value and fuel molecular weight parameters for the combustion equipment sources and flare stacks.

7.2 Putomayo and Middle Magdalena Valley Basin Facilities

For the Putomayo and MMV basin facilities in Colombia, flared gas and gas-driven turbine generators are metered using Flow Boss meters. Flared gas volume and generator gas consumption data were reported on an annual basis. Monthly diesel consumption data was directly provided by GTE for diesel-driven fire pumps and internal combustion engines. Fuel consumptions used for the GHG emission calculations for the turbine generators were provided and used in the equations outlined in the attached methodology report.

8.0 Conclusions.

The 2016 GHG emissions for GTE are summarized in **Table 3** and presented by emission source category, facility and total emissions. The results show 2016 GHG emissions within the reporting boundary totalled **158,176.05 tonnes CO_2 equivalent (CO_2e).** Of note among the 2016 totals, Acordionero contributed 46.39% of total CO_2e emissions, respectively.

The largest source of GHG emissions for all facilities were stationary sources of combustion, specifically internal combustion engines and flares.

At Tie, the flare contributed 15.89% and stationary combustion sources contributed <1% of the total CO_2e emissions. All other combustion emission sources, together with fugitive emissions, contributed less than 1% of total CO_2e emissions.

For Acordionero, the flare contributed 11.46%, tank venting contributed 19.99% and stationary combustion sources contributed 14.87% of total CO_2e emissions, and fugitive emissions contributed less than 1%.

Costayaco and Moqueta were also significant contributors of GHG emissions, contributing 13.03% and 10.03% to the total CO_2e emissions, respectively. All other facilities contributed less than 12% of the total CO_2e emissions collectively.

For both Costayaco and Moqueta, gas-driven turbine generators are located within the facility physical boundary, but are owned and operated by other companies. The fuel consumption data was provided and emissions were calculated and are presented as reference information only.

Table 3: GHG Emission Summary for Each Facility and Total Emissions

Facility	Emission Category	Emission Source	t CO_2	t CH_4	t N_2O	Total tCO_2e	Percentage of Total CO_2e
			tonnes/year				%
Tie Field	Stationary Combustion	Diesel Fire Pumps	1.87	0.00	0.00	1.87	0.00%
		Diesel Internal Combustion Engine Generator	32.45	0.00	0.00	32.56	0.02%
		Gas Heater/Treater	705.83	0.01	0.00	706.88	0.45%
	Mobile Combustion	2 Pick up Trucks	250.87	0.01	0.00	251.74	0.16%
	Flaring	TA-6011.01-001	17,279.10	64.10	20.96	25,126.89	15.89%
	Tank Venting	Flashing Losses	2.35	154.28	-	3,859.42	2.44%
		Other Losses	0.15	26.92	-	673.21	0.43%
	Fugitive	Fugitive Components	0.33	1.66	-	41.95	0.03%
	Total Emission for Tie Field		**18,272.95**	**246.99**	**20.96**	**30,694.51**	**19.41%**
CPF Costayaco	Stationary Combustion	Diesel Fire Pumps	2.68	0.00	0.00	2.69	0.00%
		Gas Internal Combustion Engine Generator	8.89	0.00	0.00	8.91	0.01%
		Diesel Internal Combustion Engine Generator	11,560.08	0.47	0.09	11,599.67	7.33%
		Turbine Generators	23,874.01	1.15	0.41	24,025.35	-
	Flaring	TEA ALTA	4,709.89	17.47	5.71	6,849.02	4.33%
		TEA BAJA	455.97	1.69	0.55	663.06	0.42%
	Tank Venting	Flashing Losses	0.38	0.42	-	10.95	0.01%
		Other Losses	16.17	49.29	-	1,248.49	0.79%
		Produced Water Tank	-	7.01	-	175.29	0.11%
	Fugitive	Fugitive Components	0.47	2.37	-	59.71	0.04%
	Total Emission for CPF Costayaco		**16,754.52**	**78.73**	**6.36**	**20,617.78**	**13.03%**

CPF Moqueta	Stationary Combustion	Diesel Internal Combustion Engine Generator	7,480.69	0.30	0.06	7,506.31	4.75%
		Turbine Electric Generators	4,623.61	0.22	0.08	4,652.92	-
	Flaring	TEA ALTA	1,883.42	6.99	2.28	2,738.82	1.73%
		TEA BAJA	470.85	1.75	0.57	684.71	0.43%
	Tank Venting	Flashing Losses	20.32	159.05	-	3,996.45	2.53%
		Produced Water Tank	1.66	35.74	-	895.22	0.01%
		Other Losses	-	0.32	-	7.91	0.57%
	Fugitive	Fugitive Components	0.2784	1.4179	-	35.73	0.02%
	Total Emission for CPF Moqueta		**9,857.22**	**205.56**	**2.92**	**15,865.14**	**10.03%**
Guayuyaco	Stationary Combustion	Diesel Internal Combustion Engine Generator	261.55	0.01	0.00	262.45	0.17%
	Fugitive	Fugitive Components	0.1954	0.9954	-	25.08	0.02%
	Total Emission for Guayuyaco		**261.75**	**1.01**	**0.00**	**287.53**	**0.18%**
Juanambu	Stationary Combustion	Diesel Internal Combustion Engine Generator	65.39	0.00	0.00	65.61	0.04%
	Fugitive	Fugitive Components	0.0616	0.3139	-	7.91	0.01%
	Total Emissions for Juanambu		**65.45**	**0.32**	**0.00**	**73.52**	**0.05%**
Acordionero	Stationary Combustion	Gas Internal Combustion Engine Generator	18,132.80	0.53	0.15	18,189.73	11.51%
		Diesel Internal Combustion Engine Generator	2,350.62	0.10	0.02	2,358.67	1.49%
		Gas Heater/Treater	2,974.59	0.05	0.01	2,979.52	1.89%
	Flaring	Gas Burners	12,207.05	59.87	14.85	18,128.20	11.47%
	Tank Venting	Flashing Losses	19.66	976.89	-	24,441.91	15.46%
		Frac Tank	-	0.02	-	0.55	0.00%
		Other Losses	2.10	286.70	-	7,169.71	4.54%
	Fugitive	Fugitive Components	0.8071	4.1108	-	103.58	0.07%
	Total Emissions for Acordionero		**35,687.62**	**1,328.25**	**15.03**	**73,371.31**	**46.39%**

Los Ángeles	Stationary Combustion	Gas Heater/Treater	2,857.89	0.05	0.01	2,863.64	1.81%
		Diesel Internal Combustion Engine Generator	92.81	0.00	0.00	93.13	0.06%
	Flaring	Gas Burners	0.61	0.00	0.00	0.94	0.00%
	Tank Venting	Flashing Losses	2.10	119.02	-	2,977.54	1.88%
		Frac Tank	-	0.00	-	0.10	0.00%
		Other Losses	0.51	79.46	-	1,987.03	1.26%
	Fugitive	Fugitive Components	0.5602	2.8533	-	71.89	0.05%
	Total Emissions for Los Ángeles		**2,954.48**	**201.40**	**0.02**	**7,994.26**	**5.05%**
Santa Lucia	Stationary Combustion	Gas Heater/Treater	134.19	0.00	0.00	134.39	0.09%
		Diesel Internal Combustion Engine Generator	1.55	0.00	0.00	1.55	0.00%
	Flaring	Gas Burners	518.83	2.17	0.61	755.47	0.48%
	Tank Venting	Flashing Losses	0.21	11.17	-	279.38	0.18%
		Frac Tank	-	0.05	-	1.29	0.00%
		Other Losses	0.20	28.60	-	715.18	0.45%
	Fugitive	Fugitive Components	0.3269	1.6648	-	41.95	0.03%
	Total Emissions for Santa Lucia		**655.30**	**43.66**	**0.61**	**1,929.21**	**1.22%**
Colón	Stationary Combustion	Diesel Internal Combustion Engine Generator	15.98	0.00	0.00	16.04	0.01%
	Flaring	Gas Burners	414.20	1.64	0.48	599.36	0.38%
	Tank Venting	Flashing Losses	1.22	38.29	-	958.55	0.61%
		Frac Tank	-	0.00	-	0.01	0.00%
		Other Losses	0.59	50.49	-	1,262.86	0.80%
	Fugitive	Fugitive Components	0.1573	0.8010	-	20.18	0.01%
	Total Emissions for Colón		**432.15**	**91.23**	**0.48**	**2,857.01**	**1.81%**

Juglar	Stationary Combustion	Diesel Internal Combustion Engine Generator	1,175.77	0.05	0.01	1,179.80	0.75%
	Flaring	Gas Burners	0.75	0.00	0.00	1.10	0.17%
	Tank Venting	Flashing Losses	0.50	24.97	-	624.66	0.39%
		Frac Tank	-	0.07	-	1.69	0.00%
		Other Losses	0.22	29.62	-	740.73	0.47%
	Fugitive	Fugitive Components	0.17	0.89	-	22.36	0.01%
	Total Emissions for Juglar		**1,177.41**	**55.59**	**0.01**	**2,570.34**	**1.62%**
Chuira	Stationary Combustion	Diesel Internal Combustion Engine Generator	112.86	0.00	0.00	113.24	0.07%
	Flaring	Gas Burners	186.03	0.55	0.21	263.26	0.17%
	Tank Venting	Flashing Losses	1.99	32.53	-	815.14	0.52%
		Frac Tank	-	0.00	-	0.00	0.00%
		Other Losses	0.63	28.21	-	705.79	0.45%
	Fugitive	Fugitive Components	0.14	0.69	-	17.46	0.01%
	Total Emissions for Chuira		**301.64**	**61.98**	**0.21**	**1,914.89**	**1.21%**
Querbin	Tank Venting	Other Losses	0.13	19.69	-	492.41	0.31%
		Frac Tank	-	0.01	-	0.19	0.00%
	Fugitive	Fugitive Components	0.03	0.16	-	4.09	0.00%
	Total Emissions for Querbin		**0.16**	**19.86**	**-**	**496.69**	**0.31%**
Gaitero	Tank Venting	Other Losses	0.31	0.94	-	23.73	0.02%
		Frac Tank	-	0.01	-	0.19	0.00%
	Fugitive	Fugitive Components	0.03	0.16	-	4.09	0.00%
	Total Emissions for Gaitero		**0.34**	**1.11**	**-**	**28.02**	**0.02%**
Zoe	Tank Venting	Other Losses	0.11	2.39	-	59.93	0.04%
	Fugitive	Fugitive Components	0.02	0.11	-	2.73	0.00%
	Total Emissions for Zoe		**0.13**	**2.50**	**-**	**62.66**	**0.04%**

Tronos	Tank Venting	Other Losses	0.06	0.17	-	4.40	0.00%
	Fugitive	Fugitive Components	0.02	0.11	-	2.73	0.00%
	Total Emissions for Tronos		**0.08**	**0.28**	**-**	**7.13**	**0.00%**
Total Emissions for Gran Tierra			**86,420.5**	**2,314.7**	**46.6**	**158,176.1**	**100.00%**

Note: Greyed sources are owned by a third party and their total emissions are not included under GTE.
Other Losses under Tank Venting include standing and working losses.

8.1 Facility Emission Comparison

The most recent available year (2015) GHG emissions reported to Environment and Climate Change Canada from various oil and gas facilities across Canada were collected and summarized in **Table 4** below. For comparison purposes, facilities with similar total CO_2e emissions, were gathered. For a daily production rate of 31,700 boe/day, similar GHG emissions to those quantified for GTE are reported by Canadian oil production facilities of similar size.

Table 4: 2015 NPRI Reported GHG Emissions of Oil and Gas Facilities across Canada (in tonnes CO_2e)

Facility	Province	Production boe/d	t CO_2	t CH_4	t N_2O	Total tCO_2e
Orion Facilities – Osum Production Corp.	Alberta	35,000	197,358	717	290	198,364
Rush Lake Thermal Pilot & Commercial 12-03-048-21W3 – Husky Oil Operations Limited	Saskatchewan	10,000	144,996	871	331	146,198
AOC Hangingstone SAGD – Athabasca Oil Corporation	Alberta	12,000	171,521	2,517	307	174,345

8.2 Emission Intensity Comparison

Carbon emissions intensities were calculated for the 2015 and 2016 production totals following Carbon Disclosure Project reporting requirements. As shown in **Table 5**, the emissions intensity generally increased at each production field from 2015 to 2016 with the exception of the Tie Field in Brazil. As GTE acquired Guayuyaco and the MMV fields in 2016, there are no emissions intensities to report for 2015 for these fields. A general increase in oil production, newly acquired fields, and the addition of equipment, all attribute to the increase in tonnes of CO_2e emitted per barrels of oil equivalent (boe) in 2016.

Table 5: Carbon Emissions Intensities

Fields	2015 Metric Tonnes CO_2e per 1,000 boe	2016 Metric Tonnes CO_2e per 1,000 boe
Brazil	104.2	73.8
Costayaco	2.9	4.0
Guayuyaco	-	1.0
MMV	-	34.4
Moqueta	6.4	7.0
Total	**6.7**	**14.7**

9.0 Reforestation

Absorption of greenhouse gases through GTE reforestation and conservation initiatives were measured by calculating carbon stocks in biomass using IPCC 2006 Guidelines. The largest contribution to the reforestation initiative was the 145.5-acre plot of land in Putumayo planned to be converted to forest land. The reforestation totals are shown below in **Table 4.**

Table 6: Reforestation Carbon Stock Summary

Region	Emission Category	Emission Source	Carbon Stocks in Biomass tonnes C /year	% of Total
Santander - Mantanza	Conservation	Land Remaining Forest	72.52	2.30%
Santander - Rionegro	Reforestation	Land Converted to Forest	65.71	2.09%
Santander - Rionegro	Conservation	Land Remaining Forest	18.13	0.58%
Cesar - Rio de Oro	Conservation	Land Remaining Forest	45.33	1.44%
Cesar - Rio de Oro	Reforestation	Land Converted to Forest	147.59	4.69%
Putumayo	Reforestation	Land Converted to Forest	2799.95	88.91%
Total for Colombia			**3149.24**	**100.00%**

10.0 Recommendations

The 2016 GHG quantification summary was developed using the best available operational data and most representative gas analyses at the time of reporting. According to the GHG reporting principles, to improve the accuracy and completeness of the GHG reporting, some potential opportunities are identified for future improvement:

1. Reliable and current process flow charts and site plans for facilities are valuable for identifying the complete emission sources and representative gas analyses. Records documenting the operational changes, addition and/or removal of equipment in the reporting year allow for accurate tracking of the changes in GHG emissions by year.
2. For flare emissions, current and relevant gas analyses are requested, and that the relative monthly flared volumes are metered and recorded. This will improve emission accuracy by applying the calculated monthly carbon content, HHV and molecular weight to the respective monthly flare volumes.
3. A better inventory of vulnerable leak components should be prepared for fugitive emission estimation. In the report, the leak components were estimated based on the limited equipment information.
4. Gas volumes and relative gas compositions should be continued to be recorded during maintenance, turn-over activities and non-routine emergency conditions for quantifying the related venting emissions. These activities include, but not limited to:
   - mud degassing;
   - low pressure gas well casing;
   - pipeline pigging;
   - gathering pipeline blowdowns;
   - vessel blowdowns;
   - emergency shutdown / emergency safety blowdown;
   - pressure relief valves (PRVs);
   - well unloading and workovers; and,
   - well blowouts (when not flared).
5. For combustion equipment, in addition to fuel estimates based on fuel consumption from invoices, it is recommended that direct measurement using a flowmeter is used at least once a year. Leak detection measurements would assist in refining these estimates.
6. The addition of tank vapour control technology to the separators at Acordionero, Colón, Juglar, and Los Ángeles would help reduce emissions from tanks. Vapour control efficiencies can control up to 90% of emissions, drastically reducing emissions of greenhouse gases due to flashing.

7. An accurate inventory of the tanks products, including tracking of product throughput per facility would allow for refined estimates of tank venting emissions, especially at Acordionero where tank emissions estimates are significant.
8. A fully transparent data management system would assure that the operational and fuel data is relevant, accountable, accurate, transparent and trackable for GHG reporting purposes. The management system should clearly describe the process and relevant quality control and assurance procedures for data collection, transfer, documentation, storage, backup and reporting.
9. The meter calibration records should be kept and be accessible to auditors or users.

11.0 References

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