REPORT

Central Térmica de Temane Project - Greenhouse Gas Assessment

Moz Power Invest, S.A. and Sasol New Energy Holdings (Pty) Ltd

Submitted to:

Ministry of Land, Environment and Rural Development (MITADER)

Submitted by:

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Executive Summary

This GHG emissions assessment assesses the potential impacts of the GHG emissions that are expected to be emitted by the Central Termica de Temane (CTT) project, a 450 MW gas to power plant, which will be fed by gas from reservoirs to be produced in Phase I of development of the PSA license area of the Pande and Temane well fields in the Inhassoro District of Mozambique. The assessment considers the potential impacts of the two power technology options that are currently being evaluated:

- Open Cycle Gas Engines (OCGE); and
- Combined Cycle Gas Turbine (CCGT).

Moz Power Invest, S.A., a company to be incorporated under the laws of Mozambique with shareholding by Electricidade de Mozambique E.P. (EDM) and Temane Energy Consortium (Pty) Ltd (TEC), in a joint development agreement with Sasol New Energy Holdings (Pty) Ltd (SNE), hereafter referred to as the Proponent, is proposing the construction and operation of a gas to power facility, known as the Central Térmica de Temane (CTT) project. Based on equity share approach, it is expected that Moz Power Invest, S.A will account for 51% of the estimated GHG emissions, while SNE will account for the remaining 49% of estimated GHG emissions.

The assessment has been undertaken in accordance with the *GHG Protocol Corporate Accounting and Reporting Standard*, as well as the requirements of *IFC (2012) Performance Standard 3* and the *Equator Principles (2013)*. Relevant Mozambican policies and programmes are also considered.

In terms of the *GHG Protocol Corporate Accounting and Reporting Standard*, the following three 'scopes' are used for GHG accounting and reporting:

- **Scope 1: Direct GHG emissions:** Occur from sources that are owned or controlled by the organisation. This includes for example, emissions from combustion in boilers, furnaces, generators and company-owned vehicles;
- **Scope 2: Indirect electricity emissions:** Occur from the generation of purchased electricity or steam that is brought onto the organisation's property; and
- **Scope 3: Other indirect GHG emissions:** Occur from sources that are not owned or controlled by the organisation. This includes for example, purchased materials, transportation of materials, and the use of products sold to consumers.

The following are the Scope 1 and 2 emission sources that were included in the assessment:

- Stationary combustion (e.g. diesel generators, gas engines/turbines); and
- Mobile combustion (e.g. fleet vehicles, barges and tugs, construction vehicles and heavy goods vehicles).

Note that no purchased electricity (Scope 2) was included in the assessment as is assumed that the CTT project will be powered by onsite diesel generators during the construction and decommissioning phases, and the gas engines/turbines during the operational phase.

In terms of Scope 1 and 2 emissions, the OCGE and CCGT have similar a carbon footprint during the site preparation and construction phase (**4,273 tCO_2e** versus **5,652 tCO_2e**), as well as the decommissioning and closure phase (**2,818 tCO_2e** versus **3,448 tCO_2e**). While the recommended mitigation measures included in the GHG Emissions Management Plan (see Section 9.0) could potentially reduce these emissions by between 5%

and 15%, these savings are insignificant in comparison to carbon footprint during the operational phase. These mitigation measures should however still be implemented in accordance with good international industry practice.

During the operational phase, CCGT has a significantly smaller carbon footprint (**31.4 Mt**) than the OCGE (**38.6 Mt**). As a consequence, the technology option can have a significant influence on the magnitude of the carbon footprint. Thus, from a purely GHG Emissions perspective, CCGT is the preferred technology option as the carbon footprint is approximately 19% smaller.

In terms of the relevant Scope 3 emissions, OCGE has a marginally larger carbon footprint than CCGT in the site preparation and construction phase (**12,818 tCO_2e** versus **12,914 tCO_2e**), as well as the decommissioning and closure phase (**2,322 tCO_2e** versus **2,298 tCO_2e**). This is largely as a result of CCGT having a marginally higher number of units (39) that need to be transported between the cargo ship and the site using barges and heavy goods vehicles than OCGE (30).

The potential impacts of the CTT project's GHG emissions were assessed in terms of the following three benchmarks:

- Contribution of the CTT project to Mozambique's national GHG emissions;
- Product unit intensity; and
- Pre-defined thresholds.

While both options are rated the same in terms of the three benchmarks (i.e. **high**), it is worth noting that CCGT scored better than OCGE in respect of all three benchmarks, but not to the extent, that the overall rating was less than that of OCGE.

Table of Contents

TABLES

FIGURES

APPENDICES

No table of contents entries found.

ACRONYMS

Acronym	Description
ADT	Articulated dump truck
CCGT	Combined Cycle Gas Turbine
CH_4	Methane
CO_2	Carbon dioxide
CPF	Central Processing Facility
CTRG	Central Térmica de Ressano Garcia
CTT	Central Termica de Temane
DNAIA	Directorate of Environmental Impact Assessment
EBRD	European Bank of Reconstruction and Development
EDM	Electricidade de Mozambique
ESIA	Environmental and Social Impact Assessment
GHG Protocol	GHG Protocol Corporate Accounting and Reporting Standard
HFCs	Hydrofluorocarbons
INDC	Intended Nationally Determined Contribution
kV	KiloVolt
kW	KiloWatt
LDVs	Light delivery vehicles
LULUCF	Land Use, Land Use Change and Forestry
MITADER	Ministério da Terra, Ambiente e Desenvolvimento Rural
MW	Megawatt
MtCO2eq	Megatonnes carbon dioxide equivalent
N_2O	Nitrous oxide
NGICE	Natural gas internal combustion engine
NCCAMS	National Climate Change Adaptation and Mitigation Strategy
OCGE	Open Cycle Gas Engines
PFCs	Perfluorocarbons

Acronym	Description
PPZ	Partial protection zone
SF_6	Sulphur hexafluoride
SNE	Sasol New Energy Holdings (Pty) Ltd
SEPI	Sasol Exploration and Production International
tCO2eq	Tonnes carbon dioxide equivalent
TEC	Temane Energy Consortium (Pty) Ltd
UNFCCC	United Nations Framework Convention on Climate Change
VSDs	Variable speed drives

1.0 INTRODUCTION

The Mozambican economy is one of the fastest growing economies on the African continent with electricity demand increasing by approximately 6-8% annually. In order to address the growing electricity demand faced by Mozambique and to improve power quality, grid stability and flexibility in the system, Moz Power Invest, S.A. (MPI), a company to be incorporated under the laws of Mozambique and Sasol New Energy Holdings (Pty) Ltd (SNE) in a joint development agreement is proposing the construction and operation of a gas to power facility, known as the Central Térmica de Temane (CTT) project. MPI's shareholding will be comprised of EDM and Temane Energy Consortium (Pty) Ltd (TEC). The joint development partners of MPI and SNE will hereafter be referred to as the Proponent. The Proponent propose to develop the CTT, a 450MW natural gas fired power plant.

The proposed CTT project will draw gas from either the Sasol Exploration and Production International (SEPI) gas well field via the phase 1 development of the PSA License area, covering gas deposits in the Temane and Pande well fields in the Inhassoro District and the existing Central Processing Facility (CPF) or from an alternative gas source. Consequently, the CTT site is in close proximity to the CPF. The preferred location for the CTT is approximately 500 m south of the CPF. The CPF, and the proposed site of the CTT project, is located in the Temane/Mangugumete area, Inhassoro District, Inhambane Province, Mozambique; and approximately 40 km northwest of the town of Vilanculos. The Govuro River lies 8 km east of the proposed CTT site. The estimated footprint of the CTT power plant is approximately 20 ha (see Figure 1).

Associated infrastructure and facilities for the CTT project will include:

1) Electricity transmission line (400 kV) and servitude; from the proposed power plant to the proposed Vilanculos substation over a total length of 25 km running generally south to a future Vilanculos substation. [Note: the development of the substation falls outside the battery limits of the project scope as it is part of independent infrastructure authorised separately (although separately authorised, the transmission line will be covered by the Project ESMP, and the Vilanculos substation is covered under the Temane Transmission Project (TTP) Environmental and Social Management Plans). Environmental authorisation for this substation was obtained under the STE/CESUL project. (MICOA Ref: 75/MICOA/12 of 22nd May)];

2) Piped water from one or more borehole(s) located either on site at the power plant or from a borehole located on the eastern bank of the Govuro River (this option will require a water pipeline approximately 11km in length);

3) Access road; over a total length of 3 km, which will follow the proposed water pipeline to the northeast of the CTT to connect to the existing Temane CPF access road;

4) Gas pipeline and servitude; over a total length of 2 km, which will start from the CPF high pressure compressor and run south on the western side of the CPF to connect to the power plant or from an alternative gas source;

5) Additional nominal widening of the servitude for vehicle turning points at points to be identified along these linear servitudes;

6) A construction camp and contractor laydown areas will be established adjacent to the CTT power plant footprint; and

7) Transhipment and barging of equipment to a temporary beach landing site and associated logistics camp and laydown area for the purposes of safe handling and delivery of large oversized and heavy equipment and infrastructure to build the CTT. The transhipment consists of a vessel anchoring for only approximately 1-2 days with periods of up to 3-4 months between shipments over a maximum 15 month period early in the construction phase, in order to offload heavy materials to a barge for beach landing. There are 3 beach

landing site options, namely SETA, Maritima and Briza Mar (Figure 7). The SETA site is considered to be the preferred beach landing site for environmental and other reasons; it therefore shall be selected unless it is found to be not feasible for any reason;

8) Temporary bridges and access roads or upgrading and reinforcement of existing bridges and roads across sections of the Govuro River where existing bridges are not able to bear the weight of the equipment loads that need to be transported from the beach landing site to the CTT site. Some new sections of road may need to be developed where existing roads are inaccessible or inadequate to allow for the safe transport of equipment to the CTT site. The northern transport route via R241 and EN1 is considered as the preferred transport route (Figure 8) on terrestrial impacts; however, until the final anchor point is selected, and the barge route confirmed, the marine factors may still have an impact on which is deemed the overall preferable route.

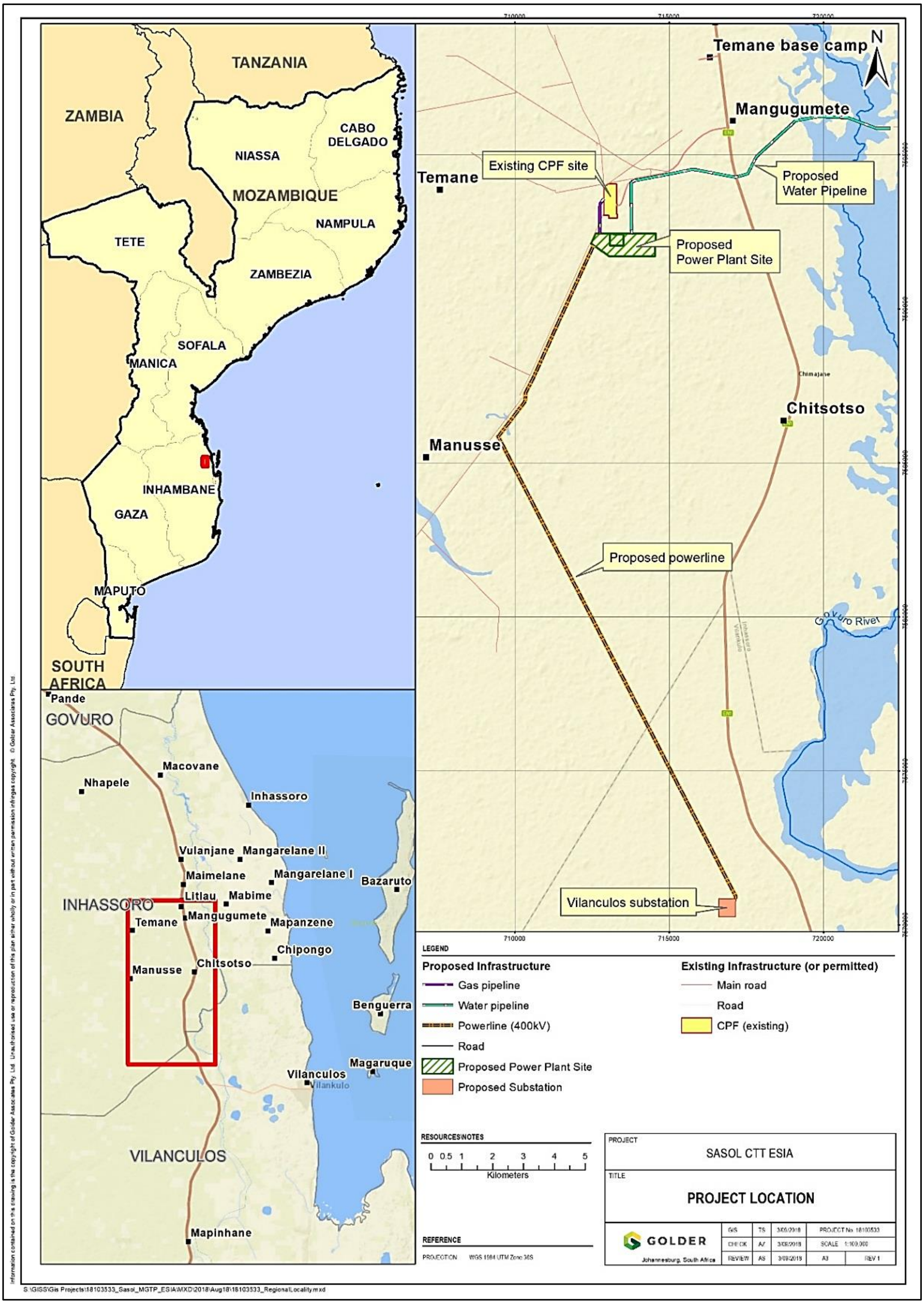

Figure 1: Project Location

2.0 DESCRIPTION OF THE KEY PROJECT COMPONENTS

The CTT project will produce electricity from natural gas in a power plant located 500m south of the CPF. The project will consist of the construction and operation of the following main components:

- Gas to Power Plant with generation capacity of 450MW;
- Gas pipeline (±2 km) that will feed the Power Plant with natural gas from the CPF or from an alternative gas source;
- 400kV Electrical transmission line (± 25 km) with a servitude that will include a fire break (vegetation control) and a maintenance road to the Vilanculos substation. The transmission line will have a partial protection zone (PPZ) of 100m width. The transmission line servitude will fall inside the PPZ;
- Water supply pipeline to a borehole located either on site or at borehole located east of the Govuro River;
- Surfaced access road to the CTT site and gravel maintenance roads within the transmission line and pipeline servitudes;
- Temporary beach landing structures at Inhassoro for the purposes of delivery of equipment and infrastructure to build the power plant. This will include transhipment and barging activities to bring equipment to the beach landing site for approximately 1-2 days with up to 3-4 months between shipments over a period of approximately 8-15 months;
- Construction camp and contractor laydown areas adjacent to the CTT power plant site; and
- Temporary bridge structures across Govuro River and tributaries, as well possible new roads and/or road upgrades to allow equipment to be safely transported to site during construction.

Figure 2: Examples of gas to power plant sites (source: www.industcards.com and www.wartsila.com)

The final selection of technology that will form part of the power generation component of the CTT project has not been determined at this stage. The two power generation technology options that are currently being evaluated are:

- Steam turbines for Combined Cycle Gas Turbine (CCGT); and
- Open Cycle Gas Engines (OCGE).

Please refer to Chapter 4 of the main ESIA document for further details on the technology option.

At this early stage in the project a provisional layout of infrastructure footprints, including the proposed linear alignments is indicated in Figure 1. A conceptual layout of the CTT plant site is shown below in Figure 3.

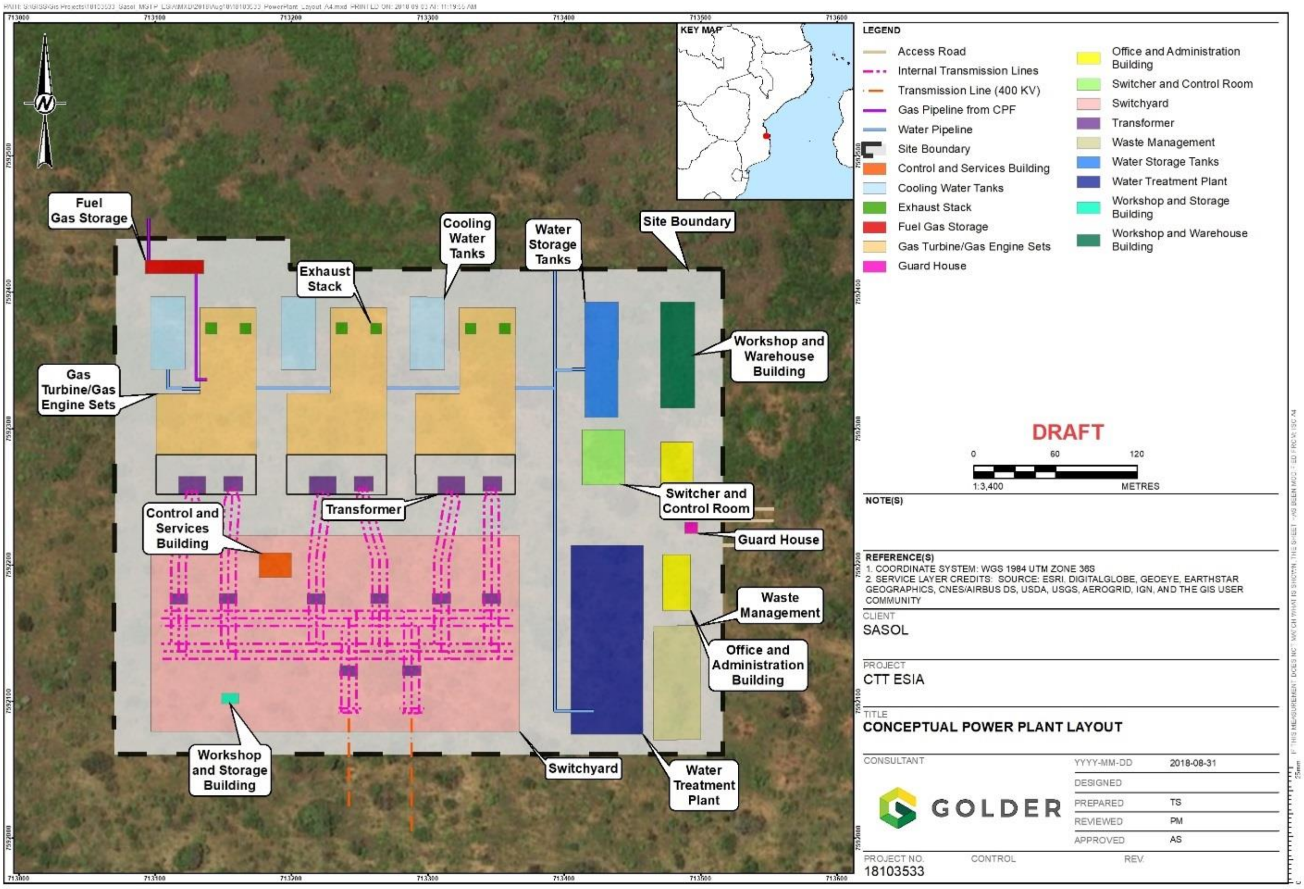

Figure 3: Conceptual layout of CTT plant site

2.1 Ancillary Infrastructure

The CTT project will also include the following infrastructure:

- Maintenance facilities, admin building and other buildings;
- Telecommunications and security;
- Waste (solid and effluent) treatment and/or handling and disposal by third party;
- Site preparation, civil works and infrastructure development for the complete plant;
- Construction camp (including housing/accommodation for construction workers); and
- Beach landing laydown area and logistics camp.

The heavy equipment and pre-fabricated components of the power plant will be brought in by ship and transferred by barge and landed on the beach near Inhassoro. The equipment and components will be brought to site by special heavy vehicles capable of handling abnormally heavy and large dimension loads. Figure 4, Figure 5 and Figure 6 show examples of the activities involved with a temporary beach landing site, offloading and transporting of large heavy equipment by road to site.

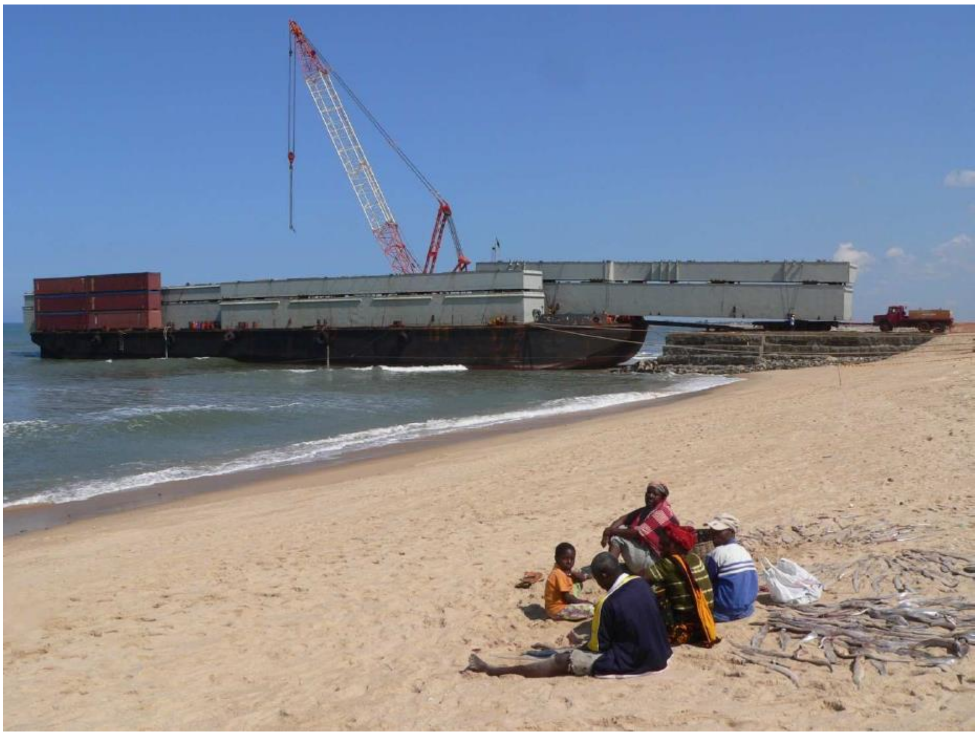

Figure 4: Typical beach landing site with barge offloading heavy equipment (source: Comarco)

Figure 5: Example of large equipment being offloaded from a barge. Note the levels of the ramp, the barge and the jetty (source: SUBTECH)

Figure 6: Heavy haulage truck with 16-axle hydraulic trailer transporting a 360 ton generator (source: ALE)

2.2 Water and electricity consumption

The type, origin and quantity of water and energy consumption are still to be determined based on the selected technology to construct and operate the CTT plant. At this stage it is known that water will be sourced from existing boreholes located on site or east of the Govuro River for either of the technology options below:

- Gas Engine: ± 12 m^3/day; or
- Gas Turbine (Dry-Cooling): ± 120 – 240 m^3/day.

2.3 Temporary Beach Landing Site and Transportation Route Alternative

As part of the CTT construction phase it was considered that large heavy equipment and materials would need to be brought in by a ship which would remain anchored at sea off the coast of Inhassoro. Equipment and materials would be transferred to a barge capable of moving on the high tide into very shallow water adjacent to the beach to discharge its cargo onto a temporary off-loading jetty (typically containers filled with sand) near the town of Inhassoro. As the tide changes, the barge rests on the beach and off-loading of the equipment commences.

Currently, the SETA beach landing site is the preferred beach landing site together with the road route option to be used in transporting equipment and materials along the R241 then the EN1 then via the existing CPF access road to the CTT site near the CPF. Figure 7 and Figure 8 indicate the beach landing site and route transportation option. The alternative beach landing sites of Maritima and Briza Mar are still being evaluated as potential options, as well as the southern transport route, which would also require road upgrades and a temporary bridge construction across the Govuro at the position of the existing pipe bridge. As part of the transportation route, the Grovuro River bridge may need to be upgraded / strengthened to accommodate the abnormal vehicle loads. Alternatively, a temporary bypass bridge will be constructed adjacent to the existing bridge.

Figure 7: The three beach landing site options and route options at Inhassoro

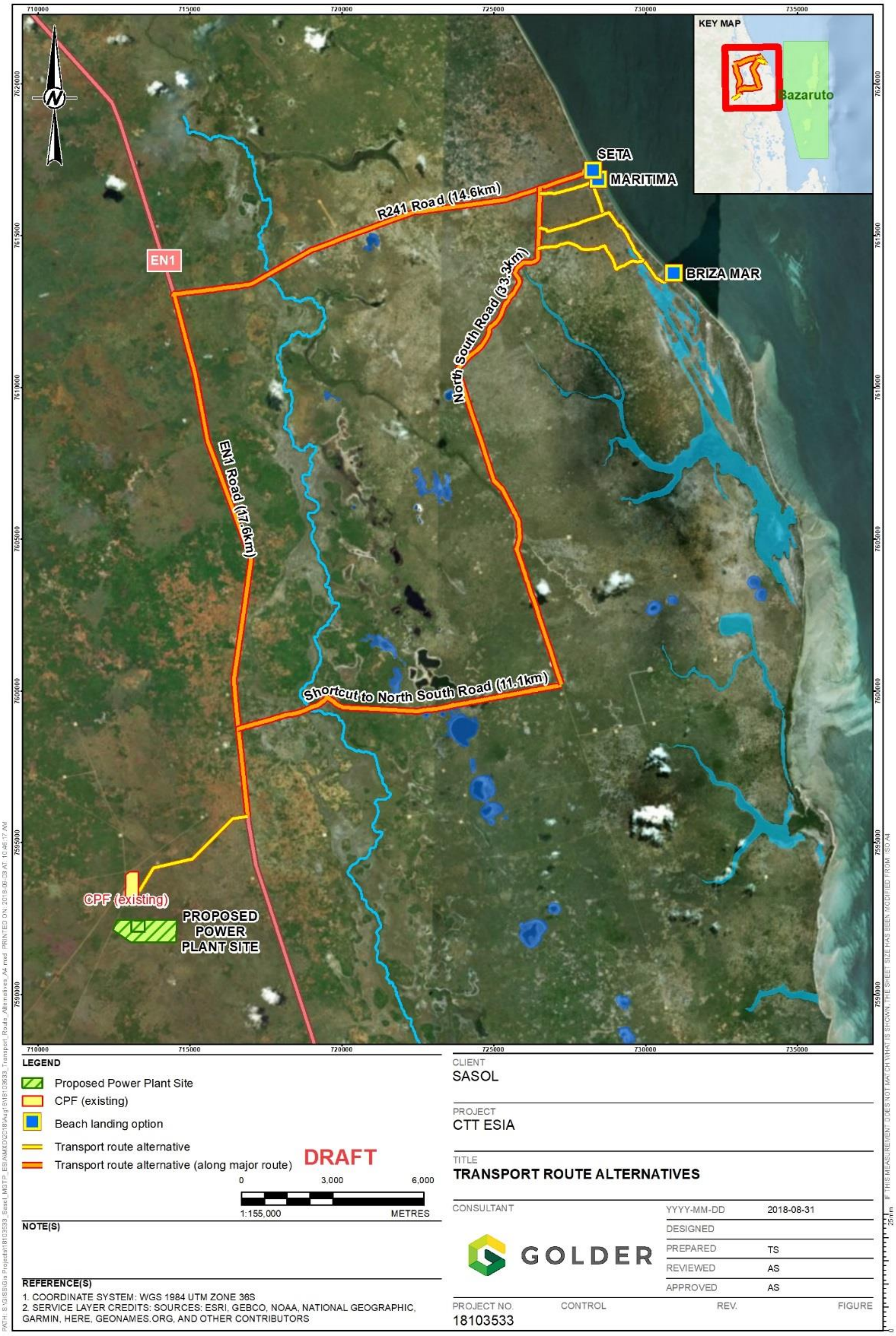

Figure 8: The two main transportation route alternatives from the beach landing sites to the CTT site

3.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The proposed project has been determined as ‘Category A’ in terms of Mozambique’s environmental law (Decree 54/2015 of 31 December, which has been in force since April 2016). For ‘Category A’ projects, an Environmental and Social Impact Assessment (ESIA) must be prepared by independent consultants as a basis for whether or not environmental authorisation of the project is to be granted, and if so, under what conditions. The final decision maker is the Ministry of Land, Environment and Rural Development (Ministério da Terra, Ambiente e Desenvolvimento Rural (MITADER) through the National Directorate of Environmental Impact Assessment (DNAIA). MITADER consults with other relevant government departments prior to making a decision.

This document represents the GHG Emissions Assessment undertaken to support the ESIA. This study is undertaken in terms of the IFC Performance Standard 3 on Resource Efficiency and Pollution Prevention (2012), the Equator Principles (2013), and the relevant Mozambican policies and regulations.

3.1 International Framework

3.1.1 IFC Performance Standards

With respect to resource efficiency and greenhouse gas emissions, the requirements of IFC (2012) Performance Standard 3 are as follows:

“6. The client will implement technically and financially feasible and cost effective measures for improving efficiency in its consumption of energy, water, as well as other resources and material inputs, with a focus on areas that are considered core business activities. Such measures will integrate the principles of cleaner production into product design and production processes with the objective of conserving raw materials, energy, and water. Where benchmarking data are available, the client will make a comparison to establish the relative level of efficiency.

7. In addition to the resource efficiency measures described above, the client will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. These options may include, but are not limited to, alternative project locations, adoption of renewable or low carbon energy sources, sustainable agricultural, forestry and livestock management practices, the reduction of fugitive emissions and the reduction of gas flaring.

8. For projects that are expected to or currently produce more than 25,000 tonnes of CO_2-equivalent annually, the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary, as well as indirect emissions associated with the off-site production of energy used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice” (IFC Performance Standard 3, 2012:)

3.1.2 Equator Principles

In terms of the Equator Principles (2013), a project which exceeds 100,000 tonnes of CO_2e (tCO_2e) annually for the operational phase of the project, is required to report on its combined Scope 1 and Scope 2 GHG emissions for the duration of the loan. Further to this, an evaluation of less GHG intensive alternatives is also required if the 100,000 tCO_2e threshold is exceeded.

3.2 Local Framework

In addition to the relevant IFC Performance Standards, this GHG Emissions Assessment also took cognisance of the following Mozambican policies and strategies relating to GHG emissions and climate change:

3.2.1 Intended Nationally Determined Contribution, 2015

As a signatory of the Paris Agreement (2015), Mozambique was required to develop and submit its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC). The INDC outlines Mozambique's proposed and adaptation measures for the period post-2020 (Republic de Mozambique, 2015).

The INDC will be implemented between 2020 and 2030. During this period, Mozambique aims to reduce its GHG emissions by 76.5 $MtCO_2e$, with 23.0 $MtCO_2e$ by 2024 and 53.4 $MtCO_2e$ from 2025 to 2030. The INDC acknowledges that these reductions are estimates with a significant level of uncertainty and will be updated as more detailed information becomes available.

According to the INDC, these reductions will be achieved through the implementation of existing policy actions and programmes, such as the National Climate Change Adaptation and Mitigation Strategy (2012) – see Section 3.2.2. The extent of the reductions is however conditional on the provision of financial, technological and capacity building from the international community.

3.2.2 National Climate Change Adaptation and Mitigation Strategy, 2012

The purpose of Mozambique's National Climate Change Adaptation and Mitigation Strategy (NCCAMS) is to establish a set of guidelines for action in order to increase the resilience of communities and the national economy (Republic de Mozambique, 2012). This includes the reduction of climatic risks, and promoting low carbon development and the green economy through the integration of adaptation and mitigation in sectoral and local planning. The time period of the NCCAMS is 2013 to 2030.

The NCCMS acknowledges that Mozambique is particularly vulnerable to the effects of climate due to its location in the zone of inter-tropical convergence, its location downstream of shared watersheds, its long shoreline and the existence of extensive lowlands below sea level. Mozambique's vulnerability is further exacerbated by its low adaptive capacity, poverty, limited investment in modern technology, and weaknesses in its infrastructure and social services, especially those related to health and sanitation.

According to the NCCAMS, the effects of climate change can already be seen in Mozambique with changes in temperature and precipitation patterns, sea-level rises and the increase in the frequency and intensity of extreme climatic events, such as droughts, floods and tropical cyclones. These events result not only in the destruction of infrastructure, but also the loss of human lives, crops, livestock and wildlife.

The NCCAMS recognises that adaptation and climate risk reduction is a national priority, and that there is a need to make use of the opportunities that the country has, without compromising development, in order to reduce the potential impacts of climate change through a set of mitigation and low-carbon development actions. These actions are grouped under two main pillars, namely adaptation and climate risk reduction and mitigation and low carbon development, as well as cross sectoral issues.

3.2.3 Other Relevant Polices and Programmes

In addition to INDC and NCCAMS, this assessment also considered the following policies and programmes:

- Energy Strategy (being updated and to be approved by 2016);
- Biofuel Policy and Strategy;
- New and Renewable Energy Development Strategy (2011 to 2025);
- Conservation and Sustainable Use of the Energy from Biomass Energy Strategy (2014 to 2025);
- Master Plan for Natural Gas (2014 to 2030);

- Renewable Energy Feed-in Tariff Regulation (REFIT);
- Mozambique's Integrated Urban Solid Waste Management Strategy (2013 – 2025);
- National REDD+ Strategy (in preparation and to be approved in 2016);
- Renewable Energy Atlas for Mozambique;
- Project to build and manage two solid waste landfills with the recovery of methane;
- Project of Urban Mobility in the Municipality of Maputo;
- Poverty Reduction Action Plan, 2011;
- Gender, Environment and Climate Change National Strategy, 2010; and
- Initial National Communication, 2003.

4.0 BASELINE

4.1 Mozambique's Net GHG Emissions

In 2013, the total GHG emissions of Mozambique was estimated to be 66.8 MtCO^{2}e (USAID, 2017). If global GHG emissions at the time was approximately 48,257 MtCO^{2}e, Mozambique's contribution to the world total GHG emissions was 0.14%.

Mozambique's GHG profile was dominated by the emissions from Land Use, Land Use Change and Forestry (LULUCF), which accounted for 58.8% of total emissions. Agriculture was the second largest contributor with 26.8%, followed by energy (8.9%), waste (4%), and industrial processes (1.5%).

On average, Mozambique's GHG emissions increased by 1% per annum from 55.1 MtCO^{2}e in 1990 to 66.8 MtCO^{2}e (11.7 MtCO^{2}e increase). During this period, GHG emissions from LULUCF increased by on average 0.5% per annum, agriculture (1.5%), energy (2.2%), waste (7.9%), and industrial processes (26%).

5.0 STUDY METHODOLOGY

This GHG Emissions Assessment has been undertaken in accordance with the *GHG Protocol Corporate Accounting and Reporting Standard* (GHG Protocol).

This standard was developed by the World Resources Institute and World Business Council for Sustainable Development, in consultation with businesses, non-governmental organisations, and governments (WBCSD and WRI, 2004). The aim was to develop an internationally accepted GHG accounting and reporting standard for organisations preparing a GHG inventory.

The standard covers the six GHGs covered by the Kyota Protocol. This includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

6.0 PROJECT BOUNDARIES

In determining the GHG inventory of the CTT project, it is critical to firstly define the organisational and operational boundaries of the assessment.

6.1 Organisational Boundaries

Organisations vary in their legal and organisational structures, and like financial accounting, reporting on the GHG emissions of operations is dependent on the structure of the organisation, and whether the operations are wholly owned, joint ventures or subsidiaries (WBCSD and WRI, 2004). The organisation boundaries should clearly state the makeup of the company, and the operations that the organisation owns or controls.

In defining the organisational boundaries, there are generally two distinct approaches, namely equity share and control (WBCSD and WRI, 2004). With the equity share approach, the organisation accounts for GHG emissions from operations according to its share of equity in the operation. Typically, the equity share is equivalent to the organisation's percentage ownership. With the control approach, the organisation accounts for 100% of the GHG emissions from operations over which it has control. In terms of this approach, an organisational is not accountable for operations in which it owns a percentage but has no control. Control can be in the form of either financial control, in which the organisation directs the financial and operational policies of the operation, or operational control, where the organisation has the full authority to introduce and implement operational policies.

This GHG Emissions Assessment will report on GHG emissions from the CTT project in terms of the equity share approach, where it is expected that Moz Power Invest, S.A will account for 51% of the estimated GHG emissions, while SNE will account for the remaining 49% of estimated GHG emissions.

6.2 Operational Boundaries

In defining the operational boundaries, the GHG emissions associated with the organisations operations are identified and characterised as either direct or indirect emissions (WBCSD and WRI, 2004).

In order to help with the characterisation of direct and indirect emission sources, three 'scopes' are used for GHG accounting and reporting. The use of scopes not only improves transparency and consistency in reporting, but also ensures that different organisations do not account for emissions in the same scope (i.e. double counting). A brief description of the three scopes is provided below:

- **Scope 1: Direct GHG emissions:** Occur from sources that are owned or controlled by the organisation. This includes for example, emissions from combustion in boilers, furnaces, generators and company-owned vehicles;
- **Scope 2: Indirect electricity emissions:** Occur from the generation of purchased electricity or steam that is brought onto the organisation's property; and
- **Scope 3: Other indirect GHG emissions:** Occur from sources that are not owned or controlled by the organisation. This includes for example, purchased materials, transportation of materials, and the use of products sold to consumers.

Figure 9 below presents an overview of Scope 1, Scope 2, and Scope 3 emissions across the value chain of an organisation.

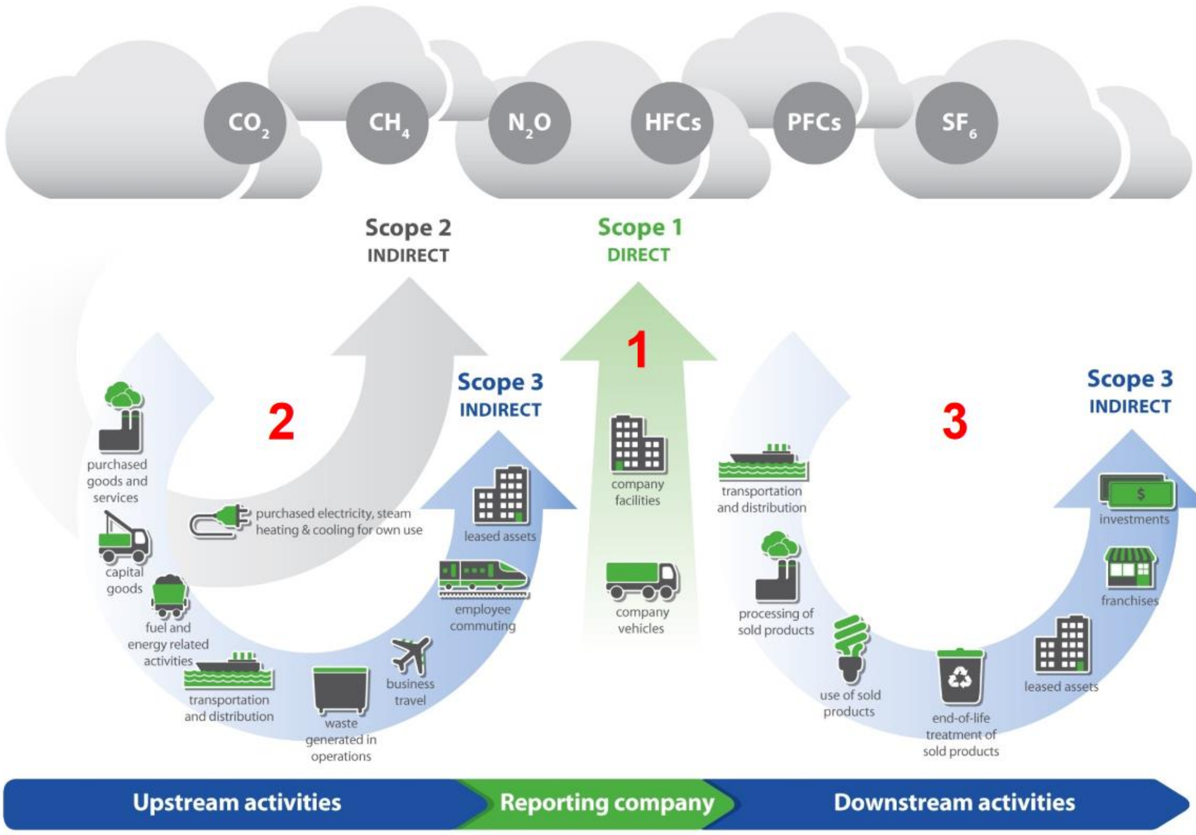

Figure 9: Overview of Scope 1, Scope 2 and Scope 3 emissions across the value chain (Source: WBCSD & WRI, 2004)

In terms of the GHG Protocol, organisations are required to report on both Scope 1 and Scope 2 emissions. As mentioned previously this also a requirement of IFC Performance Standard 3 for projects that are expected to produce more than 25,000 tCO_2e annually, as well the Equator Principles for projects that are expected to produce more than 100,000 tCO_2e annually.

Table 1 below presents a summary of the GHG emissions sources that were considered in this assessment, in each of the three project phases, namely site preparation and construction, operation, and decommissioning and closure.

Table 1: Summary of GHG emissions sources included in the assessment

Scope	Site preparation and construction	Operation	Decommissioning and Closure
1	■ Fleet vehicles (mobile combustion); ■ Diesel generators (stationary combustion); and ■ Water supply (stationary combustion).	■ Gas engines/turbines (stationary combustion); ■ Fleet vehicles (mobile combustion); ■ Diesel generators (stationary combustion); and	■ Fleet vehicles (mobile combustion); ■ Diesel generators (stationary combustion); and ■ Water supply (stationary combustion).

Scope	Site preparation and construction	Operation	Decommissioning and Closure
		■ Water supply (stationary combustion).	
2	■ n/a	■ n/a	■ n/a
3	■ Barges and tugs (mobile combustion); ■ Heavy goods vehicles between beach landing and site (mobile combustion); ■ Construction vehicles (mobile combustion); and ■ Heavy goods vehicles delivery locally-sourced construction materials.	■ n/a	■ Barges and tugs (mobile combustion); ■ Heavy goods vehicles between site and beach landing (mobile combustion); and ■ Construction vehicles (mobile combustion).

6.3 Reporting Period

The reporting period of this GHG Emissions Assessment is from the start of construction of the CTT project (approximately 21-22 months), during the operational phase (approximately 25 years), and to the end of decommissioning and closure (approximately 12 months).

This assessment is the first GHG inventory for the CTT project, which can be used as a baseline against which to track and compare the GHG emissions of the CTT project over time. It is recommended that this inventory or baseline is retrospectively recalculated should any new or additional information become available, or there are changes to the project which would compromise the accuracy of the baseline.

Further to this, it is recommended that the GHG baseline for the CTT project is reviewed, and updated if required, on an annual basis during the operational phase. Importantly, the baseline should be informed by credible data collected in accordance with the recommended GHG Emissions Monitoring Programme as detailed below in Section 10.0.

6.4 Exclusions

Table 2 presents a summary of the GHG emissions that have been excluded from this assessment, and the motivation for the exclusion.

Table 2: Summary of the exclusions of this GHG Emissions Assessment

Scope	Category	Emissions Source	Comment
1	Water treatment	Water treatment plant	It is proposed that the CTT project will have an onsite water treatment plant to supply treated water to the gas engines/turbines. The GHG emissions of the

Scope	Category	Emissions Source	Comment
			water treatment plant have however been excluded as these have been accounted for in the gas consumption of the gas engines/turbines during the operational phase.
1	Water treatment	Sewage treatment plant	It is proposed that the CTT project will have an onsite sewage treatment plant to treat domestic sewage from the construction camp during the construction phase and operations during the operational phase. The GHG emissions of the sewage treatment plant have however been excluded as these have been accounted for in the diesel consumption of the diesel generators during the construction phase and the gas consumption of the gas engines/turbines during the operational phase.
1	Water treatment	Effluent treatment plant	It is proposed that the CTT project will have an onsite effluent treatment plant to treat effluent from the gas to power plant during the operational phase. The GHG emissions of the effluent treatment plant have however been excluded as these have been accounted for in the gas consumption of the gas engines/turbines during the operational phase.
1	Liquid fuels	Lubricants	The GHG emissions resulting from the consumption of lubricants has been excluded as it is expected to be minimal, and to have limited impact on the overall GHG emissions.
1	Fugitive emissions	Gas pipelines	The GHG emissions resulting from leaks or unintended releases from the gas pipelines. Fugitive emissions have been excluded as it is expected to be minimal, and to have limited impact on the overall GHG emissions.
2	Stationary combustion	Purchased electricity	It is proposed that the CTT project will be powered by onsite diesel generators during the construction and decommissioning phases and the gas engines/turbines during the operational phase. No electricity generated offsite will be used by the CTT project.
3	Freighting goods	Cargo ship	The GHG emissions resulting from the cargo ship transporting the gas engines/turbines, transformers, and HSRGs has been excluded from the assessment as this is owned and operated by a third-party.

Scope	Category	Emissions Source	Comment
3	Employee travel	Vehicles and aircraft	The GHG emissions resulting from the travel of employees to and from site has been excluded from the assessment as this will constitute a relatively small contribution to overall GHG emissions.
3	Waste disposal	Landfill	The GHG emissions resulting from the offsite disposal of waste has been excluded from the assessment as this will constitute a relatively small contribution to overall GHG emissions.
LULUCF	Land use change	Site preparation	The GHG emissions resulting from the clearing of biomass on site. Land use change has been excluded from the assessment due to the limited area affected by the land use change (< 20 ha), the degraded state of the natural habitat on site, and the small contribution of land use change to the overall GHG emissions.

7.0 GHG EMISSIONS

The calculation of the CTT project's GHG emissions was based on the methodology as detailed above in Section 5.0. The activity data, which is defined as the non-financial data associated with activities that generate emissions during the reporting period, was sourced from a number of documents provided by the SNE. These documents are cited in the text below and referenced in Section 13.0.

7.1 Scope 1 and 2 Emissions

Table 3 presents the estimated Scope 1 and Scope 2 GHG emissions for OCGE and CCGT during the site preparation and construction, operation, and decommissioning and closure phases.

Table 3: Estimated Scope 1 and Scope 2 emissions for OCGE and CCGT

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
Site preparation and closure	1	Fleet vehicles	Diesel	146	158	Based on the diesel consumption of 2 x utility vehicles and 1 x bus operating on average 40 hours per month, and 1 x ambulance operating on average 4 hours per month, for the duration of site preparation and construction phase.
	1	Diesel generators	Diesel	4 073	5 435	Based on the diesel consumption of 5 x 450 kW (500 kVA) generator sets operating on average 12 hours per day for the duration of site preparation and construction phase. The demand is based on average number of workers that are expected to be living at the construction camp.
	1	Water supply	Diesel	54	59	Based on the diesel consumption of 1 x 25 kW generator and pump set operating on average 24 hours per day for the duration of site preparation and construction phase. The demand is based on average number of workers that are expected to be living at the construction camp, and an average 1,200 kℓ/day for construction activities.
	2	Electricity	n/a	n/a	n/a	Not applicable as the construction camp will be powered by diesel generator sets during the site preparation and construction phase.
			Sub-Total	**4 273**	**5 652**	
Operational	1	Fleet vehicles	Diesel	2 232	2 232	Based on the diesel consumption of 2 x utility vehicles and 1 x bus operating on average 40 hours per month, and 1 x

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
						ambulance operating on average 4 hours per month, for the duration of the operational phase.
	1	Diesel generators	Diesel	17 899	17 899	Based on the diesel consumption of 5 x 450 kW (500 kVA) operating at full load to power essential plant components when the gas engines/turbines are down. The utilisation rate is estimated to be 10% for the duration of the operational phase. It is assumed that there will be no workers living on site.
	1	Gas engines/turbines	Natural gas	38 625 930	31 409 398	Based on the natural gas consumption of the gas engines/turbines during the operational phase. It is assumed that the average gas consumption of the OCGE will be 21.8 PJ/yr in years 1-5, and 28.6 PJ/yr in years 6-25 (Foster Wheeler, 2014a), while the gas consumption of the CCGT will be 18.8 PJ/yr in years 1-5, and 23 PJ/yr in years 6-25 (Foster Wheeler, 2014b). Note that the gas consumption estimates were increased by on average 12% to account for possible increase in the net electrical power output from 400 MW to 450 MW.
	1	Water supply	Diesel	39	270	Based on the diesel consumption of 1 x 25 kW generator and pump set operating on average 24 hours per day for the duration of operational phase. The demand is based on average number of workers that are expected to be working at the gas to power plant, and the estimated water requirements of the gas engines/turbines (Coffey, 2014).

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
	2	Purchased electricity	n/a	n/a	n/a	Not applicable as the plant will power itself, and use the diesel generator sets when the plant is down.
			Sub-Total	**38 646 100**	**31 429 799**	
Decommissioning & Closure	1	Fleet vehicles	Diesel	88	88	Based on the diesel consumption of 2 x utility vehicles and 1 x bus operating on average 40 hours per month, and 1 x ambulance operating on average 4 hours per month, for the duration of decommissioning and closure phase.
	1	Diesel generators	Diesel	2 715	3 345	Based on the diesel consumption of 5 x 450 kW (500 kVA) generator sets operating on average 8 hours per day for the duration of the decommissioning and closure phase. It is assumed that a similar number of workers as the site preparation and construction phase will be living on site during the decommissioning and closure phase.
	1	Water supply	Diesel	15	15	Based on the diesel consumption of 1 x 25 kW generator and pump set operating on average 24 hours per day for the duration of decommissioning and closure phase. The demand is based on average number of workers that are expected to be living on site (assumed to be the same as the site preparation and construction phase), and an average 300 kℓ/day for decommissioning activities.
	2	Electricity	n/a	n/a	n/a	Not applicable as the construction camp will be powered by diesel generator sets during the site preparation and construction phase.

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
			Sub-Total	**2 818**	**3 448**	
			TOTAL	**38 653 190**	**31 438 899**	

7.2 Relevant Scope 3 Emissions

Table 4 presents the estimations of the relevant Scope 3 GHG emissions for OCGE and CCGT during the site preparation and construction, operational, and decommissioning and closure phases.

Table 4: Estimated Scope 3 emissions for OCGE and CCGT

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
Site preparation and closure	3	Barges and tugs	Diesel	180	218	Based on the diesel consumption of a tug with 6,450 kW engines towing a 5,000 t barge. It is assumed, based on Subtech (2014), that there will be on average four barge trips per day, and that it will take approximately 14 days for OCGE and 17 days for OCGT to barge the gas engines, gas turbines, transformers, and/or HRSGs between the cargo ship and the beach landing. It is assumed that the proposed increase in the net electrical power output from 400 MW to 450 MW will not result in additional units requiring to be transported to site.
	3	Heavy goods vehicles (> 33 t)	Diesel	18	13	Based on the diesel consumption of heavy good vehicles with load capacity > 33 t transporting the gas engines, gas turbines,

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
						transformers, and/or HRSGs between the beach landing and construction site. It is assumed, based on Subtech (2014), that in total 30 trips will be required to transport a total of 7,626 t, 36.9 km for OCGE, while 39 trips will be required to transport a total of 5,385 t, 36.9 km for OCGT. It is assumed that the proposed increase in the net electrical power output from 400 MW to 450 MW will not result in additional units requiring to be transported to site.
	3	Construction vehicles	Diesel	1 742	1 805	Based on the diesel consumption of the following construction vehicles, and the estimated operating hours per month: ■ 3 x Graders (50 hr/month); ■ 1 x Excavator (50 hr/month); ■ 2 x 1t Roller (50 hr/month); ■ 2 x Dozer (50 hr/month); ■ 4 x Water cart (40 hr/month); ■ 2 x Diesel truck (40 hr/month); ■ 4 x Tipper truck (40 hr/month); ■ 2 x Articulated dump truck (ADT) (40 hr/month); ■ 2 x 4t Truck (40 hr/month); ■ 1 x Crane Truck (8 hr/month);

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
						■ 1 x Lowbed (40 hr/month); and ■ 4 x Light delivery vehicles (LDVs) (40 hr/month). It is assumed, based on information provided by SNE, that the earthmoving equipment, such as the graders, excavators and dozers, will only be used for the first 9 months for site preparation.
	3	Heavy goods vehicles (>33t) for local deliveries	Diesel	10 878	10 878	Based on the diesel consumption of heavy goods vehicles (>33 t) transporting locally sourced construction materials from Beira and Maputo. It is assumed that a total of 6,015 trips will be generated with 70% of trips from Beira and 30% of trips from Maputo. It is assumed that the max load of each trip will be 42 t based on maximum design capacity of roads.
	2	Purchased electricity	n/a	n/a	n/a	Not applicable as the construction camp will be powered by diesel generator sets during the site preparation and construction phase.
			Sub-Total	**12 818**	**12 914**	
Decommissioning & Closure	3	Barges and tugs	Diesel	180	218	Based on the diesel consumption of a tug with 6,450 kW engines towing a 5,000 t barge. It is assumed, based on Subtech (2014), that there will be on average four barge trips per day, and that it will take approximately 14 days for OCGE and 17 days for OCGT to barge the gas engines, gas turbines, transformers, and/or HRSGs between the cargo ship and the beach landing. It

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
						is assumed that the proposed increase in the net electrical power output from 400 MW to 450 MW will not result in additional units requiring to be transported to site.
	3	Heavy goods vehicles (> 33 t)	Diesel	18	13	Based on the diesel consumption of heavy good vehicles with load capacity > 33 t transporting the gas engines, gas turbines, transformers, and/or HRSGs between the beach landing and construction site. It is assumed, based on Subtech (2014), that in total 30 trips will be required to transport a total of 7,626 t, 36.9 km for OCGE, while 39 trips will be required to transport a total of 5,385 t, 36.9 km for CCGT. It is assumed that the proposed increase in the net electrical power output from 400 MW to 450 MW will not result in additional units requiring to be transported to site.
	3	Construction vehicles	Diesel	2 100	2 100	Based on the diesel consumption of the following construction vehicles, and the estimated operating hours per month: ▪ 3 x Graders (50 hr/month); ▪ 1 x Excavator (50 hr/month); ▪ 2 x 1t Roller (50 hr/month); ▪ 2 x Dozer (50 hr/month); ▪ 4 x Water cart (40 hr/month); ▪ 2 x Diesel truck (40 hr/month);

Phase	Scope	Category	Emission source	OCGE est. emissions (tCO_2eq)	CCGT est. emissions (tCO_2eq)	Activity data and assumptions
						■ 4 x Tipper truck (40 hr/month); ■ 2 x Articulated dump truck (ADT) (40 hr/month); ■ 2 x 4t Truck (40 hr/month); ■ 1 x Crane Truck (8 hr/month); ■ 1 x Lowbed (40 hr/month); and ■ 4 x Light delivery vehicles (LDVs) (40 hr/month). It is assumed, based on information provided by SNE, that the earthmoving equipment, such as the graders, excavators and dozers, will only be used for the first 9 months for site preparation.
			Sub-Total	**2 298**	**2 332**	
			TOTAL	**15 116**	**15 246**	

8.0 IMPACT ASSESSMENT

In an ESIA, the potential impact of a project is typically assessed in terms of direction, intensity (or severity), duration, extent and probability of occurrence of the impact. However, given that the contribution of the CTT project to global GHG emissions is relatively insignificant, and the extended period between the emission of GHGs and potential climate change impacts, the conventional approach to impact assessment may not be appropriate.

As a result, GHG emissions assessments typically use an alternative approach to impact assessment based on benchmarks. In the context of this assessment, three benchmarks are considered:

- Contribution of the CTT project to Mozambique's national GHG emissions;
- Product unit intensity; and
- Pre-defined thresholds.

These benchmarks will be used to assess the significance of potential impacts associated with the operational phase of Options 1 and 2 of the CTT project. The GHG emissions from the site preparation and construction and decommissioning phases have been excluded as they are insignificant in comparison to the GHG emissions from the operational phase (< 1%).

8.1 Contribution to Mozambique's National GHG Emissions

As mentioned previously, Mozambique's total GHG emissions was 66.8 $MtCO_2e$ in 2013 (see Section 4.1), with an average increase of 1% per annum. According to Mozambique's Intended Nationally Determined Contribution (INDC) (2009), Mozambique is committed to reducing its GHG emissions by 75.6 $MtCO_2e$ between 2020 and 2030, with 23.0 MtCO2e by 2024 (average 5.75 $MtCO_2e$ per annum) and 53.4 MtCO2e from 2025 to 2030 (average 8.9 $MtCO_2e$ per annum). Assuming that site preparation and construction for both OCGE and CCGT commences in 2019, the CTT project is expected to be operational by 2021.

8.1.1 OCGE

Table 5 presents the estimated contribution of the CTT project using OCGE to the total annual GHG emissions of Mozambique, with and without the mitigation measures proposed in the INDC.

Without mitigation, the CTT project will contribute between 8.2% and 8.6% to the total annual GHG emissions for the first five years (2021 – 2025), and between 35.3% and 42.7% for the next 20 years (2025 – 2045) without mitigation. With mitigation, the CTT project will contribute between 8.9% and 9.3% to the total annual GHG emissions for the first five years (2021 – 2025), and between 35.3% and 46.1% for the next 20 years (2025 – 2045).

Given that with OCGE, the CTT project will contribute between 8.2% and 9.3% to Mozambique's annual GHG emissions for the first 5 years and between 35.3% and 46.1% for the next 20 years, the significance of the impact is rated as **high** as it is not an insignificant contribution**.**

As mentioned previously, the contribution of the energy sector to the total annual GHG emissions of Mozambique was 5.9 $MtCO_2e$ in 2013. The GHG emissions of the energy sector was also growing on average 2.2%, per annum. It is estimated that the CTT project will increase the GHG emissions from the Mozambican energy sector by between 80.3% and 411%.

It is important to note that 93% of Mozambique's 2,308 MW operating capacity is generated by hydro (SADC, 2016). As a result, the contribution of the energy sector to the country's total GHG emissions is relatively small. Further to this, and any large scale fossil fuel based power plant, regardless of its operational efficiency, will make a significant contribution to Mozambique's total GHG emissions.

Table 5: Contribution of CTT project using OCGE to the annual GHG emissions of Mozambique with and without mitigation

Year	Without mitigation			With mitigation		
	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution
2013	66 800 000	n/a	n/a	66 800 000	n/a	n/a
2014	67 468 000	n/a	n/a	67 468 000	n/a	n/a
2015	68 142 680	n/a	n/a	68 142 680	n/a	n/a
2016	68 824 107	n/a	n/a	68 824 107	n/a	n/a
2017	69 512 348	n/a	n/a	69 512 348	n/a	n/a
2018	70 207 471	n/a	n/a	70 207 471	n/a	n/a
2019	70 909 546	n/a	n/a	70 909 546	n/a	n/a
2020	71 618 642	n/a	n/a	65 868 642	n/a	n/a
2021	72 334 828	6 199 223	8.6%	66 584 828	6 199 223	9.3%
2022	73 058 176	6 199 223	8.5%	67 308 176	6 199 223	9.2%
2023	73 788 758	6 199 223	8.4%	68 038 758	6 199 223	9.1%
2024	74 526 646	6 199 223	8.3%	68 776 646	6 199 223	9.0%
2025	75 271 912	6 199 223	8.2%	69 521 912	6 199 223	8.9%
2026	76 024 631	32 426 707	42.7%	70 274 631	32 426 707	46.1%
2027	76 784 877	32 426 707	42.2%	71 034 877	32 426 707	45.6%
2028	77 552 726	32 426 707	41.8%	71 802 726	32 426 707	45.2%
2029	78 328 253	32 426 707	41.4%	72 578 253	32 426 707	44.7%
2030	79 111 536	32 426 707	41.0%	73 361 536	32 426 707	44.2%
2031	79 902 651	32 426 707	40.6%	79 902 651	32 426 707	40.6%

Year	Without mitigation			With mitigation		
	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution
2032	80 701 678	32 426 707	40.2%	80 701 678	32 426 707	40.2%
2033	81 508 695	32 426 707	39.8%	81 508 695	32 426 707	39.8%
2034	82 323 782	32 426 707	39.4%	82 323 782	32 426 707	39.4%
2035	83 147 019	32 426 707	39.0%	83 147 019	32 426 707	39.0%
2036	83 978 490	32 426 707	38.6%	83 978 490	32 426 707	38.6%
2037	84 818 275	32 426 707	38.2%	84 818 275	32 426 707	38.2%
2038	85 666 457	32 426 707	37.9%	85 666 457	32 426 707	37.9%
2039	86 523 122	32 426 707	37.5%	86 523 122	32 426 707	37.5%
2040	87 388 353	32 426 707	37.1%	87 388 353	32 426 707	37.1%
2041	88 262 237	32 426 707	36.7%	88 262 237	32 426 707	36.7%
2042	89 144 859	32 426 707	36.4%	89 144 859	32 426 707	36.4%
2043	90 036 308	32 426 707	36.0%	90 036 308	32 426 707	36.0%
2044	90 936 671	32 426 707	35.7%	90 936 671	32 426 707	35.7%
2045	91 846 037	32 426 707	35.3%	91 846 037	32 426 707	35.3%

8.1.2 CCGT

Table 6 presents the estimated contribution of CTT project using CCGT to the total annual GHG emissions of Mozambique, with and without the mitigation measures proposed in the INDC.

Without mitigation, the CTT project will contribute between 7.1% and 7.4% to the total annual GHG emissions for the first five years (2021 – 2025), and between 28.4% and 34.3% for the next 20 years (2025 – 2045) without mitigation. With mitigation, the CTT project will contribute between 7.7% and 8.0% to the total annual GHG emissions for the first five years (2021 – 2025), and between 28.4% and 37.1% for the next 20 years (2025 – 2045).

Given that with CCGT, the CTT project will contribute between 7.1% and 8.0% to Mozambique's annual GHG emissions for the first 5 years and between 28.4% and 37.1% for the next 20 years, the significance of the impact is rated as **high** as it is not an insignificant contribution**.**

As mentioned previously, the contribution of the energy sector to the total annual GHG emissions of Mozambique was 5.9 $MtCO_2e$ in 2013, and that the GHG emissions of the energy sector was also growing on average 2.2%, per annum. It is estimated that the CTT project will increase the GHG emissions from the Mozambican energy sector by between 69.2% and 330%.

Table 6: Contribution of the CTT project using CCGT to the annual GHG emissions of Mozambique with and without mitigation

Year	Without mitigation			With mitigation		
	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution
2013	66 800 000	n/a	n/a	66 800 000	n/a	n/a
2014	67 468 000	n/a	n/a	67 468 000	n/a	n/a
2015	68 142 680	n/a	n/a	68 142 680	n/a	n/a
2016	68 824 107	n/a	n/a	68 824 107	n/a	n/a
2017	69 512 348	n/a	n/a	69 512 348	n/a	n/a
2018	70 207 471	n/a	n/a	70 207 471	n/a	n/a
2019	70 909 546	2 826	0.004%	70 909 546	2 826	0.004%
2020	71 618 642	2 826	0.004%	65 868 642	2 826	0.004%
2021	72 334 828	5 340 869	7.4%	66 584 828	5 340 869	8.0%
2022	73 058 176	5 340 869	7.3%	67 308 176	5 340 869	7.9%
2023	73 788 758	5 340 869	7.2%	68 038 758	5 340 869	7.8%
2024	74 526 646	5 340 869	7.2%	68 776 646	5 340 869	7.8%
2025	75 271 912	5 340 869	7.1%	69 521 912	5 340 869	7.7%
2026	76 024 631	26 068 529	34.3%	70 274 631	26 068 529	37.1%
2027	76 784 877	26 068 529	34.0%	71 034 877	26 068 529	36.7%
2028	77 552 726	26 068 529	33.6%	71 802 726	26 068 529	36.3%
2029	78 328 253	26 068 529	33.3%	72 578 253	26 068 529	35.9%
2030	79 111 536	26 068 529	33.0%	73 361 536	26 068 529	35.5%
2031	79 902 651	26 068 529	32.6%	79 902 651	26 068 529	32.6%

Year	Without mitigation			With mitigation		
	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution	Total GHG emissions (tCO2e)	CTT contribution (tCO2e)	% CTT contribution
2032	80 701 678	26 068 529	32.3%	80 701 678	26 068 529	32.3%
2033	81 508 695	26 068 529	32.0%	81 508 695	26 068 529	32.0%
2034	82 323 782	26 068 529	31.7%	82 323 782	26 068 529	31.7%
2035	83 147 019	26 068 529	31.4%	83 147 019	26 068 529	31.4%
2036	83 978 490	26 068 529	31.0%	83 978 490	26 068 529	31.0%
2037	84 818 275	26 068 529	30.7%	84 818 275	26 068 529	30.7%
2038	85 666 457	26 068 529	30.4%	85 666 457	26 068 529	30.4%
2039	86 523 122	26 068 529	30.1%	86 523 122	26 068 529	30.1%
2040	87 388 353	26 068 529	29.8%	87 388 353	26 068 529	29.8%
2041	88 262 237	26 068 529	29.5%	88 262 237	26 068 529	29.5%
2042	89 144 859	26 068 529	29.2%	89 144 859	26 068 529	29.2%
2043	90 036 308	26 068 529	29.0%	90 036 308	26 068 529	29.0%
2044	90 936 671	26 068 529	28.7%	90 936 671	26 068 529	28.7%
2045	91 846 037	26 068 529	28.4%	91 846 037	26 068 529	28.4%

8.2 Product Unit Intensity

Benchmarking the potential GHG emissions resulting from a project against emitters in the same sector can also be used to assess the significance of impacts of a project. In order to allow for comparison, the average emissions intensity per product unit (i.e. CO_2e per product unit) is typically used. Given that the product unit of the CCT project is power (GWh), the emissions intensity per product unit is tCO_2e/GWh or gCO_2e/kWh.

8.2.1 OCGE

It is estimated that the CTT project suing OCGE will generate 2,424 GWh per annum in years 1 to 5, and 3,200 GWh per annum in years 6 to 25 (Foster Wheeler, 2014a)[1]. The CTT project will therefore generate a total of 76,112 GWh during the operational phase. If the CTT project emits an estimated 38,625,930 tCO_2e during the

[1] Note that the total output was increased by on average 12% to account for possible increase in the net electrical power output from 400 MW to 450 MW.

operational phase (see Table 3), the GHG emissions intensity is approximately 507.5 tCO_2e/GWh or 507 gCO_2e/kWh.

According to Cai *et al.* (2013), the average emissions intensity of power plants in the United States using natural gas internal combustion engine (NGICE) is 619 gCO_2e/kWh. The emissions intensity of OCGE is estimated to be 507 gCO_2e/kWh, which is approximately 19% less than the industry average. As a result, the impact is considered to be **low**. It is worth noting however that the average efficiency of the NGICEs in the United States was 32.8%, whereas the net electrical efficiency of OCGE is estimated to be between 45.4% and 45.9%. This indicates that the technology used included in the United States sample may be older than what is proposed for the CTT.

It is also worth noting that the South African Department of Environmental Affairs recently commissioned a study to measure the GHG emissions of fossil fuel fired power stations, including a gas to power plant in Sasolburg (DEA, 2016). It was estimated that the gas to power plant would emit on average 241 gCO_2e/kWh. It was however found that during the study, the plant was only emitting 172 gCO_2e/kWh. Given that the CTT project will utilise similar gas engine technology as the Sasolburg plant, the actual GHG emissions of the CTT project could potentially be lower than the predicted values.

8.2.2 CCGT

It is estimated that the CTT project using CCGT will generate 2,338 GWh per annum in years 1 to 5, and 3,200 GWh per annum in years 6 to 25 (Foster Wheeler, 2014b) [2]. The CCT project will therefore generate a total of 75,682 GWh during the operational phase. If the CTT project emits an estimated 31,409,398 tCO2e during the operational phase (see Table 3), the GHG emissions intensity is approximately 435.5 tCO2e/GWh or 435 gCO2e/kWh.

According to Cai *et al.* (2013), the average emissions intensity of power plants in the United States using closed cycle gas turbines is 441 gCO_2e/kWh. The average efficiency of these plants was 50.6%. The emissions intensity of the CTT project using CCGT, with a net electrical efficiency of between 50.4% and 52.7%, is estimated to 435 gCO_2e/kWh, which is approximately 1% less than the industry average. As a result, the impact is considered to be **low**.

8.3 Pre-Defined Thresholds

The European Bank of Reconstruction and Development (EBRD) developed thresholds which can be used for benchmarking the magnitude of annual emissions of a project – see Table 7.

Table 7: Benchmark thresholds for annual CO2e emissions (EBRD, 2010)

GHG emissions (tCO2e/a)	Qualitative rating
< 10,000	Nominal/Negligible
10,001 – 25,000	Low
25,001 – 100,000	Medium-Low

[2] Note that the total output was increased by on average 12% to account for possible increase in the net electrical power output from 400 MW to 450 MW.

GHG emissions (tCO2e/a)	Qualitative rating
100,001 – 1,000,000	Medium-High
> 1,000,000,001	High

8.3.1 OCGE

It is estimated that the GHG emissions associated with the CTT project using OCGE will be 1,239,845 tCO_2e per annum for the first 5 years (2021-2025), and 1,621,335 per annum for the next 20 years (2025-2045) - see Table 3. Assuming a design life of 25 years, the annual emissions of the CTT project will be on average 1,545,037 tCO_2e. As such, the magnitude of the annual emissions of the use OCGE is rated as **High** in terms of the thresholds presented in Table 7.

8.3.2 CCGT

It is estimated that the GHG emissions associated with the CTT project using CCGT will be 1,068,174 tCO_2e per annum for the first 5 years (2021-2025), and 1,303,426 per annum for the next 20 years (2025-2045) - see Table 3. Assuming a design life of 25 years, the annual emissions of the CTT project will be on average 1,256,376 tCO_2e. As such, the magnitude of the annual emissions of the use of CCGT is also rated as **High** in terms of the thresholds presented in Table 7.

Further to this, according to EBRD (2010) it is recommended that projects rated as **High** prepare a GHG Management Plan. Section 11.0 presents a preliminary management strategy for managing potential GHG emissions associated with OCGE and CCGT.

8.4 Summary

Table 8 presents a summary of the potential GHG emissions resulting from CTT project using OCGE and CCGT in terms of the three benchmarks considered. While both technologies are rated the same in terms of the three benchmarks, it is worth noting that CCGT scored better than OCGE in respect of all three benchmarks, but not to the extent, that the overall rating was less than that of OCGE.

Table 8: Summary of potential impacts for CTT project using OCGE and CCGT

Potential impact	OCGE	CCGT
Contribution to Mozambique's national GHG emissions	High	High
Product unit intensity	Low	Low
Pre-defined thresholds	High	High
Overall	High	High

9.0 GHG EMISSIONS MANAGEMENT PLAN

The following section presents a high level action plan for the management of GHG emissions during the site preparation and construction, operational, and decommissioning and closure phases for both OCGE and CCGT.

9.1 OCGE

Table 9 presents a high level action plan for management of the potential GHG emissions of OCGE.

Table 9: GHG emissions action plan for OCGE

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
Site Preparation and Construction Phase				
Fleet vehicles	Contribution to GHG emissions	Driver behaviour	Monitor diesel consumption as recommended in Table 11 and investigate incidents of excessive consumption. Alternatively, install telemetry in all fleet vehicles and monitor driver behaviour in terms of speeding and excessive braking, idling and so on.	Fleet manager
Barges and tugs	Contribution to GHG emissions	Number of trips and loading	Within the carrying capacity of the barges, maximise the load transported in each trip in order to reduce the number of trips.	Operations manager
Heavy goods vehicles	Contribution to GHG emissions	Number of trips and loading	Within the carrying capacity of the vehicles, maximise the load transported in each trip in order to reduce the number of trips.	Operations manager
Diesel generators	Contribution to GHG emissions	Sizing of diesel generators	When more detailed information becomes available, recalculate the maximum electricity demand of the construction camp and size diesel generators accordingly, taking into account the operational efficiencies of the generator sets. Generator sets could be configured so that those providing the baseload run are set to run at their optimum load (based on manufacturers	Electrical engineer and procurement

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
			specifications), while those providing power during peak periods could be fitted with variable speed drives (VSDs).	
Water pump	Contribution to GHG emissions	Sizing of diesel generator and water pump	When more detailed information becomes available, recalculate the maximum water demand of the construction camp and size diesel generator and pump sets accordingly, taking into account the operational efficiency of the water pump. Generator and pump set could be fitted with a VSD to ensure that the loading of the generator and pump set is more responsive to changes in demand.	Electrical engineer and procurement
Operational Phase				
Stack emissions	Contribution to GHG emissions	Plant inefficiencies	Installation of probes in stacks to allow for continuous monitoring of stack emissions.	Operations manager
Decommissioning and Closure Phase				
See actions recommended for site preparation and construction phase.				

9.2 CCGT

Table 10 presents a high level action plan for management of the potential GHG emissions of CCGT.

Table 10: GHG emissions action plan for CCGT

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
Site Preparation and Construction Phase				
Fleet vehicles	Contribution to GHG emissions	Driver behaviour	Monitor diesel consumption as recommended in Table 11 and investigate incidents of excessive consumption. Alternatively, install telemetry in all fleet vehicles and monitor driver behaviour in terms of speeding and excessive braking, idling and so on.	Fleet manager
Barges and tugs	Contribution to GHG emissions	Number of trips and loading	Within the carrying capacity of the barges, maximise the load transported in each trip in order to reduce the number of trips.	Operations manager
Heavy goods vehicles	Contribution to GHG emissions	Number of trips and loading	Within the carrying capacity of the vehicles, maximise the load transported in each trip in order to reduce the number of trips.	Operations manager
Diesel generators	Contribution to GHG emissions	Sizing of diesel generators	When more detailed information becomes available, recalculate the maximum electricity demand of the construction camp and size diesel generators accordingly, taking into account the operational efficiencies of the generator sets. Generator sets could be configured so that those providing the baseload run are set to run at their optimum load (based on manufacturers specifications), while those providing power during peak	Electrical engineer and procurement

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
			periods could be fitted with variable speed drives (VSDs).	
Water pump	Contribution to GHG emissions	Sizing of diesel generator and water pump	When more detailed information becomes available, recalculate the maximum water demand of the construction camp and size diesel generator and pump sets accordingly, taking into account the operational efficiency of the water pump. Generator and pump set could be fitted with a VSD to ensure that the loading of the generator and pump set is more responsive to changes in demand.	Electrical engineer and procurement
Operational Phase				
Stack emissions	Contribution to GHG emissions	Plant inefficiencies	Installation of probes in stacks to allow for continuous monitoring of stack emissions.	Operations manager
Decommissioning and Closure Phase				
See actions recommended for site preparation and construction phase.				

10.0 GHG EMISSIONS MONITORING PROGRAMME

The following section presents a high level programme for the monitoring of GHG emissions during the site preparation and construction, operational, and decommissioning and closure phases for both OCGE and CCGT.

10.1 OCGE

Table 11 presents a programme for monitoring of GHG emissions of OCGE.

Table 11: GHG emissions monitoring programme for OCGE

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Site Preparation and Construction Phase				
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Construction camp	Monthly	Fleet manager
Reduce diesel consumption of barges and tugs	Calculate average consumption of tugs based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of heavy good vehicles	Calculate average consumption of heavy goods vehicles based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Construction camp	Monthly	Head electrician
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician
Operational Phase				
Reduce gas consumption of gas engines	Calculate average consumption of gas engines based on consumption of natural gas and electricity produced (i.e. product unit intensity). Monitor stack emissions to ensure compliance with relevant regulations and determine efficiency of gas engines.	Gas to energy plant Gas to power plant	Monthly Continuous	Operations manager Operations manager

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Gas to power plant	Monthly	Fleet manager
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Gas to power plant	Monthly	Operations manager
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician
Decommissioning and Closure Phase				
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Decommissioning camp	Monthly	Fleet manager
Reduce diesel consumption of barges and tugs	Calculate average consumption of tugs based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of heavy good vehicles	Calculate average consumption of heavy goods vehicles based on diesel consumption, mass of the load transported, and distance travelled.	Between beach landing and construction camp	Daily	Site foreman
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Decommissioning camp	Monthly	Head electrician
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician

10.2 CCGT

Table 12 presents a programme for monitoring of GHG emissions of CCGT.

Table 12: GHG emissions monitoring programme for CCGT

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Site Preparation and Construction Phase				
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Construction camp	Monthly	Fleet manager
Reduce diesel consumption of barges and tugs	Calculate average consumption of tugs based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of heavy good vehicles	Calculate average consumption of heavy goods vehicles based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Construction camp	Monthly	Head electrician
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician
Operational Phase				
Reduce gas consumption of gas engines	Calculate average consumption of gas turbines based on consumption of natural gas and electricity produced (i.e. product unit intensity). Monitor stack emissions to ensure compliance with relevant	Gas to energy plant Gas to power plant	Monthly Continuous	Operations manager Operations manager

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
	regulations and determine efficiency of gas engines.			
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Gas to power plant	Monthly	Fleet manager
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Gas to power plant	Monthly	Operations manager
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician
Decommissioning and Closure Phase				
Reduce diesel consumption of fleet vehicles	Calculate average consumption of vehicles based on diesel consumption and distance travelled.	Decommissioning camp	Monthly	Fleet manager
Reduce diesel consumption of barges and tugs	Calculate average consumption of tugs based on diesel consumption, mass of the load transported, and distance travelled.	Between cargo ship and beach landing	Daily	Site foreman
Reduce diesel consumption of heavy good vehicles	Calculate average consumption of heavy goods vehicles based on diesel consumption, mass of the load transported, and distance travelled.	Between beach landing and construction camp	Daily	Site foreman
Reduce diesel consumption of diesel generators	Calculate average consumption of diesel generators based on diesel consumption and running time.	Decommissioning camp	Monthly	Head electrician

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Reduce diesel consumption of generator and water pump sets	Calculate average consumption of generator and water pump sets based on diesel consumption and running time.	Site of abstraction	Monthly	Head electrician

11.0 CONCLUSIONS AND RECOMMENDATIONS

In terms of Scope 1 and 2 emissions, OCGE and CCGT have similar carbon footprint during the site preparation and construction phase (**4,273 tCO_2e** versus **5,652 tCO_2e**), as well as the decommissioning and closure phase (**2,818 tCO_2e** versus **3,448 tCO_2e**). While the recommended mitigation measures included in the GHG Emissions Management Plan (see Section 9.0) could potentially reduce these emissions by between 5% and 15%, these savings are insignificant in comparison to carbon footprint during the operational phase. These mitigation measures should however still be implemented in accordance with good international industry practice.

During the operational phase, CCGT has a significantly smaller carbon footprint (**31.4 Mt**) than OCGE (**38.6 Mt**). As a consequence, the technology option can have a significant influence on the magnitude of the carbon footprint. Thus, from a purely GHG Emissions perspective, CCGT is the preferred technology option as the carbon footprint is approximately 19% smaller.

In terms of the relevant Scope 3 emissions, OCGE has a marginally larger carbon footprint than CCGT in the site preparation and construction phase (**12,818 tCO_2e** versus **12,914 tCO_2e**), as well as the decommissioning and closure phase (**2,322 tCO_2e** versus **2,298 tCO_2e**). This is largely as a result of CCGT having a marginally higher number of units (39) that need to be transported between the cargo ship and the site using barges and heavy goods vehicles than OCGE (30).

The potential impacts of the CTT project's GHG emissions were assessed in terms of the following three benchmarks:

- Contribution of the CTT project to Mozambique's national GHG emissions;
- Product unit intensity; and
- Pre-defined thresholds.

While both options are rated the same in terms of the three benchmarks (i.e. **high**), it is worth noting that CCGT scored better than OCGE in respect of all three benchmarks, but not to the extent, that the overall rating was less than that of OCGE.

No offsets were considered in this assessment as no information regarding specific offsetting mechanisms was provided by SNE at the time that the report was being prepared.

12.0 SPECIALIST RECOMMENDATION

From a GHG emissions perspective, CCGT is the preferred option as the total Scope 1 and 2 GHG emissions are lower than those of OCGE.

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