Appendix H Greenhouse Gas Assessment

Newcastle Power Station

Greenhouse Gas Assessment

30 October 2019

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The business of sustainability

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30 October 2019

Newcastle Power Station

Greenhouse Gas Assessment

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ABBREVIATIONS

Abbreviation	Meaning
CCGT	Combined Cycle Gas Turbine
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
GHG	Greenhouse gas
GHGA	Greenhouse gas assessment
GJ	Gigajoule
GWh	Gigawatt hour
HHV	Higher Heating Value
Mt	Megatonne
MW	Megawatt
MWh	Megawatt hour
N_2O	Nitrous oxide
NGER Act	National Greenhouse Energy Reporting Act
OCGT	Open Cycle Gas Turbine
t	Metric tonne
TJ	Terajoule

EXECUTIVE SUMMARY

Environmental Resources Management Australia Pacific Pty Ltd (ERM) was commissioned by Aurecon Australia Pty Ltd (Aurecon) on behalf of AGL, to undertake a greenhouse gas (GHG) assessment (GHGA) for the Newcastle Power Station Proposal. AGL proposes to construct and operate a dual-fuel (gas/diesel) power station (approximately 250-megawatt (MW)) and associated infrastructure, including gas supply and electricity transmission connections (the Proposal).

The Proposal is proposed to be constructed on a greenfield site at Tomago, approximately 14 km north-west of Newcastle within the Port Stephens Council Local Government Area.

This report provides an assessment of potential greenhouse gas emissions in accordance with conventional greenhouse gas accounting methodologies.

Operational forecasts have estimated that the Proposal will operate during peak fluctuations in market demand with a capacity factor in the order of 14% during its initial years of operation, and annual starts ranging from 50 to 200.

The selection of the generation technology (i.e. engine or turbine) and arrangement of the specific generation units would require further design following EIS finalisation. The generation technology has been assessed throughout the EIS and specialist studies using an envelope approach that covers likely operational outcomes of the proposed technology options.

Plant design data were reviewed, with estimation of net power output, and fuel consumption for worst case operating modes, inclusive of both reciprocating engine and gas turbine technologies.

With the assumption of a 14% capacity factor, total annualised operational Scope 1 emissions were estimated at between approximately 140 – 220 kilotonnes on a carbon dioxide equivalent basis (kt CO_2-e) per annum. Expansion of this estimate to a continuous operating scenario resulted in estimated emissions of approximately 1.0 – 1.6 Mt CO_2-e per annum.

These estimates indicate that at 14% capacity factor, GHG emissions from the Proposal would equate to approximately 0.46% and 0.12% of the 2017 NSW and national inventories for electricity generation (respectively), and to approximately 0.18% and 0.04% of the 2017 NSW and national inventory totals (respectively). With expansion of this estimate to continuous operation, GHG emissions from the Proposal were estimated to equate to approximately 3.3% and 0.9% of the 2017 NSW and national inventories for electricity generation (respectively), and to approximately 1.3% and 0.3% of the 2017 NSW and national inventory totals (respectively).

With the adoption of worst case heat rates for each design option, the corresponding full fuel cycle (Scope 1 + 3) emission intensity were estimated at between 570 – 780 kg CO_2-e/MWh, indicating that the achievable emission intensities of the proposed generation technologies are broadly consistent with best achievable emission intensity utility scale fossil fuel peaking power generation, with a slightly lower emission intensity predicted for reciprocating engine plant.

Based on this analysis, the impacts of the Proposal are anticipated to be below the current grid average emission intensity of 910 kg CO_2-e/MWh, whilst also providing fast response electricity generation, consistent with the accommodation of an increased proportion of renewable energy sources into the electricity grid.

1. INTRODUCTION

Environmental Resources Management Australia Pacific Pty Ltd (ERM) has been commissioned by Aurecon Australia Pty Ltd (Aurecon) on behalf of AGL, to undertake a greenhouse gas (GHG) assessment (GHGA) for the Newcastle Power Station (the Proposal). AGL proposes to construct and operate a dual-fuel (gas/diesel) power station (approximately 250-megawatt (MW)) and associated infrastructure, including gas supply and electricity transmission connections.

The Proposal will be constructed on a greenfield site at Tomago, approximately 14 km north-west of Newcastle within the Port Stephens Council Local Government Area.

This report provides an assessment of potential greenhouse gas emissions in accordance with conventional greenhouse gas accounting methodologies.

1.1 Assessment Scope

The Secretary's Environmental Assessment Requirements (SEARs) (Ref: SSI 9837) were issued by the NSW Department of Planning, Industry and Environment (DPIE) on 18 February 2019 and form the basis of the environmental impact assessment for the Proposal.

The SEARs include the following matters which are relevant to the assessment of greenhouse gas emissions:

> *"In particular, the EIS must address the following matters:*
>
> ***Air Quality:***
>
> - *an assessment of the likely greenhouse gas impacts of the project;."*

To address this requirement, and allow a consideration of the Proposal in the context of potential greenhouse gas performance, this GHGA has incorporated the following elements:

- An estimate of greenhouse gas emission quantities.
- An estimate of generator emission intensity.

Associated detail, methodology and findings are provided within the remainder of this document.

2. PROPOSAL DESCRIPTION

2.1 Overview

The Newcastle Power Station would be a dual fuel (gas and diesel) fast-start peaking power station with a nominal operating capacity of 250MW at Tomago in NSW. The Newcastle Power Station would supply electricity to the grid at short notice during periods of high electricity demand, and/or low supply, particularly during periods where intermittent renewable energy supply is low or during supply outages. This operation is aligned with AGL's move to a renewable energy mix. While the primary role of the Newcastle Power Station would be to provide firming or peaking capacity to the National Electricity Market, to maximise operational flexibility each unit of the power station would be designed for continuous operation. This impact assessment considers both the peaking load operation and the continuous operation.

The Proposal would also involve the construction and operation of gas pipelines and an electricity transmission line. The pipelines would supply the proposed power station with gas from the eastern Australia gas transmission pipelines via the Jemena network and the Newcastle Gas Storage Facility (NGSF). A new electricity transmission line would transfer the electricity produced by the proposed power station to the national electricity network via connection to the existing 132kV Transgrid switching station.

The Proposal has a capital investment value of approximately $400 million and is anticipated to be operational in the year 2022.

The main elements of the Proposal are as follows:

- Power station comprising of either large reciprocating engine generators or aeroderivative gas turbine generators, necessary supporting ancillary equipment and supporting infrastructure. The power station would be capable of operating with diesel fuel, if necessary.
- 132kV electricity transmission line to the existing Tomago switching station, operated by TransGrid.
- Gas transmission pipelines and receiving station, compressor units, and ancillary infrastructure.
- Storage tanks and laydown areas.
- Water management infrastructure including ponds, a connection to Hunter Water potable service in line with Hunter Water requirements, and process water tanker loading facilities.
- Diesel storage and truck unloading facilities.
- Site access road.
- Office / administration, amenities, workshop / storage areas and car parking.

2.2 Power station

The power station would capable of generating about 250 MW of electricity. The proposed power station would either consist of large reciprocating engine generators or aero-derivate gas turbine generators. Generation units would be dual fuel capable, meaning they would be able to be supplied by natural gas and/or liquid fuel.

The decision to install gas turbines or reciprocating engine technology would be made based on a range of environmental, social, engineering and economic factors that will be considered as the power station design progresses.

2.2.1 Gas Turbine Technology

Electricity would be generated by gas turbine technology through the combustion of natural gas and/or liquid fuel in turbines. With its heritage in the airline industry, aero derivative gas turbine units consist of a compressor, combustion chamber, turbine and generator. Air is compressed to a high pressure before being admitted into the combustion chamber. Fuel (natural gas or diesel as required) is injected into the combustion chamber where combustion occurs at very high temperatures and the gases expand. The resulting mixture of hot gas is admitted into the turbine causing the turbine to turn, generating power. In an open cycle configuration, hot exhaust gas is vented to the atmosphere through an exhaust stack, without heat recovery.

The turbines would be fitted with emission controls as required to meet regulatory emission limits under both natural gas and distillate oil ('distillate') operation.

2.2.2 Reciprocating Engine Technology

With its heritage in the shipping industry and a form of internal combustion engine, reciprocating engines used for power generation harness the controlled ignition of gas and/or diesel to drive a piston within a cylinder. A number of pistons move sequentially to rotate a crank shaft which turns the generator.

2.3 Construction Activities and Construction Staging

Key construction activities for the Proposal would include:

- Clearing of limited vegetation at the proposed power station site and as required along the electrical transmission and gas pipeline(s) easements.
- Demolition of an existing house if not repurposed during construction and operation.
- Installation of gas pipeline(s) and electrical transmission line infrastructure.
- Earthworks to prepare the power station site and construction areas.
- Installation of foundations and underground services.
- Installation of aboveground civil, mechanical and electrical plant and equipment.
- Commissioning and testing.

3. LEGISLATION AND GUIDELINES

This section outlines the key international, federal and state government policies and laws regulating greenhouse gas emissions, as well as prescribed methods and factors for estimating greenhouse gas emissions.

3.1 International Context

3.1.1 Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is a panel established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to provide independent scientific advice on climate change. The panel was originally asked to prepare a report, based on available scientific information, on all aspects relevant to climate change and its impacts and to formulate realistic response strategies. This first assessment report of the IPCC served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC).

The IPCC also produce a variety of guidance documents and recommended methodologies for GHG emissions inventories, including (for example):

- the 2006 IPCC Guidelines for National GHG Inventories (IPCC, 2006)
- the 2019 Refinements to the 2006 IPCC Guidelines for National GHG Inventories (IPCC, 2019)
- the Good Practice Guidance and Uncertainty Management in National GHG Inventories (IPCC, 2000).

Since the UNFCCC entered into force in 1994, the IPCC remains the pivotal source for scientific and technical information relevant to GHG emissions and climate change science.

The IPCC operates under the following mandate: "*to provide the decision-makers and others interested in climate change with an objective source of information about climate change*". The IPCC does not conduct any research nor does it monitor climate-related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide, relevant to the understanding of the risk of human-induced climate change, it's observed and projected impacts and options for adaptation and mitigation.

IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. The IPCC is comprised of three Working Groups, one Task force and one Task Group. The three working groups assess scientific information relevant to:

- the physical and scientific basis of climate change
- the vulnerability of socio-economic and natural systems to climate change
- options for adaptation and mitigation.

The IPCC released its fifth assessment report in 2013/2014. The sixth assessment report is anticipated to be published in 2021/2022.

3.1.2 United Nations Framework Convention on Climate Change (UNFCC)

The UNFCCC sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognises that the climate system is a shared resource, the stability of which can be affected by industrial and other emissions of carbon dioxide (CO_2) and other GHGs. The convention has near-universal membership, with 172 countries (parties) having ratified the treaty, the Kyoto Protocol.

Under the UNFCCC, governments:

- Gather and share information on GHG emissions, national policies and best practices.
- Launch national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries.
- Cooperate in preparing for adaptation to the impacts of climate change.

3.1.3 Kyoto Protocol

The Kyoto Protocol entered into force on 16 February 2005. The Kyoto Protocol built upon the UNFCCC by committing to individual, legally binding targets to limit or reduce GHG emissions. Annex I Parties are countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition such as Russia. The GHGs included in the Kyoto Protocol are:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulfur hexafluoride (SF_6).

Each of the above gases has a different effect on the earth's warming and this is a function of radiative efficiency and lifetime in the atmosphere for each individual gas. To account for these variables, each gas is given a 'global warming potential' (GWP) that is normalised to CO_2. For example, CH_4 has a GWP of 28 over a 100 year lifetime (IPCC, 2014). This factor is multiplied by the total mass of gas to be released to provide a CO_2 equivalent mass, termed 'CO_2-equivalent' or CO_2-e.

The emission reduction targets were calculated based on a party's domestic GHG emission inventories (which included land use change and forestry clearing, transportation and stationary energy sectors). Domestic inventories required approval by the Kyoto Enforcement Branch. The Kyoto Protocol required developed countries to meet national targets for GHG emissions over its first commitment period of five years between 2008 and 2012.

To achieve their targets, Annex I Parties had to implement domestic policies and measures. The Kyoto Protocol provided an indicative list of policies and measures that might help mitigate climate change and promote sustainable development.

Under the Kyoto Protocol, developed countries could use a number of flexible mechanisms to assist in meeting their targets. These market-based mechanisms include:

- Joint Implementation – where developed countries invest in GHG emission reduction projects in other developed countries.
- Clean Development Mechanism (CDM) – where developed countries invest in GHG emission reduction projects in developing countries.

Annex I countries that failed to meet their emissions reduction targets during the 2008-2012 period were liable for a 30 percent penalty (additional to the level of exceedance).

In Doha, Qatar, the "Doha Amendment to the Kyoto Protocol" was adopted on 8 December 2012. The amendment includes:

- New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020.

- A revised list of GHGs to be reported on by Parties in the second commitment period
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

During the second commitment period, Parties committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

3.1.4 Paris Agreement

In 2015, a historic global climate agreement was reached under the UNFCCC at the 21st Conference of the Parties (COP21) in Paris (known as the Paris Agreement). The Paris Agreement sets in place a durable and dynamic framework for all countries to take action on climate change from 2020 (that is, after the Kyoto period), building on existing efforts in the period up to 2020.

Key outcomes of the Paris Agreement include:

- A global goal to hold average temperature increase to well below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels.
- All countries to set mitigation targets from 2020 and review targets every five years to build ambition over time, informed by a global stocktake.
- Robust transparency and accountability rules to provide confidence in countries' actions and track progress towards targets.
- Promoting action to adapt and build resilience to climate change.
- Financial, technological and capacity building support to help developing countries implement the Paris Agreement.

Australia ratified the Paris Agreement in November 2016. Australia's target under the Paris Agreement is to reduce emissions by 26-28 per cent below 2005 levels by the year 2030, thus progressing the levels of reduction required to meet the Kyoto Protocol targets.

3.2 Australian Context

3.2.1 Australia and the Kyoto Protocol

Australia submitted its "instrument of ratification" on 12 December 2007. Ratification came into force for Australia on 11 March 2008 following a mandatory 90 day waiting period. Under the protocol, developed countries are legally required to take domestic action to reduce greenhouse gas emissions. Each developed country's target was negotiated and agreed. Australia's national target for the five years of the first commitment period (2008-2012) was to achieve an average of 108% of 1990 emissions. Australia met its first commitment period Kyoto Protocol target. In 2013 the Second Commitment Period (CP2) of the Kyoto Protocol started, which will run to 2020. The changes made to the Kyoto Protocol for CP2 were finalised at the UNFCCC Climate Change Conference in 2012 in Doha, Qatar, leading to the Doha Amendment. Australia negotiated two emission reduction targets for CP2: an 'unconditional' target of 5 per cent to 15 per cent below 2000 emission levels by 2020, plus a 'conditional' target of 25 per cent below 2000 emission levels by 2020.

3.2.2 Australia and the Paris Agreement

In accordance with the Australian Government Department of the Environment and Energy, Australia has set an ambitious target to reduce emissions by 26-28 % below 2005 levels by 2030, which builds on Australia's 2020 target of reducing emissions by 5% below 2000 levels. Australia's targets will be achieved through a credible policy suite that is already reducing emissions, encouraging technological innovation and expanding Australia's clean energy sector. With a total of 611 Mt CO_2-e reported in

2005, this equates to a 2030 target of 440–452 Mt CO_2-e. At present, Australia is on track to meet its 2020 target.

3.2.3 The National Greenhouse and Energy Reporting Framework

Federal parliament passed the *National Greenhouse and Energy Reporting Act 2007* (the NGER Act) in September 2007 (CER, 2007). The NGER Act establishes the legislative framework for the NGER Scheme, which comprises a national framework for reporting greenhouse gas emissions, greenhouse gas projects and energy consumption and production by corporations in Australia.

The NGER Act is one of a number of legislative instruments related to greenhouse reporting, which together form the National Greenhouse and Energy Reporting (NGER) System. These include the following:

- The *National Greenhouse and Energy Reporting Regulations 2008* (CoA, 2018) the most recent amendments and provide the necessary details that allow compliance with, and administration of, the NGER Act.
- The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (CoA, 2017) provides methods and criteria for calculating greenhouse gas emissions and energy data under the NGER Act.
- The *National Greenhouse and Energy Reporting (Audit) Determination 2009* (CoA, 2009) sets out the requirements for preparing, conducting and reporting on greenhouse and energy audits.
- The *National Greenhouse and Energy Reporting (Measurement) Technical Guidelines* (DEE, 2017) ('the NGER Technical Guidelines') assist corporations and liable entities to understand and apply the NGER (Measurement) Determination 2008.
- The *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (COA, 2019) sets out the details that establish compliance rules and procedures for administering the safeguard mechanism (commenced on 1 July 2016).

The NGER Act is seen as an important step in the establishment of a domestic emissions trading scheme. This intention is explicitly stated in the objectives for the NGER Act, as follows:

- establish a baseline of emissions for participants in a future Australian emissions trading scheme;
- inform the Australian public;
- meet international reporting obligations; and
- assist policy formulation of all Australian governments while avoiding duplication of similar reporting requirements.

Companies with operational control over facilities that exceed the reporting thresholds (Table 3.1) are required to report their annual emissions, energy consumption and production as part of their NGER report. The NGER Regulations state that the NGER report must include specific information regarding the contractor if in a reporting year, a contractor conducts an activity or activities that exceed the contractor thresholds in Table 3.1.

Table 3.1: NGER Reporting Thresholds

Category	Corporate	Facility	Contractors
Scope 1 and Scope 2 GHG emissions	50 kt CO_2-e/year or more	25 kt CO_2-e/year or more	
Energy consumption	200 TJ/year or more	100 TJ/year or more	
Energy production			

If a corporation has operational control over facilities whose GHG emissions or energy use in a given reporting year:

- Individually exceed the relevant facilities threshold; or
- When combined with other facilities under the corporation's operational control, exceed the relevant corporate thresholds.

That corporation must report the relevant GHG emissions or energy use (as the case may be) for that year under the NGER Act. This may include construction or other contractors, for example.

It is anticipated that during construction, there will be multiple parties with operational control over different aspects of the site development. For this reason, while it is anticipated that there is likely to be some reporting requirement under the NGER scheme, this is likely to be apportioned across the NGER reporting corresponding to several corporations.

Once operational, the Proposal's total GHG emissions are anticipated to exceed the facility threshold of 25,000 t CO_2-e. In addition, AGL as a corporate entity currently exceeds the corporate reporting threshold. Accordingly, the reporting of emissions would be required under the NGER scheme.

3.2.4 The Safeguard Mechanism

Together with the reporting obligations under the NGER Act, the safeguard mechanism provides a framework for entities to manage their emissions. It does this by encouraging large facilities, whose net emissions exceed the safeguard threshold, to keep their emissions at or below emissions baselines set by the Clean Energy Regulator. AGL propose to conform with the requirements of this rule.

The safeguard mechanism applies to facilities with Scope 1 covered emissions of more than 100 kt CO_2-e per year. Emission baselines represent the reference point against which emissions performance are measured under the safeguard mechanism.

Responsible emitters for safeguard facilities are required to register under the NGER Act. The Clean Energy Regulator is required to publish information about all designated large facilities covered by the safeguard mechanism for each reporting year. For each facility covered by the safeguard mechanism in a reporting year, information published includes the baseline emissions number in force for that year, total reported emissions, the responsible emitter(s) for each facility, and any Australian Carbon Credit Units (ACCUs) surrendered.

Sector and Facility Baselines

Baselines are set in different ways depending on whether the facility is new, the facility's industry sector and whether the baseline is fixed or annually adjusted for production. A baseline may be adjusted to accommodate economic growth or natural resource variability.

A sectoral approach is taken to grid-connected electricity generators because the electricity sector operates more like a single entity, where the output produced is centrally coordinated to meet demand in real time. Once the sectoral baseline is exceeded, individual baselines will apply to each generator inclusive of those within the NEM (i.e. the Proposal). The sectoral baseline is set at 198 Mt CO_2-e, based on electricity sector's emissions from 2009–10 to 2013–14.

An application for a calculated baseline under the new facility criteria can be submitted when covered emissions have exceeded, or are reasonably expected to exceed 100,000 t CO_2-e in the first year of the calculated baseline. A calculated baseline made under the new facility criteria must commence no later than 1 July 2019. From 1 July 2020, new facilities can apply for a benchmark baseline.

An application under the new facility criteria must be accompanied by an independent audit report providing assurance of the forecast production and emissions intensity (if forecast) and that the new facility criteria have been met.

Safeguard Obligations

Safeguard obligations rest with the person with operational control of the facility, the '*responsible emitter*'. This person is required to keep the facility's net emissions at or below its emissions baseline. The responsible emitter may be an individual, a body corporate, a trust, a corporation sole, a body politic or a local governing body.

Responsible emitters with a facility that has, or is likely to, exceed its baseline have a number of options to manage the excess emissions situation. For example, the responsible emitter can reduce the facility's net emissions by purchasing and surrendering ACCUs to offset their emissions. Both Kyoto and non-Kyoto ACCUs can be used as offsets under the safeguard mechanism. Responsible emitters may also apply for a calculated baseline or access other management options in certain circumstances where they have, or expect to, exceed their baseline.

3.3 New South Wales – Climate Change Policy Framework

The NSW Government has a Climate Change Policy Framework (OEH, 2016) and has committed to an aspirational target of net-zero emissions by 2050 and towards building more resilience to changing climate. The intent of the framework is to maximise the economic, social and environmental wellbeing of NSW in the context of climate change and current and emerging policy settings and actions to address climate change. The framework sets out seven policy directions for the NSW government to respond to climate change.

The Premier and the Minister for the Environment's Draft Climate Change Fund Strategic Plan (NSW Office of Environment & Heritage, 2016b), sets out priority investment areas and potential actions for up to $500 million of new funding from the Climate Change Fund for five years from 2017 to 2022. It organises potential actions into three priority investment areas

- *Accelerating advanced energy* – aims to provide greater investment certainty for private sector, accelerating new technology to reduce future costs and helping communities make informed decisions on a net-zero emissions future.
- *National leadership in energy efficiency* - focuses on building energy productivity and lowering energy prices
- *Preparing for a changing climate* – aims to reduce costs to public and private assets that arise from climate change, reduce impacts on health and wellbeing, particularity in vulnerable communities and manage impacts of climate change on natural resources, ecosystems and communities

4. ACCOUNTING METHODOLOGY

Quantification of GHG emissions has been performed in accordance with the GHG Protocol (WRI & WBCSD, 2004), IPCC and Australian Government GHG accounting/classification systems.

This GHGA is also guided by the emission estimation methodologies endorsed under the NGER Regulations. These describe the detailed requirements for reporting under the NGER framework and also provide a basis for estimating emissions from proposed activities.

GHGs are gases in the Earth's atmosphere that play an important role in regulating the earth's temperature. Anthropogenic GHG, such as the burning of fossil fuels (e.g. coal and oil) and deforestation have caused the GHG levels in the Earth's atmosphere to increase significantly. As this occurs, the Earth's surface temperature is increasing (referred as global warming).

The NGER Guidelines are reported year specific, and outline calculation methods and criteria for determining GHG emissions, energy production, energy consumption and potential GHG emissions embodied in combusted fuels. The latest published NGER Guidelines (at the time of writing) have been referenced. GHGs do not, in themselves, cause a direct local impact but are important in the global context of climate change. GHG emissions are all expressed as tonnes of carbon dioxide equivalents (t CO_2-e).

Global Warming Potential (GWP) is a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide. Carbon dioxide equivalent (CO_2-e) is a metric measure used to compare the emissions from various GHG based on their GWP.

The GWP values of the common greenhouse gas are presented in Table 4-1:

Table 4.1: Global Warming Potential Values

Greenhouse Gas	Global Warming Potential Value
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298

Source: DoEE (2017), Appendix C

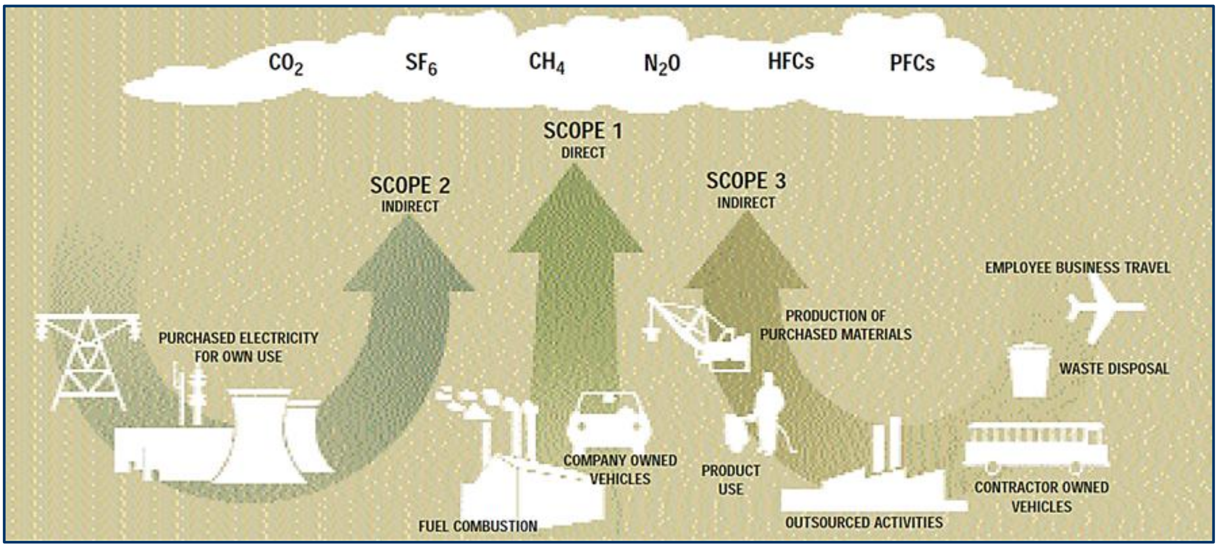
4.1 The GHG Protocol

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organization for Standardisation, endorsed by GHG initiatives (such as the Carbon Disclosure Proposal) and is compatible with existing GHG trading schemes.

Key principles applied within the GHG protocol are as follows:

- *Relevance*: The inventory must contain the information that both internal and external users need for their decision making.
- *Completeness*: All relevant emissions sources within the inventory boundary need to be accounted for so that a comprehensive and meaningful inventory is compiled.
- *Consistency*: The consistent application of accounting approaches, inventory boundary and calculation methodologies is essential to producing comparable GHG emissions over time.
- *Transparency*: Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
- *Accuracy*: Data should be sufficiently precise to enable intended users to make decisions with reasonable assurance that the reported information is credible.

Under this protocol, three "scopes" of emissions (Scope 1, Scope 2 and Scope 3) are defined for GHG accounting and reporting purposes. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The definitions for Scope 1, Scope 2 and Scope 3 emissions are provided in the following sections, with a visual representation provided in Figure 4.1.



Source: WRI & WBCSD 2004

Figure 4.1: Overview of Scopes and Emissions across a Reporting Entity

4.1.1 Scope 1: Direct Greenhouse Gas Emissions

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct greenhouse gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources, the principal source of greenhouse emissions associated with the operation of the Proposal.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc.
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, e.g., trucks, trains, ships, aeroplanes, buses and cars.
- Fugitive emissions. These emissions result from intentional or unintentional releases, e.g., equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; HFC emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport.

4.1.2 Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that accounts for greenhouse gas emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 covers purchased electricity defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the (third-party) facility/s where electricity is generated. Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as Scope 2.

In the context of this GHGA, it has been assumed that the Proposal will import electricity to power ancillary equipment at the Site, as well as auxiliary (parasitic) loads associated with operation of the Proposal.

4.1.3 Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services. In the case of BIPS, Scope 3 emissions will include emissions associated with fuel cycles.

The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that Scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with Scope 1 and Scope 2. However, the GHG Protocol notes that reporting Scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

Under the NGER Act, facilities triggering greenhouse emission and energy usage thresholds are required to report Scope 1 and Scope 2, but not Scope 3.

4.2 Materiality of Emissions

ISO 14064.1-2006 provides the following definition of Materiality:

> "*Materiality – concept that individual or an aggregate of actual errors, omissions and misrepresentations in the GHG assertion that could affect the decisions of the intended users*"

ISO 14064 also states that acceptable materiality is determined by the validator, verifier or GHG program, based on the agreed level of assurance. Most definitions of materiality adopt a similar approach and are non-prescriptive, usually leaving the assessment of materiality to the judgement of a verifier.

In practice and as the GHG Protocol states; as a rule of thumb, an error is considered to be materiality misleading if its value exceeds 5% of the total inventory. All emissions that are within the organisational boundary are included in the inventory unless they are excluded on materiality grounds or data was otherwise unavailable at the time of preparing the greenhouse gas assessment.

5. GHG IMPACTS

This section provides detail of GHG impacts associated with the Proposal.

5.1 Key Emission Sources

This assessment has focused on operational emissions associated with the combustion of fuels within generator plant. Emissions associated with the importation of electricity, as well as activities such as construction and trucking of waste water are anticipated to be negligible in the context of this quantitative analysis and therefore have not been considered further.

At the time of preparation, limited detail was available for gas reception and emergency diesel generators. Whilst potential GHG contribution from this infrastructure is anticipated to be minor, consideration of these sources should be made as the plant design is progressed and such detail becomes available.

5.2 Operating Conditions

The estimation of greenhouse gas emissions requires an understanding of the generating loads and frequency of operation at which the Proposal would operate. AGL anticipates that the Proposal would operate with a capacity factor in the order of 14% during its initial years of operation, with the number of annual starts ranging from 50 to 200. This analysis has assumed that individual generation units will operate at or near to full output.

5.3 Emission Factors

GHG emission factors have been compiled for Scope 1 and Scope 3 emissions associated with natural gas and diesel fuel combustion, as sourced from DoEE (2019a) *National Greenhouse Accounts Factors.* It is noted that the Scope 1 emission factors contained in DoEE (2017) align with those presented within the NGER (Measurement) Determination (CoA, 2017).

Table 5-1 provides a summary these factors for natural gas and diesel fuels.

Table 5.1: Summary of NGA Emission Factors – fuel combustion for stationary energy (kg CO_2-e/GJ)

Emission Scope	Natural Gas	Diesel
Scope 1	51.5	70.2
Scope 3	13.6	3.6
Scope 1 + Scope 3	65.4	73.8

5.4 Activity Estimates

Activity data has been prepared for a range of plant options being considered (by AGL) for the Proposal. This data is based on an estimate of typical operating duty based on AGL forecasts. Whilst these estimates provide a historically conservative representation of peaking plant operation, they do not constitute an upper limit for the Proposal.

Scaling estimates of startup and shutdown fuel consumption and auxiliary loads have been performed in order to incorporate an allowance for these factors.

For the purposes of this assessment, the following assumptions have been made:

- The plant is operational at full electrical output for 14% of the year.

- The plant will start 200 times per year, with startup and shutdown fuel consumption equivalent to that consumed over 12 minutes at an average fuel consumption equal to 20% of that at full load[1].
- Electricity demand associated with plant auxiliary equipment comprises 1.5% of electrical output, and will be energised off the plant generator.
- Scope 2 emissions (for electricity consumed by non-auxiliary plant) is minor.

Allowance for fuel associated with startup have been incorporated using coarse estimates.

Within each plant option, generator output and associated fuel consumption have been selected for the operating mode with the highest heat rate at full operating load (i.e. thermal energy input per unit of electrical output). Emissions have been prepared for each fuel and technology / plant option. Actual operation would likely comprise a mix of fuel types.

Table 5.2 through Table 5.5 provide estimates of short-term and annualised electrical output and fuel consumption that have formed the basis for emission intensity.

Table 5.2: Plant output at full load (MW sent out, net basis)

Plant Option	Natural Gas Operation	Diesel Operation
Reciprocating Engine 1	255	254
Reciprocating Engine 2	257	257
Gas Turbine 1	255	252
Gas Turbine 2	256	243
Gas Turbine 3	274	215

Note: Operating mode (for each option) selected on the basis of worst case heat rate. Plant outputs may vary for alternate operating modes.

Table 5.3: Plant fuel consumption at full load (GJ/hr, HHV)

Plant Option	Natural Gas Operation	Diesel Operation
Reciprocating Engine 1	2,212	2,261
Reciprocating Engine 2	2,278	2,266
Gas Turbine 1	2,519	2,447
Gas Turbine 2	2,728	2,564
Gas Turbine 3	2,735	2,171

Note: Operating mode (for each option) selected on the basis of worst case heat rate. Fuel consumption may vary for alternate operating modes.

Table 5.4: Annualised fuel consumption (TJ/annum, HHV)

Plant Option	Natural Gas Operation	Diesel Operation
Reciprocating Engine 1	2,731	2,791
Reciprocating Engine 2	2,812	2,797
Gas Turbine 1	3,109	3,021
Gas Turbine 2	3,367	3,165
Gas Turbine 3	3,376	2,680

Note:
- Operating mode (for each option) selected on the basis of worst case heat rate. Fuel consumption may vary for alternate operating modes.

[1] Based on publicly available GE estimates for an LM6000 turbine, inclusive of startup fuel consumed from ignition to completion of synchronisation, and shutdown fuel consumed from commencement of idle through to closure of fuel valve (total ~ 20 MMBTU over approximately 12 minutes).

- Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase (assuming continuous operation in addition to 200 startup and 200 shutdown events per annum).

Table 5.5: Annualised electricity output (GWh sent out, net basis)

Plant Option	Natural Gas Operation	Diesel Operation
Reciprocating Engine 1	313	312
Reciprocating Engine 2	316	316
Gas Turbine 1	313	309
Gas Turbine 2	314	298
Gas Turbine 3	336	264

Note: Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase.

5.5 Emission Estimates

Table 5.6 presents the operational emission estimates as by scope, fuel type and plant option. Figure 5.1 provides a graphical representation of these data.

Table 5.6: Annualised operational emission estimates (kt CO_2-e/annum)

Plant Option	Natural Gas Operation			Diesel Operation		
	Scope 1	Scope 3	Scope 1 + 3	Scope 1	Scope 3	Scope 1 + 3
Reciprocating Engine 1	141	37	178	196	10	206
Reciprocating Engine 2	145	38	183	196	10	206
Gas Turbine 1	160	42	202	212	11	223
Gas Turbine 2	173	46	219	222	11	234
Gas Turbine 3	174	46	220	188	10	198

Note: Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase (assuming continuous operation in addition to 200 startup and 200 shutdown events per annum).

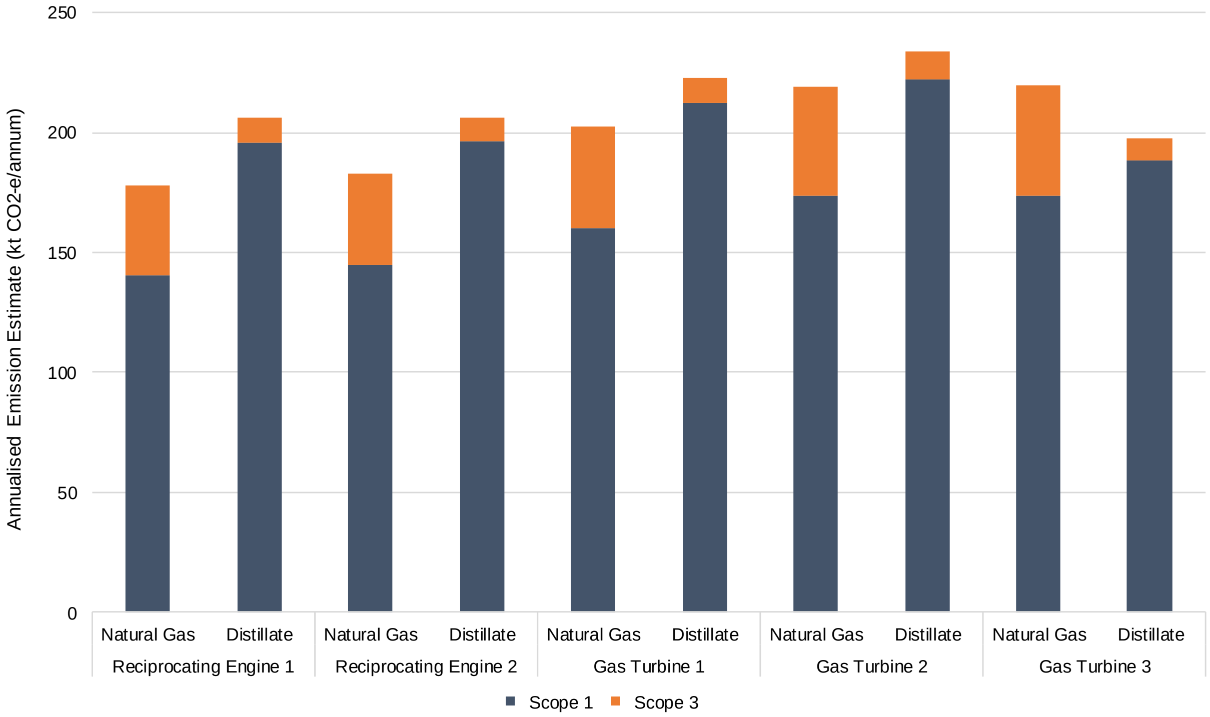


Figure 5.1: Annualised operational emission estimates

Table 5.7 presents these data as a function of the 25 year Proposal lifetime.

Table 5.7: Proposal lifetime emission estimate (Mt CO_2-e)

Plant Option	Natural Gas Operation			Diesel Operation		
	Scope 1	Scope 3	Scope 1 + 3	Scope 1	Scope 3	Scope 1 + 3
Reciprocating Engine 1	3.5	0.9	4.4	4.9	0.3	5.1
Reciprocating Engine 2	3.6	1.0	4.6	4.9	0.3	5.2
Gas Turbine 1	4.0	1.1	5.1	5.3	0.3	5.6
Gas Turbine 2	4.3	1.1	5.5	5.6	0.3	5.8
Gas Turbine 3	4.3	1.1	5.5	4.7	0.2	4.9

Notes:

- Scope 1 + 3 totals may appear non-additive due to rounding.
- Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase (assuming continuous operation in addition to 200 startup and 200 shutdown events per annum).

5.6 Comparison to NSW and National GHG Inventories

In order to provide an indication of the relative scale of emissions from the Proposal, a comparison against inventory data reported within *State and Territory Greenhouse Gas Inventories 2017, Australia's National Greenhouse Accounts* (DoEE, 2019b) has been made.

Table 5.8 provides a comparison of annualised Proposal emissions (highest scenario) against NSW and national inventories for the electricity generation sector and all sectors. Table 5.8 shows the Proposal as a relative percentage of these corresponding inventory quantities, whilst Figure 5.2 provides a visual representation of these data.

Table 5.8: Comparison of annualised Proposal emissions to 2017 NSW and national inventories

Sector	Annualised GHG Emissions (Mt CO_2-e)		
	Proposal	NSW	National
Stationary Energy - Electricity Generation	0.2	51.1	190
All		131.5	535

Note: Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase (assuming continuous operation in addition to 200 startup and 200 shutdown events per annum).

Table 5.9: Comparison of annualised Proposal emissions to 2017 NSW and national inventories (by percentage)

Sector	NSW	National
Stationary Energy - Electricity Generation	0.46%	0.12%
All Sectors	0.18%	0.04%

Note: Estimates based on a plant capacity factor of 14%. Expansion of these estimates to continuous operation would result in a seven-fold increase (assuming continuous operation in addition to 200 startup and 200 shutdown events per annum).

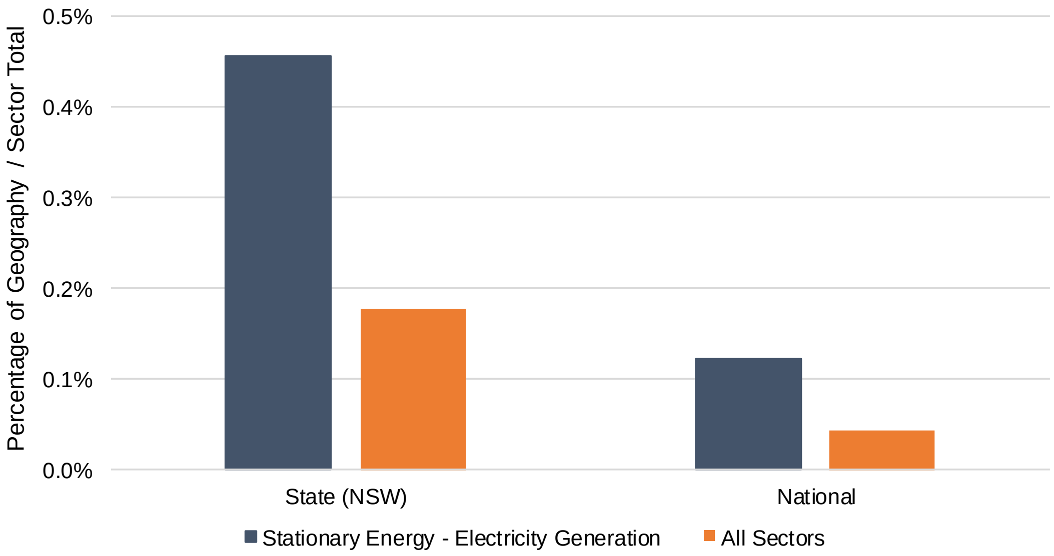


Figure 5.2: Comparison of Proposal emissions to 2017 NSW and national inventories (by percentage)

These data show that with the assumption of a 14% capacity factor, GHG emissions from the Proposal would equate to approximately 0.46% and 0.12% of the 2017 NSW and national inventories for electricity generation, and to approximately 0.18% and 0.04% of the 2017 NSW and national inventory totals (respectively).

5.7 Operational Emission Intensity

Table 5.8 presents estimates of the annualised operational emission intensity for the various plant options and fuel types. These data are inclusive of Scope 1 + 3 emissions, including an allowance for auxiliary loads and plant startups, thus reflecting an overall average of the quantity of GHG emissions per unit of electricity output.

A graphical representation of this data is provided in Figure 5.2.

Table 5.10: Annualised operational (Scope 1 + 3) emission intensity estimate (kg CO_2-e / MWh)

Plant Option	Natural Gas Operation	Diesel Operation
Reciprocating Engine 1	568	661
Reciprocating Engine 2	580	654
Gas Turbine 1	647	721
Gas Turbine 2	698	785
Gas Turbine 3	654	749

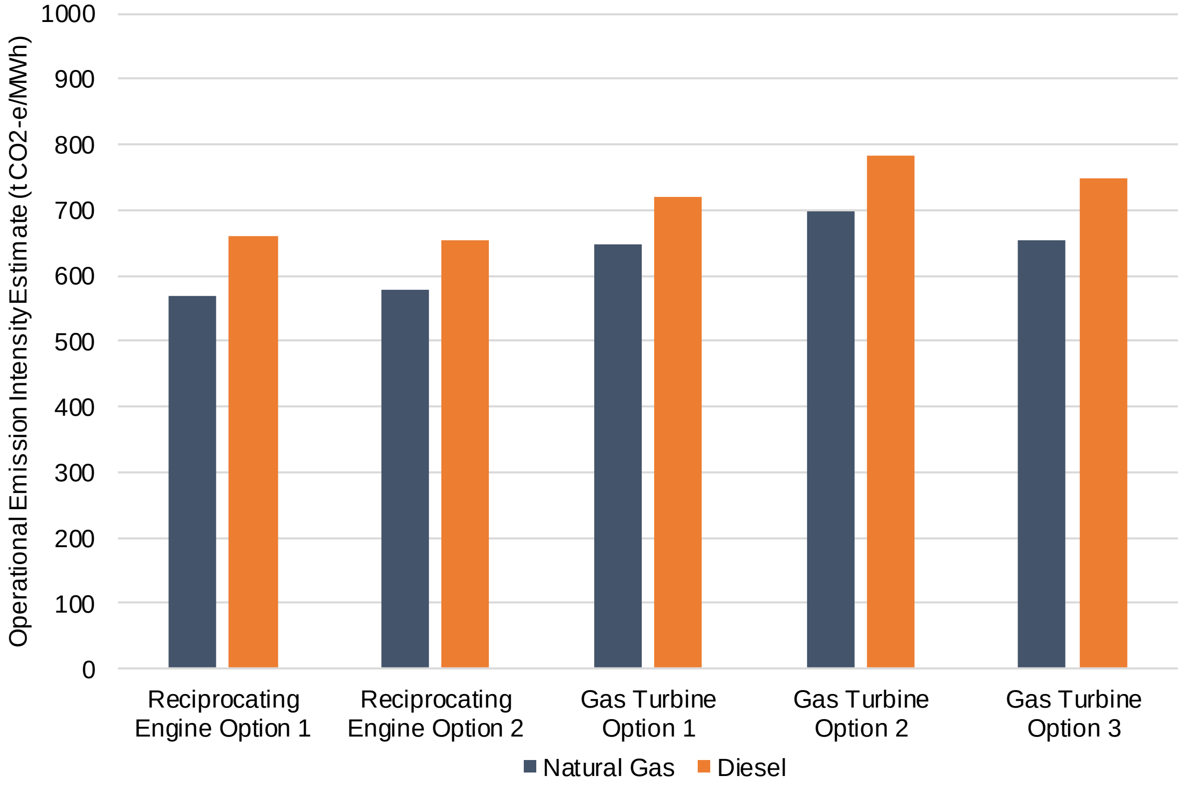


Figure 5.3: Annualised operational (Scope 1 + 3) emission intensity estimate

To further contextualise these operational emission intensity estimates, a comparison has been made against reference data provided for a range of existing NSW generators and generic technologies within ACIL Allen (2016), as well as the NSW grid average as provided in DoEE (2017). This comparison is shown in Table 5.11 and Figure 5.4.

Table 5.11: Comparison of scope 1 + 3 emission intensities

Source	Technology - Fuel	Scope 1 + 3 Emission Intensity (kg/CO_2-e/MWh)
Bayswater	Steam turbine - Black Coal	953
Eraring*	Steam turbine - Black Coal	948
Liddell	Steam turbine - Black Coal	1,019
Mt Piper	Steam turbine - Black Coal	938
Vales Point B	Steam turbine - Black Coal	947
Tallawarra	CCGT - Natural gas	453
Smithfield	Cogeneration - Natural gas	593
Colongra GT	OCGT - Natural gas	774
Uranquinty	OCGT - Natural gas	717
Generic	CCGT - Natural gas	453
	OCGT - Natural gas	674
	Supercritical PC - Black coal	801
Proposal (Worst Case Option and Heat Rate)	Reciprocating Engine - Natural Gas	568
	Reciprocating Engine - Distillate	661
	Gas Turbine - Natural Gas	698
	Gas Turbine - Distillate	785
NSW	Grid Average	910*

Note: *Includes DoEE (2017) Scope 2 emission factor of 830 kg CO_2-e/MWh and DoEE(2019a) distribution network operator specific scope 3 emission factor of 80 kg CO2-e/MWh (footnote of Table 44 with NGA Factors document). Collectively, these two factors encompass emissions at the point of generation, as well as those associated with extraction and distribution of the fuel, thus comprising a representation of grid average Scope 1 and Scope 3 generator emissions in the context of this comparison.

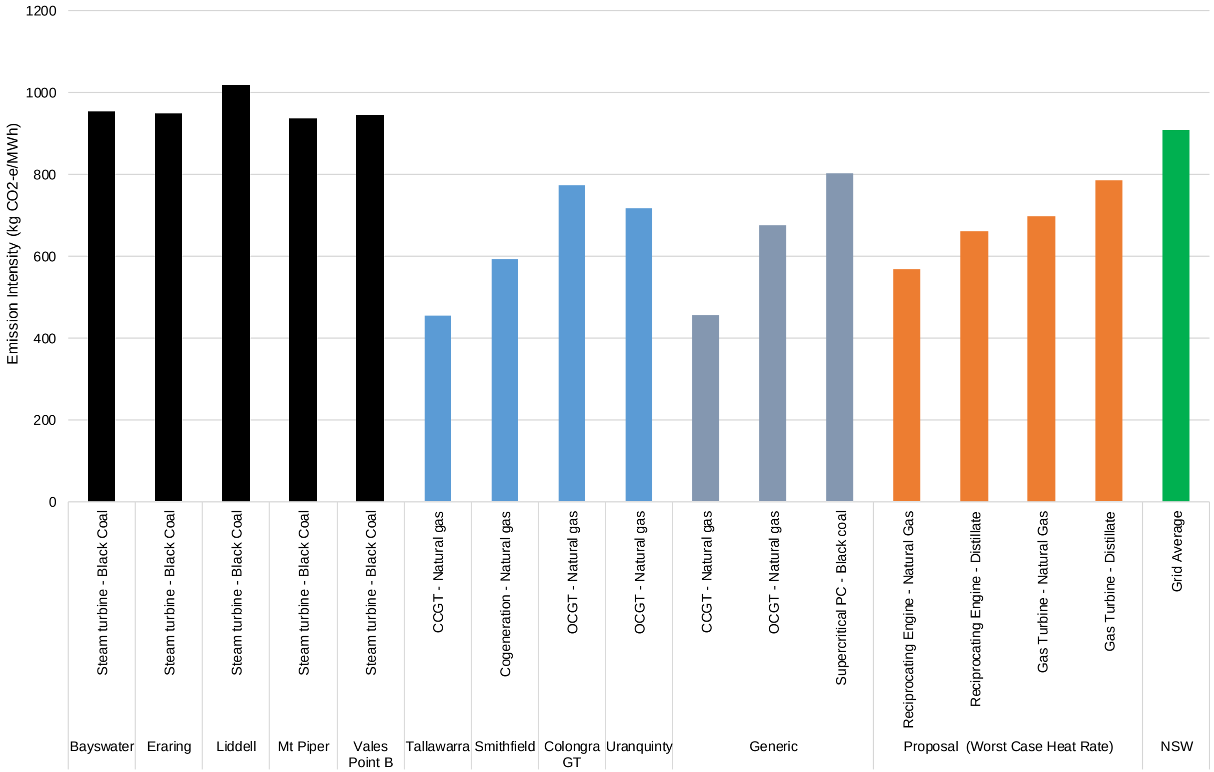


Figure 5.4: Comparison of scope 1 + 3 emission intensities

As shown in Figure 5.4, the emission intensity of the proposed generation technologies are broadly consistent with best achievable emission intensity for utility scale fossil fuel peaking power generation, with a slightly lower emission intensity predicted for reciprocating engine plant. The only technology with a lower emission intensity is Combined Cycle Gas Turbine (CCGT). Given the startup duration and increased capital costs, CCGT is less suited to the peaking operation proposed by AGL.

6. CONCLUSIONS

ERM has undertaken an assessment of greenhouse gas emissions from the Proposal. Operational forecasts have estimated that the Proposal would operate during peak fluctuations in market demand with a capacity factor in the order of 14% during its initial years of operation, and annual starts ranging from 50 to 200. When operational, AGL anticipate that the plant will typically operate at or near to full output of approximately 250 MW.

The selection of the generation technology (i.e. engine or turbine) and arrangement of the specific generation units would require further design following EIS finalisation. The generation technology has been assessed throughout the EIS and specialist studies using an envelope approach that covers likely operational outcomes of the proposed technology options.

Plant design data has been reviewed, with estimation of net power output, and fuel consumption for worst case operating modes, inclusive of both reciprocating engine and gas turbine technologies.

With the assumption of a 14% capacity factor, total annualised operational Scope 1 emissions have been estimated at between approximately 140 – 220 kt CO_2-e per annum, requiring reporting of emissions under the NGER scheme. Expansion of this estimate to a continuous operating scenario results in estimated emissions of approximately 1.0 – 1.6 Mt CO_2-e per annum.

These estimates indicate that at 14% capacity factor, GHG emissions from the Proposal would equate to approximately 0.46% and 0.12% of the 2017 NSW and national inventories for electricity generation (respectively), and to approximately 0.18% and 0.04% of the 2017 NSW and national inventory totals (respectively). With expansion of this estimate to continuous operation, GHG emissions from the Proposal would equate to approximately 3.3% and 0.9% of the 2017 NSW and national inventories for electricity generation (respectively), and to approximately 1.3% and 0.3% of the 2017 NSW and national inventory totals (respectively).

With the adoption of worst case heat rates for each design option, the corresponding full fuel cycle (Scope 1 + 3) emission intensity has been estimated at between 570 – 780 kg CO_2-e/MWh, indicating that the achievable emission intensities for the proposed generation technologies are broadly consistent with best achievable emission intensity utility scale fossil fuel peaking power generation, with a slightly lower emission intensity predicted for reciprocating engine plant.

Based on the analysis in this GHGA, the impacts of the Proposal are anticipated to be below the current grid average emission intensity of 910 kg CO_2-e/MWh, whilst also providing fast response electricity generation, consistent with the accommodation of an increased proportion of renewable energy sources into the electricity grid.

7. REFERENCES

ACIL Allen 2016, May 2016, *Emission Factors Assumptions Update - Final Report*, ACIL Allen, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2016/Data_Sources/ACIL-ALLEN---AEMO-Emissions-Factors-20160511.pdf (accessed September 2019)

CoA 2017a, *National Greenhouse and Energy Reporting (Measurement) Determination 2008* Commonwealth of Australia, 1 July 2017, https://www.legislation.gov.au/Series/F2008L02309 (accessed July 2019)

CoA 2017b*, National Greenhouse and Energy Reporting (Audit) Determination 2009*, (as amended), Commonwealth of Australia, 1 July 2017, https://www.legislation.gov.au/Series/F2010L00053 (accessed July 2019)

COA 2019, *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*, Commonwealth of Australia, 7 March 2019, https://www.legislation.gov.au/Details/F2019C00208 (accessed July 2019)

COA 2019, *National Greenhouse and Energy Reporting Regulations 2008,* (as amended), Commonwealth of Australia, 7 March 2019, https://www.legislation.gov.au/Details/F2018C00533 (accessed July 2019)

DoEE, 2017*, National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines for the estimation of emissions by facilities in Australia,* Australian Government, Department of the Environment and Energy, October 2017, http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/nger/technical-guidelines (accessed July 2019)

DoEE 2019a, *National Greenhouse Accounts Factors, Australian National Greenhouse Accounts*, Australian Government, Department of the Environment and Energy, August 2019, http://www.environment.gov.au/system/files/resources/5a169bfb-f417-4b00-9b70-6ba328ea8671/files/national-greenhouse-accounts-factors-july-2017.pdf (accessed September 2019)

DoEE 2019b, *State and Territory Greenhouse Gas, Inventories 2017, Australia's National Greenhouse Accounts*, Australian Government, Department of the Environment and Energy, June 2019, http://www.environment.gov.au/system/files/resources/917a98ab-85cd-45e4-ae7a-bcd1b914cfb2/files/state-territory-inventories-2017.pdf (accessed September 2019)

IPCC. (2000). Good Practice Guidance and Uncertainty Management in National GHG Inventories published by Intergovernmental Panel on Climate Change (IPCC).

IPCC. (2006). Guidelines for National Greenhouse Gas Inventories by Intergovernmental Panel on Climate Change (IPCC).

IPCC. (2019). 2019 Refinements to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories.

WBCSD & WRI 2004, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Revised Edition, World Business Council for Sustainable Development & World Resources Institute 2004.

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