Darwin

First Floor
48-50 Smith Street
Darwin NT 0800

GPO Box 1782
Darwin NT 0800

p: +61 8 8943 0675
e: darwin@appea.com.au
w: www.appea.com.au

30 June 2017

Justice Rachel Pepper
Chair
Hydraulic Fracturing Taskforce
GPO Box 4396
Darwin, NT 0801, Australia

Dear Justice Pepper,

As referenced in APPEA's submission to the Background and Issues Paper, we had commissioned EcOz Environmental Consulting to prepare a report on comparative industry environmental impacts in the Northern Territory. Please find attached a copy of that report.

APPEA commissioned EcOz to analyse the environmental impacts associated with the potential development of natural gas reservoirs using hydraulic fracturing, and then compare these to other major industries that currently operate in the NT.

EcOz is the Territory's longest established locally-owned environmental consultancy. Formed in 1990, EcOz provides a broad range of environmental services to a diverse range of local, national and international clients.

For the purpose of its analysis, EcOz modelled a hypothetical unconventional gas development project. EcOz assumed three identical projects are developed concurrently in the NT's Beetaloo Basin.

APPEA looks forward to continued engagement with the Inquiry on this important work for the Northern Territory. Please contact [redacted] or [redacted] should you or your staff wish to discuss any aspect of this work.

Sincerely,

Matthew Doman
Director – South Australia/Northern Territory

Comparative Impacts Study

Content to support APPEA's submission to the *Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*

June 2017

DOCUMENT CONTROL RECORD

Document code	EZ17048-C0301-EIA-R-0004
Catalogue number	D000079891 (M ID 156633)
Author(s)	[redacted]
Approved by	[redacted]
	[redacted]
Approval date	26 June 2017

EcOz Pty Ltd.
ABN: 81 143 989 039
Winlow House, 3rd Floor
75 Woods Street
DARWIN NT 0800
GPO Box 381, Darwin NT 0800

Telephone: +61 8 8981 1100
Facsimile: +61 8 8981 1102
Email: ecoz@ecoz.com.au
Internet: www.ecoz.com.au

APPROVED COMPANY
AS/NZS 4801
OH&S
Management Systems
QMS Certification Services

APPROVED COMPANY
ISO 9001
Quality
Management Systems
QMS Certification Services

TABLE OF CONTENTS

1 Introduction 1
2 Water use 2
2.1 Existing industry 2
2.1.1 Pastoralism 2
2.1.2 Agriculture 2
2.1.3 Tourism 3
2.1.4 Mining 3
2.1.5 Aquaculture 3
2.2 Onshore unconventional gas industry 4
2.3 Comparison of water use 4
3 Land use 6
3.1 Existing industry 6
3.1.1 Pastoralism 6
3.1.2 Agriculture 6
3.1.3 Forestry 7
3.1.4 Tourism 7
3.1.5 Mining 7
3.1.6 Other 7
3.2 Onshore unconventional gas industry 7
3.3 Comparison of land use 8
4 Greenhouse gas emissions 9
4.1 Existing industry 9
4.2 Onshore unconventional gas industry 9
4.3 Comparison of CO_2e emissions 11
5 References 13

Tables

Table 2-1. Estimated annual volume of water consumption (by industry) in the NT 5
Table 3-1. Total area of cropped land in the NT (by produce type) 6
Table 3-2. Estimated area of land use (by industry) in the NT 8
Table 4-1. CO_2e emissions (by industry) in the NT 11

Figures

Figure 2-1. Graph comparing estimated annual water use (by industry) in the NT 5
Figure 4-1. Graph comparing CO_2e emissions (by industry) in the NT 12

1 INTRODUCTION

This report presents information about the environmental impacts associated with the development of natural gas reservoirs using hydraulic fracturing, and compares them to those of other industries that currently operate in the NT. APPEA has engaged EcOz Environmental Consultants to provide important context for the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory when considering the acceptability of the impacts and risks associated with hydraulic fracturing of deep shale gas. The information is also relevant when considering the industry's potential contribution to cumulative impacts on the NT's land and water resources.

It is difficult to acquire statistics for some industries, and so some extrapolation or estimation has been required. Where this has occurred, the assumptions upon which these calculations were based are detailed. Throughout, the intent is to provide an indication of the relative impacts of each industry.

For this purpose of this comparative assessment, three similar hypothetical project development scenarios have been assumed to occur concurrently in the Beetaloo Basin.

2 WATER USE

Each year, around two million gigalitres (GL) of rain falls on northern Australia (including northern Queensland and Western Australia). Up to 90 % of this evaporates before it can be used (Stone & Chilcott 2016). Of the remaining 10 %, less than 2 % enters groundwater (Stone & Chilcott 2016). Aquifers supply up to 90 % of the water used by industry and the community in the NT (Harrington & Cook 2014).

According to the Australian Bureau of Statistics, the NT consumed 153 GL of water in 2014-15, a decrease of 8.5 % from 2013-14 (ABS 2016). Households in the NT consumed about 35 GL of water in 2014-15, accounting for 22.9 % of total water consumption. Other major uses are discussed below.

Water use in the Northern Territory is regulated under the *Water Act.* The Act allows the enforceable allocation of water to various declared beneficial uses – including agriculture, aquaculture, public water supply and industry – while ensuring that adequate provisions are made to maintain cultural and environmental requirements. Notable exemptions apply to the use of water for pastoralism (i.e. watering animals), and to the petroleum and mining industries. None of these are required to hold water licenses and permits for the extraction of surface and groundwater under the *Water Act*. APPEA supports removal of the exemption for the petroleum industry – as recommended by Dr Alan Hawke in the *2014 Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory* – provided administrative arrangements allow for a one-stop-shop model for operators to gain timely approvals to access water.

2.1 Existing industry

2.1.1 Pastoralism

Pastoralism is spread across the NT land mass and involves a total herd of over two million head of cattle (NTCA 2017). An average-sized, Brahman-type cattle weighs between 250 and 400 kg and requires between 36 and 58 litres of water per day (assuming a maximum temperature of 35ºC (CSIRO 1990). A pregnant or lactating cow requires significantly more (up to 96 litres of water per day). Using the upper value of 58 L/day, an average-sized cow would require 21,170 litres of water per year. Applying the abovementioned NTCA figure of two million head of cattle in the NT, the water consumption of that total herd is estimated as 42,340 ML or 42.3 GL per year. This is more than five times the peak potential annual water use and nearly 17 times the average potential annual water use for production of shale gas in the Beetaloo Basin. The water required for producing pasture is discussed in Section 2.1.2.

2.1.2 Agriculture

Ten percent of Australia's agricultural production occurs in the NT – with hay, melon and mangoes the main crops by area and tonnage (NTFA 2015). The Municipality of Litchfield and the Katherine region account for most of the NT's agriculture production. It is likely that agricultural development will expand in the NT, but will be concentrated around existing, enabling infrastructure such as transport and water sources (NTG 2015a). High evaporation rates and predominantly flat topography will continue to be a challenge in harnessing surface water resources, resulting in a reliance on groundwater for crop irrigation (NTG 2014).

In 2014-15, agriculture was the largest consumer of water in the NT (ABS 2016). Total water use was 56 GL (36.7 % of all recorded consumptive water use), a 6 GL increase from 2013-14. Most of that water is for the irrigation of crops and pasture (ABS 2010). The amount consumed is more than nine times the the forecast annual water use for extraction of shale gas in the Beetaloo Basin at peak production.

This figure does not include water use for forestry. There are three large forestry sectors in the NT, mostly still in the planting and development phase (NTFA 2015). Only sandalwood plantations are irrigated. There is 5,000 ha of sandalwood in Katherine and Douglas Daly areas, with new plantings continuing. Water allocation for sandalwood is unknown; however, according to the NT Groundwater Extraction Licence Register (as at 14 February 2017) the largest sandalwood company has allocated water licenses totalling more than 29 GL per year, of which over a third is high security or priority allocation. This is more than three times the peak potential annual water use and over 11 times the average potential annual water use for production of shale gas in the Beetaloo Basin.

In 2016, Jindare Station near Pine Creek (owned by foreign interests) was granted a licence to extract up to 13,896 ML or 13.8 GL per year for agricultural purposes – including sandalwood, mahogany and annual crops (NTG 2017). This is one of the largest individual groundwater licences in the Northern Territory. This single licence is almost double the peak potential annual water use and over five times the average potential annual water use for production of shale gas in the Beetaloo Basin.

2.1.3 Tourism

There are no published data relating to water use by the tourism sector. Globally, tourism-related water use is less than 1 % and unlikely to increase, even with tourism growth expected to be around 4 % per year (Gössling et al. 2012). Global figures put the water use per tourist per day at between 84 and 2,000 L, with up to 3,423 L per bedroom per day (Global Water Forum 2013).

The combined total of domestic and international visitors to the NT in 2016 was over 1.5 million people, staying for an average of 5.8 nights, totalling more than 8.7 million nights (Tourism NT 2017). This equates to an estimated tourism industry consumption of 17,400 ML or 17.4 GL per year, assuming a very liberal consumption rate of 2,000 L per person per day.

2.1.4 Mining

There are 345 authorised mine sites in the NT (DME 2016), with manganese and gold being the most valuable commodities (MCA 2016). The mining industry relies heavily on secure and reliable access to water resources, and requires companies to install, operate and maintain the infrastructure required to access the water (MCA 2014). Availability of water resources continues to be one obstacle to mining (McDonald 1992).

Nationally, the minerals industry is a relatively small user of water (2.9 %) (MCA 2017). According to the Australian Bureau of Statistics, water consumption by the industry in the NT has shown a declining trend, with 48 GL consumed in 2012-13, 31 GL in 2013-14 and 21 GL for 2014-15. This most recent value is 13.7 % of total NT water consumption (ABS 2016).

2.1.5 Aquaculture

Fisheries in the NT are largely operated in coastal offshore water; however, there are also aquaculture farms producing barramundi, mud crabs, pearl oysters, prawns and sea cucumbers in operation and/or development.

There are no published data relating to fresh water use by the aquaculture industry in NT. Most aquaculture in the NT is of marine species, and so annual freshwater usage is not particularly high. However, the Environmental Impact Statement for the Project Sea Dragon prawn farm states that Stage 1 operations are expected to draw nominally 7 to 10 GL per annum of fresh surface water from a nearby dam (NTEPA 2017).

2.2 Onshore unconventional gas industry

Origin Energy estimated in a submission to the Inquiry that during peak production across the Beetaloo Basin, their expected development may have 50 – 65 well pads, with each having 8 wells. Other operators suggest up to 12 wells per drill pad. The stimulation of these 400 – 500 wells may be staggered over approximately 24 years. Average annual groundwater usage will be 1,200 ML per year. By approximately Year 8 of the project, recycled water will form a significant component of the water used for further stimulation activities (up to 30 %) – reducing average annual groundwater use to 840 ML per year. Peak groundwater usage for drilling and stimulation will be, for one year only, 2,600 ML.

The operational phase will have additional water requirements – but these are not expected to exceed a few megalitres per year.

In order to estimate maximum water usage for the onshore unconventional gas industry across the Beetaloo Basin, an assumption is made that Santos and Pangaea have similar scale developments that follow a similar timeline. In that case, peak water extraction for the industry will be three times the Origin value – totalling 7,800 ML or 7.8 GL – but likely much less as peak extraction for each project will unlikely coincide. Average annual groundwater usage will be three times the Origin value mentioned in an earlier paragraph – totalling 2,520 ML or 2.5 GL (assuming 30 % of the water budget coming from recycled water).

Prospective Beetaloo Basin shale gas projects will likely rely entirely upon groundwater resources for those developments' water needs. The Cambrian Limestone Aquifer (CLA) is the principal water resource in the basin; the sustainable yield from the Georgina Basin (which includes the CLA) is estimated to be in the order of 100 GL per year (NALWTF 2009). Existing groundwater use in the Beetaloo Basin is estimated at 6 GL per year (Fulton & Knapton 2015) – almost entirely for stock watering. An additional 2.5 GL per year groundwater usage (on average) represents an extraction of 2.5% of the CLA's sustainable yield.

2.3 Comparison of water use

Table 2-1 presents a summary of the estimated annual volume of water consumption (by industry) in the NT – see also Figure 2-1. If it proceeds, the unconventional gas industry would, on average, comprise 0.7 % of annual NT water consumption

Table 2-1. Estimated annual volume of water consumption (by industry) in the NT

Industry	Annual water consumption (GL)^
Domestic	35.0
Pastoralism†	42.3
Agriculture	56.0
Forestry*	20.0
Tourism	3.6
Mining	21.0
Aquaculture**	8.0
TOTAL* **	**185.9**
Unconventional gas (average)	2.5
Unconventional gas (peak)	7.8

† See Section 2.3 for the calculation used to acquire this value.

^ Consumption figures are for 2015-16 taken from ABS (2016) unless otherwise noted.

** There are no industry figures available, this is an estimate based on the Sandalwood Company licence mentioned in Section 2.1.2.*

*** This estimate assumes that Project Sea Dragon goes ahead. If not, then the value is likely to be less than 1 GL.*

**** It is acknowledged that this totals more than the 153 GL value from the Australian Bureau of Statistics mentioned at the start of Section 2. That is because some of the industry values in this table are likely to be over-estimates.*

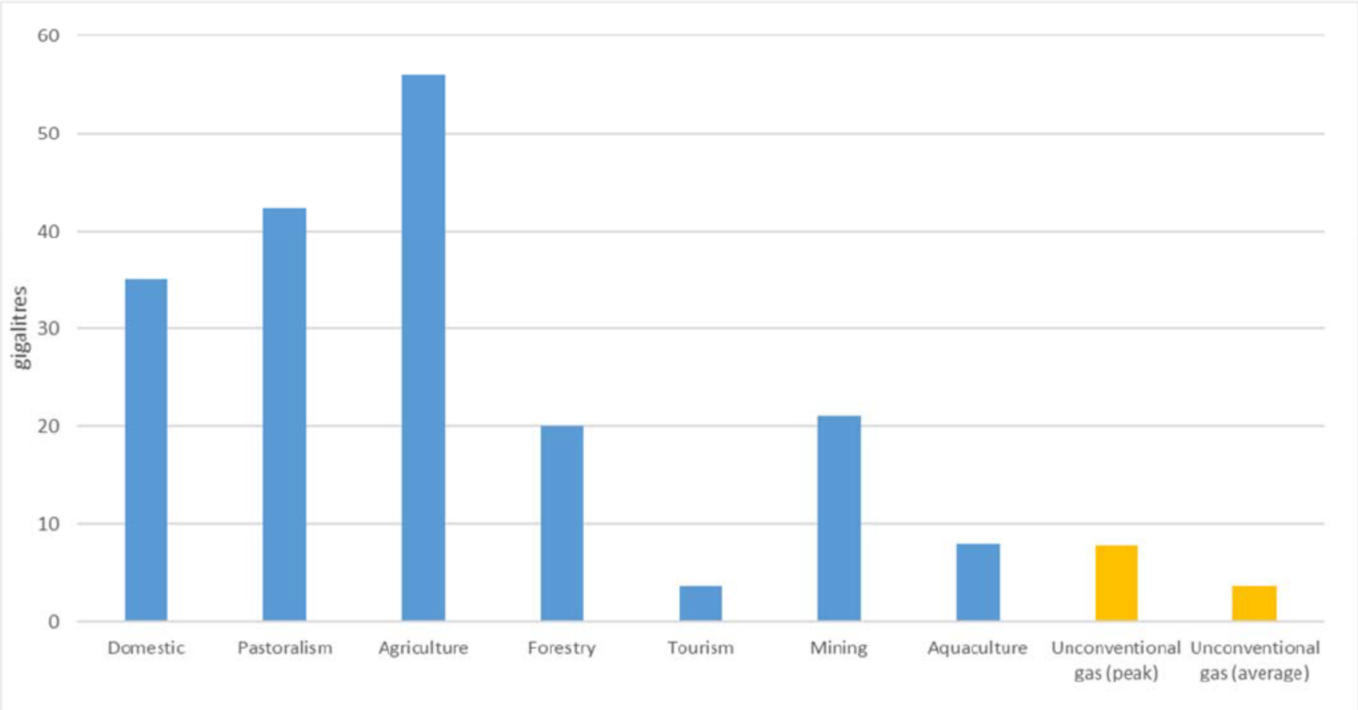

Figure 2-1. Graph comparing estimated annual water use (by industry) in the NT

See text accompanying Table 2-1 for more detail.

3 LAND USE

This chapter compares land use of various industries within the NT with the projected land use by the onshore unconventional gas industry. **In this report, the term 'land use' refers to the land area cleared for industry purposes.** Obviously, to varying degrees each industry also has impacts upon surrounding land use; however, there is no reliable metric for comparing such an impact across industries.

3.1 Existing industry

3.1.1 Pastoralism

The NT covers 1,420,000 km^2. Around 596,312 km^2 or 45 % of the NT is held under pastoral lease (NTG 2014), and it is assumed that vast majority of this is grazed by cattle – with resultant impacts on native bushland and environmental processes. Pastoral activities require land clearing for improved pasture, buildings, roads and tracks, fences, yards, holding paddocks, firebreaks, airstrips and development of waters such as dams, bores, turkey nests, tanks and troughs. However, although the total area cleared for such infrastructure is unknown, it is a very small proportion of the total area used for pastoralism in the NT. Nevertheless, according to the register of approved unzoned land clearing of native vegetation determinations made under the *Planning Act*, between 2003 and 2016 approval was granted[1] for the clearing of 418.4 km^2 of vegetation for improved pasture (an average of 29.9 km^2 per year, with a maximum single approval for 38.9 km^2). In March 2017, a single approval was granted for the clearing of 22.4 km^2 of improved pasture in the Douglas-Daly region.

3.1.2 Agriculture

The area of land required to support the agriculture industry is estimated at 288 km^2 or 0.02 % of the NT (NTFA 2015). For a breakdown by produce type, see Table 3-1. In this report, it is assumed that the area presented above reflects the total 'land use' (as defined at the start of this chapter) by the agriculture industry and that there is not a significant impact on land peripheral to that cleared.

Table 3-1. Total area of cropped land in the NT (by produce type)

Produce	Tonnes	Area (km^2)
Mango	26,500	60.3
Melon	51,000	11.0
Asian vegetables	8,800	10.0
Other vegetables	5,200	2.6
Grapes	2,000	1.5
Nursery and turf	n/a	n/a
Hay	80,000	200.0
Minor crops	2,000	1.3
NT market sales	2,000	2.0
TOTAL	**177,500**	**288.6**

Data from NTFA (2015)

[1] Not all of this may have been cleared.

3.1.3 Forestry

There are three significant forestry sectors in the NT, comprised of approximately 300 km^2 of *Acacia mangium* on the Tiwi Islands, 150 km^2 of mahogany in Douglas Daly, and over 50 km^2 of sandalwood in Katherine, Mataranka and Douglas Daly areas, with new plantings continuing (NTFA 2015). This totals 500 km^2 or 0.035 % of the NT land mass.

3.1.4 Tourism

The combined total of domestic and international visitors to the NT in 2016 was over 1.5 million people, staying for an average of 5.8 nights, totalling more than 8.7 million nights (Tourism NT 2017). The area of land required to support tourism is difficult to quantify. Tourism infrastructure occupies a negligible percentage area of the NT. However, given the natural environment is a major drawcard for many tourists, it could also be argued that a significant area of the NT is used for tourism (although the proportion of that area which is impacted upon is, again, negligible).

3.1.5 Mining

The Minerals Council of Australia (2016) states that the current area of land cleared (and not yet rehabilitated) for mining in the NT is 71 km^2 or 0.005 % of the NT land mass. Mining activities also generate noise and dust which often extend the disturbance footprint beyond the area of land cleared.

3.1.6 Other

There are other land uses across the NT, but none that occupy the same order of magnitude area as any of the industries already discussed.

3.2 Onshore unconventional gas industry

Origin Energy have concept plans of what their development area might be if allowed to proceed. For Origin's Beetaloo Basin shale gas project, the tenement area is approximately 18,500 km^2. However, only a small proportion of this will be disturbed by land clearing and/or project activities. Preliminary estimates of land clearing associated with each well pad is 0.14 km^2 – which includes the well pad, pipeline section and access tracks. The operational footprint will be smaller than this because the pipeline and a portion of the well pad will be immediately rehabilitated following construction. Based on a project description of 50 well pads, the total area of land cleared per development area over the life of the project is 7 km^2. This equates to 0.04 % of the tenement area.

As the project develops, there will also be facilities which will require vegetation clearing at a local scale – including an access track to the site, a buried pipeline to connect the development area to existing gas transmission infrastructure within the region, and onsite accommodation for the drill crews. The total disturbance area from these facilities is estimated to be an additional 1 – 2 km^2 – all of which will be within the tenure area.

Assuming that the other main players proposing activities within the Beetaloo Basin – Santos and Pangaea – have similar scale developments that follow a similar timeline, then 27 km^2 or 0.00002 % of the NT will be cleared for the onshore unconventional gas industry. In this report, it is therefore assumed that the area presented above reflects the total land use (as defined at the start of this chapter) by the onshore unconventional gas industry.

It should be noted that dominant existing land use in the Beetaloo Basin is pastoralism, and so the existing environment has been compromised because of the presence of cattle and by the installation of fences (including grid fencing), water points and other infrastructure.

It is acknowledged there is an argument that the grid nature of an onshore unconventional gas development causes 'fragmentation' of the development area – with an associated impact to biodiversity. A literature review of coal seam gas developments in the eastern states of Australia have claimed that these developments may present a risk to habitat for fauna due to fragmentation of the landscape and the creation of small, isolated populations (Williams et al. 2012). However, Williams et al. (2012) also state that the potential impacts of coal seam gas could be significantly less than the impacts and degradation already experienced as a result of agricultural and urban development over the past two centuries in Australia. This analysis was based in areas where landscape fragmentation has occurred to an extent that is orders of magnitude greater than in most of the NT, including the Beetaloo Basin. Vegetation in most of the NT still occurs in very large patches (unlike many areas in the more-developed eastern states). The larger the vegetation patch size, the less susceptible it is to fragmentation (Saunders et al. 1991). The well pads for coal seam gas are also much closer together than they are for shale gas, creating smaller patches of vegetation.

In terms of rehabilitation, shale gas developments only required the top layers of soil to be disturbed in discrete locations; all underlying rock remains intact (apart from the well holes). In contrast, mining generally requires both the soil and many layers of rock to be removed. During decommissioning, mine pits need to be dewatered, surface water needs to be managed for decades, and voids remain.

3.3 Comparison of land use

Table 2-1 presents a summary of the estimated area of land use (by industry) in the NT. Of all the major industries in the NT, the land use associated with the unconventional gas industry (if it proceeds) is the smallest and would comprise 0.0019 % of the total NT land mass.

Table 3-2. Estimated area of land use (by industry) in the NT

Industry	Land use (km^2)
Pastoralism	418.3*
Agriculture	288.0
Forestry	500.0
Mining	85.0
Unconventional gas – development**	27.0

** Approved total land clearing for improved pasture between 2003 and 2016 – a gross underestimate of total extant clearing*

*** The operational footprint will be less than that for the development phase because some rehabilitation will be undertaken immediately post-construction*

4 GREENHOUSE GAS EMISSIONS

This chapter compares greenhouse gas emissions by various industries within the NT with the projected emissions of the onshore unconventional shale gas industry.

In 2015, the NT Government made a submission to the *Commonwealth's Setting Australia's Post-2020 Target for Greenhouse Gas Emissions* (NTG 2015b), in which it is stated that:

> *The NT has a unique emissions profile due to its large land mass, small population, high rate of bushfires, large cattle industry and the presence of emissions-intensive industries such as the mining and the oil and gas sector.*

According to the *State and Territory Greenhouse Gas Emission Inventories 2014* (DoE 2016), carbon dioxide equivalent [2] (CO_2e) emissions for NT in 2013 totalled 13.3 million tonnes.

4.1 Existing industry

According to DoE (2016), in 2013 agriculture and energy production collectively accounted for 12.3 million tonnes or 93 % of total CO2e emissions in the NT – see Table 4-1. Land-use change and forestry, industrial processes and waste accounted for the bulk of the remainder.

Of all states and territories, the NT was the only one where more CO_2e emissions were produced as a result of activities associated with agriculture than with energy production. Natural gas accounts for 82.3 % of energy production in the NT (DoEE 2017). Using natural gas for power generation produces significantly less CO_2e per megawatt hour than using coal (NTEL 2010), which is the main fuel used for power generation in NSW, Qld and Victoria.

Agriculture in this instances includes pastoralism. The majority of emissions within the sector as the result of the digestive processes of ruminant animals such as cattle, buffalo and camels (40 %), and from prescribed savannah burning (58 %) (DoE 2016).

The energy production sector comprises energy industries, manufacturing and construction, transport, combustion of fuel in electricity generation, and energy used in equipment in the agriculture, forestry and fishing industries (NTG 2015b).

The NT does not have specific air quality regulations; however, it is a signatory to various air quality National Environment Protection Measures (NEPM's). Impacts to air quality are considered under the NT *Environmental Assessment Act*. Although NEPM's are not transcribed into legislation, there is a regulatory trigger to ensure developments are assessed against them.

The *National Greenhouse and Energy Reporting Act 2007* establishes a national framework for corporations to report greenhouse gas emissions.

4.2 Onshore unconventional gas industry

Greenhouse gas emissions from the unconventional shale gas industry arise from a number of potential sources (Cook et al. 2013):

- Emissions of methane during pre-production operations associated with well completion

[2] 'Carbon dioxide equivalent' is a term for describing different greenhouse gases in a common unit

- Emissions of methane during gas production operations
- Carbon dioxide vented from gas sweetening operations
- Carbon dioxide emissions from fuels and energy used during operations
- Carbon dioxide from flaring of gas during operations
- Carbon dioxide emissions from fuels and energy used during compression and pipe-lining of the gas to markets
- On a life-cycle basis, the carbon dioxide emitted during combustion of the fuel, including for electricity generation.

In order to make cross-industry comparisons (which are based on emissions during production only), the last point listed above is not discussed in this report.

'Fugitive emissions' are the gases that leak or are vented during the extraction, production, processing, storage, transmission and distribution of fossil fuels such as coal, crude oil and natural gas. Day et al. (2017) state that median fugitive emissions represent 0.02 % of total gas production. Cook et al. (2013) present estimates of fugitive emissions generated; the lowest value of CO_2e emissions during the well completion stage being 877 tonnes CO_2e per well [3]. That value assumes that 70 % of the potential fugitive methane is captured, 15 % flared and 15 % vented. Advancements in hydraulic fracture stimulation allow for the capture of almost all of the gas that would have historically been vented. According to the USEPA (2012), this reduces such fugitive emissions by approximately 95 %.

Applying this information to the Cook et al. (2013) values implies that if 95 % of fugitive emissions are captured, then each well will generate 146 tonnes CO_2e during development. However, a recent report from CSIRO (Day et al. 2017) found total methane emissions from nine coal seam gas well completions in Queensland were low, ranging from virtually zero to a maximum of 0.373 tonnes CH_4 (or 9.3 tonnes CO_2e) for the entire completion. This is equivalent to fugitive emissions of 0.01 %. No further emissions were detected on completed wells after they had been fitted with the wellhead

Conceptually, for Origin's Beetaloo Basin shale gas project, peak well completion is estimated to be 41 wells in a year, equating to 0.006 million tonnes of fugitive CO_2e emissions (based on 95 % capture of fugitive emissions). Assuming that the other main players – Santos and Pangaea – have similar scale developments that follow a similar timeline, then three projects would collectively, at peak development, produce 17,978 tonnes (or 0.018 million tonnes) of fugitive CO_2e emissions. This is for peak development which occurs only for a few years of the total project lifetime. Average annual fugitive emissions (based on three operators each developing 456 wells over 24 years) will be 8,322 tonnes (or 0.008 million tonnes) of fugitive CO_2e emissions.

The industry expects the majority of emissions to be related to the burning of natural gas as a fuel source for compression of the gas for pipeline transport and power generation during operations. For their Narrabri gas project in NSW, Santos calculated that total direct emissions (assuming a self-generated onsite power supply using natural gas) would be 24.1 million tonnes of CO_2e emissions over 25 years (not including 2.2 million tonnes of CO_2e emissions from development flaring and venting) [4]. This is predominantly comprised of 12 million tonnes of CO_2e emissions due to burning gas for power generation, and 12 million tonnes of CO_2e emissions from processing the extracted gas. These can be considered peak values; Santos state that conservative estimates were used so that emissions were over-estimated rather than under-estimated.

The Narrabri gas has a substantially higher CO_2 content than Beetaloo gas [5] (10 % compared with less than 4 %). However, the Narrabri gas project calculations were based on the processing 225 terajoules of gas

---

[3] From Table A.2.1. in Appendix 2

[4] Appendix R of the *Santos Narrabri Gas Project EIS:* https://majorprojects.accelo.com/public/9277a58f39742f632bb6dac0c1a08705/Appendix%20R%20Greenhouse%20gas%20assessment.pdf

[5] http://www.falconoilandgas.com/uploads/pdf/No ification_of_Discovery_-_Amungee_NW-1H.pdf

per day, and in their submission to the inquiry Origin have indicated the potential production of 400 to 500 terajoules per day [6]. Taking these factors into account, a single operator in the Beetaloo Basin producing 450 terajoules per day would generate – from processing emissions only (not emissions associated with power consumption) – 9.6 million tonnes of CO_2e emissions over 25 years.

Added to that are emissions from power consumption. When comparing project power consumptions, it is relevant that the higher CO_2 content of Narrabri gas necessitates extra processing that Beetaloo gas will not need. The Narrabri project also requires a water treatment plant that accounts for a significant proportion of the project power consumption. Collectively, these mean that terajoule-for-terajoule, the Narrabri project has, at minimum, a 20 % higher power consumption. However, the Narrabri project emissions were based on production of 225 terajoules per day – half that indicated by Origin. Assuming that to produce and compress twice as much gas requires generating twice as much operational energy, and taking into the other factors mentioned above that increase the Narrabri projects power consumption, a single operator in the Beetaloo Basin producing 450 terajoules per day would generate – due to power consumption only – 19.2 million tonnes of CO_2e emissions over 25 years.

Therefore, a single operator would produce, in total, 28.8 million tonnes of CO_2e emissions over 25 years. This is equivalent to 1.15 million tonnes of CO_2e emissions per year.

On the assumption that the three main players – Origin, Santos and Pangaea – have similar scale developments that follow a similar timeline, then three projects would collectively, at peak development, produce 3.51 million tonnes CO_2e emissions (operational and fugitive combined) – but probably less because peak extraction for each project is unlikely to coincide.

4.3 Comparison of CO_2e emissions

Table 2-1 presents a summary of the estimated CO_2e emissions (by industry) in the NT – see also **Figure 4-1**. Peak CO_2e emissions associated with the unconventional gas industry would comprise 21 % of the total NT annual emissions (based on 2013 figures).

Table 4-1. CO_2e emissions (by industry) in the NT

Industry	CO_2e * (million tonnes)
Agriculture (including pastoralism)	6.30
Energy production	6.02
Land-use change and forestry	0.57
Waste	0.26
Industrial processes	0.18
Unconventional gas (peak)	3.51

** Based on DoE (2016) data for all industries other than unconventional gas, which is based on Section 4.2.*

[6] See Section 3.2.3.2 of Origin's *Submission to the Scientific Inquiry into Hydraulic Fracturing in the NT*.

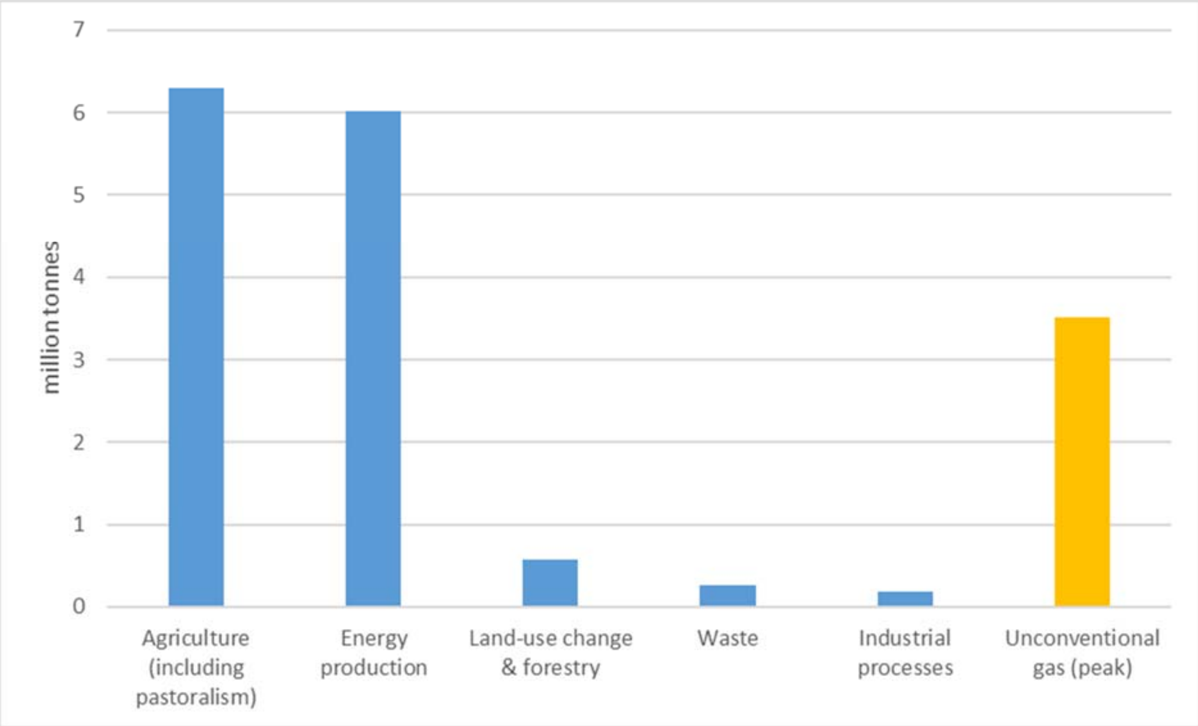

Figure 4-1. Graph comparing CO_2e emissions (by industry) in the NT

5 REFERENCES

Australian Bureau of Statistics (ABS) (2010). *Water consumption by sector*. Australia's Environment: Issues and Trends, 2007. [online] Available at: http://www.abs.gov.au/ausstats/abs@.nsf/0/5B7279AC135904A4CA2573C6001043E0?opendocument [Accessed 11 April 2017].

Australian Bureau of Statistics (ABS) (2016). *Water Account Australia 2014-15*. State and Territory Summaries. [online] Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4610.0Main%20Features32014-15?opendocument&tabname=Summary&prodno=4610.0&issue=2014-15&num=&view [Accessed 11 April 2017].

Cook, P., Beck, V., Brereton, D., Clark, R., Fisher, B., Kentish, S., Toomey, J. and Williams, J. (2013). *Engineering Energy: Unconventional Gas Production – A study of shale gas in Australia*. Report for the Australian Council of Learned Academies. [online] Available at: https://www.acola.org.au/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf [Accessed 14 April 2017].

CSIRO (1990). *Feeding standards for Australian livestock: Ruminants*. Standing Committee on Agriculture and Resource Management: Ruminant Subcommittee. CSIRO Publications, Victoria, Australia.

Day, S., Marvig, P., White, S., Halliburton, B. (2017). *Methane emissions from CSG well completion activities*. CSIRO, Australia. [online] Available at: http://www.environment.gov.au/system/files/resources/862e56d7-664a-4479-a30b-a2d58470d953/files/csiro-csg-well-completions-report.pdf [Accessed 2 June 2017].

Department of the Environment (DoE) (2016). *State and Territory Greenhouse Gas Emission Inventories 2014*. Commonwealth Government of Australia. [online] Available at: http://www.environment.gov.au/system/files/resources/319ea5f4-e3d9-4af1-97eb-2a4ba661713e/files/state-territory-inventories-2014.pdf [Accessed 13 April 2017].

Department of the Environment and Energy (DoEE) (2017), *Australian Energy Statistics, Table O*, May 2017. [online] Available at: https://www.environment.gov.au/system/files/resources/5e8702a7-f70e-451c-8455-d96a8f9d1588/files/aes-table-o-dec-2016-update.pdf [Accessed 26 May 2017].

Department of Mines and Energy (DME) (2016). *2015-16 Annual Report*. Northern Territory Government. [online] Available at: https://dpir.nt.gov.au/__data/assets/pdf_file/0008/396755/dme-annual-report-15-16.pdf [Accessed 13 April 2017].

Fulton, S. and Knapton, A. (2015) *Beetaloo Basin Hydrogeological Assessment*. Prepared by CloudGMS for Origin Energy Pty Ltd. February 2015.

Global Water Forum (2013). *Tourism and water: Interrelationships and management*. [online] Available at: http://www.globalwaterforum.org/2013/07/16/tourism-and-water-interrelationships-and-management/ [Accessed 10 April 2017].

Gössling, S., Peeters, P., Hall, C.M., Dubois, G., Ceron, J.P., Lehmann, L. and Scott, D. (2012). Tourism and water use: supply, demand, and security. An international review, Tourism Management, Vol. 33(1), pp. 1-15. [online] Available at: http://www.sciencedirect.com/science/article/pii/S0261517711000793 [Accessed 10 April 2017].

Harrington, N. and Cook, P. (2014). *Groundwater in Australia*. National Centre for Groundwater Research and Training, Australia.

McDonald, P. (1992). Water resource development in northern Australia's arid zone. Commonwealth of Australia. BMR *Journal of Australian Geology & Geophysics*, Vol. 13, pp. 67 – 74.

Minerals Council of Australia (MCA) (2014). *Submission to the green paper on developing northern Australia. The Development of Northern Australia*. [online] Available at: http://www.minerals.org.au/file_upload/files/submissions/Minerals_Council_of_Australia_NT_Division_Developing_Northern_Australia_Green_Paper_Response.pdf [Accessed 10 April 2017].

Minerals Council of Australia (MCA) (2016). *Agenda for Growth – Northern Territory Mining Industry*. [online] Available at: http://www.minerals.org.au/file_upload/files/publications/NT_Agenda_for_growth_web.pdf [Accessed 13 April 2017].

Minerals Council of Australia (MCA) (2017). *Our water future – Northern Territory. Minerals Council of Australia*. [online] Available at: http://www.minerals.org.au/news/our_water_future_-_northern_territory [Accessed 12 April 2017].

National Energy Technology Laboratory (NETL) (2010). *Cost and performance baseline for fossil energy plants, Volume 1: Bituminous coal and natural gas to electricity. Revision 2. November.* DOE/NETL-2010/1397. United States Department of Energy.

Northern Australia Land and Water Taskforce (NALWTF) (2009). *Sustainable Development in Northern Australia*, A Report to Government from the Northern Australia Land and Water Taskforce. Commonwealth of Australia.

Northern Territory Cattlemen's Association (NTCA) (2017). *About us*. [online] Available at: http://www.ntca.org.au/about-us [Accessed 12 April 2017].

Northern Territory Environment Protection Authority (NTEPA) (2017). *Draft Environmental Impact Statement – Project Sea Dragon Stage 1 Legune Grow-out Facility*. Northern Territory Environment Protection Authority. [online] Available at: https://ntepa.nt.gov.au/environmental-assessments/register/legune-growout/draft-eis [Accessed 13 April 2017].

Northern Territory Farmers Association (NTFA) (2015). *Economic Profile of Plant Based Industries in the Northern Territory*. NT Farmers Association. [online] Available at: http://ntfarmers.org.au/sites/default/files/blog_attachments/NTFA%20Economic%20Profile_web.pdf [Accessed 10 April 2017].

Northern Territory Government (NTG) (2014). *Northern Territory Government Response to the Green Paper on Developing Northern Australia*. Developing the North – August 2014. Darwin, NT.

Northern Territory Government (NTG) (2015a). *Our Water Future – A discussion paper: A conversation with Territorians 2015*. Northern Territory Government – Department of Land Resource Management, Palmerston, NT.

Northern Territory Government (NTG) (2015b). Setting Australia's Post-2020 Target for Greenhouse Gas Emissions – Northern Territory Government Submission. [online] Available at: https://www.dpmc.gov.au/sites/default/files/unfccc-public-submissions/NT_Government_submission.pdf [Accessed 10 April 2017].

Northern Territory Government (NTG) (2016). *About us*. Parks and Wildlife Commission of the Northern Territory. [online] Available at: https://parksandwildlife.nt.gov.au/about [Accessed 13 April 2017].

Northern Territory Government (NTG) (2017). *Approved water extraction licences*. Northern Territory Government. [online] Available at: http://www.ntlis.nt.gov.au/walaps-portal/noiNodSod/licence/O34 [Accessed 12 April 2017].

Saunders, D.A., Hobbs, R.J. and Margules C.R. (1991). Biological Consequences of Ecosystem Fragmentation: A Review. *Conservation Biology* 5(1) pp. 18-32.

Stone, P. and Chilcott, C. (2016*). Northern Australia: the full mixed grill with side salad – just add water?* CSIRO presentation at the Water Forum. [online] Available at: https://denr.nt.gov.au/__data/assets/pdf_file/0006/275640/CSIRO-Northern-Australia-the-full-mixed-grill-with-side-salad-just-add-water.pdf [Accessed 10 April 2017].

Tourism NT (2017). *Latest facts and figures*. Northern Territory Government. [online] Available at: http://www.tourismnt.com.au/corporate/research/latest-visitor-data [Accessed 12 April 2017].

United States Environmental Protection Agency (USEPA) (2016). *Overview of final amendments to air regulations for the oil and natural gas industry.* [online] http://www.epa.gov/sites/production/files/2016-09/documents/natural_gas_transmission_fact_sheet_2012.pdf [Accessed 26 May 2017].

Williams, J., Stubbs, T. and Milligan A. (2012). *An analysis of coal seam gas production and natural resource management in Australia.* A report prepared for the Australian Council of Environmental Deans and Directors by John Williams Scientific Services Pty Ltd, Canberra, Australia.

EcOz Pty Ltd.
ABN 81 143 989 039

Winlow House, 3rd Floor
75 Woods Street
Darwin NT 0800

GPO Box 381,
Darwin NT 0800

T: +61 8 8981 1100
F: +61 8 8981 1102
E: ecoz@ecoz.com.au

www.ecoz.com.au