Waratah Coal

Galilee Power Station

Response to SARA Information Request
(SARA Reference: 2201-27010 SRA)

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Overview

On 24 February 2022 the State Assessment and Referral Agency (SARA) issued an Information Request (SARA reference: 2201-27010 SRA) for the Galilee Power Station Project (the Project).

The Information Request states that the following information is sought by the Department of Environment and Science (DES) in relation to their assessment of the application for an Environmental Authority under the *Environmental Protection Act 1994* (EP Act).

1. Air Emissions
2. The Standard Criteria set out in the EP Act
3. Human Rights
4. In addition, information is requested by SARA in relation to the use being classified as a hazardous chemical facility.

The specific 'Issues' and suggested 'Actions' provided by DES and SARA in relation to the above are replicated below (see grey boxes), along with a detailed response to each Issue/Action.

1 Air Emissions

1.1 Issue

The application material states that the power station's clients will be offered (at cost) carbon offsets sufficient to allow the client to choose to purchase certified carbon neutral power.

The application material however has not provided any further detail about how carbon offsets are intended to be offered, the timeframes for when this will be met and whether it will be economically feasible to do this considering the site is yet to have its final detailed design refined. It is also unclear how the proposed development intends to be a net zero site upon commissioning.

1.2 Action

Provide further information on:

- whether 100% of the emissions are to be offset to support the development being a net zero site; or
- whether the costs of offsetting emissions will be borne by the power stations customers if they choose to opt into purchasing a carbon neutral product.

1.3 Response

Waratah Coal have made the commitment that the project will achieve net-zero emissions and provide its product as a carbon neutral power product. This commitment of net-zero emissions has been an integral part of the preliminary concept design and will continue through to detailed design, construction and finally into the operations of the power plant. It should be noted that within the power industry, it is well understood that the CCS module required at the power station is not a 'bolt on' module and to work effectively and efficiently the module needs to be part of the original design and construction.

The proposed coal-fired power station for the Galilee Power Project ("the project") will achieve net-zero carbon emissions through a strategy consisting of the purchase and surrender of carbon offsets in the short term, and progressive implementation of carbon capture and storage (CCS) for between 90 and 95% of the carbon emissions (with the remaining 5-10% being offset), over the long term and for the life of the project.

To further reduce plant emissions the project may consider using biomass co-firing (e.g. prickly acacia) to supplement up to 10 percent of the coal fuel. This would be considered in a future stage of project development.

Between years 2028 and 2032, while one power module is operating, the power station will generate (at most) approximately 4.72 Mtpa of CO_2, of which up to 100% will be offset by the purchase and surrender of accredited offset certificates, the offsets will be a combination of Australian Carbon Credit Units (ACCUs) issued by the Clean Energy Regulator and international certificates (of high reputational standing such as Verified Carbon Units issued by the Verra Registry), resulting in net zero emissions.

Once the project CCS infrastructure is operational, between 90% and 95% of the CO_2 generated by the project will be captured and sequestered geologically. With both power modules in operation and CCS operational, the total residual carbon emissions will be approximately 0.94 Mtpa CO_2 per annum, assuming a conservative carbon capture rate of 90% and at the lowest target efficiency for the plant. These residual emissions will be offset by the purchase and surrender of offset certificates for the life of the project, resulting in net zero emissions for the life of the project.

Commercially, the project power price will include costs associated with its carbon neutral product and we expect that the total cost of base load carbon neutral power to be in the range of $90-110/MWh. Notwithstanding, the expected cost of production including the cost of carbon neutrality is below the current power price. For example, the average power price for the 2021/22 financial year to time of writing (19 May 2022) in Queensland was $150.11 MWh. The implication is that additional volume of carbon neutral power in the Queensland market would have driven power prices down had the plant been operating over the same period.

The project's cost structure must be consistent with its base load competitors (i.e. CS Energy, Stanwell, InterGen); any regulation or condition of an approval that impacts the cost structure of the Galilee Power Project must be applied consistently to all participants in the market (including existing participants), to ensure a level playing field and that the market maintains competitiveness.

Arche Energy has undertaken a market sounding for the supply of offsets to the project (attached as Appendix A) and is of the view that sufficient offsets can be obtained using a combination of ACCUs and international offsets of a similar standard. Any international offsets utilised will be subject to rigorous due diligence to ensure that a definite, measurable reduction in atmospheric greenhouse gas emissions results from their purchase.

Arche Energy has completed a short technical report (attached as Appendix B) setting out the concept for the carbon capture and storage element of the project. Note that this element of the project is subject to a separate approvals process.

2 Standard Criteria

2.1 Issue

In making a decision on a site-specific application, DES must have regard to the standard criteria in accordance with s176(2)(b)(iv) of the *Environmental Protection Act 1994*.

The application material states that ongoing operation of the power station is expected to result in 9.427 million tonnes of CO_2-equivalent/year for the 1,400 MW configuration. This does not include construction or decommissioning emissions and involves the release of greenhouse gas emissions. DES' preliminary view is that the project's impact on climate change raises concerns regarding the following criteria:

- The precautionary principle – Environmental authorities cannot be conditioned to avoid serious or irreversible damage to the environment which climate change represents
- Intergenerational equity – The project does not appear at this stage to be able to maintain or enhance the health, diversity and productivity of the environment for the benefit of future generations
- Conservation of biological diversity and ecological integrity – The project may contribute towards irreversible climate change impacts that will undermine biological diversity and ecological integrity
- Any Commonwealth or State Government plans, standards, agreements or requirements about environmental protection or ecologically sustainable development –Australia is a signatory to the Paris Agreement and has federal obligations to address climate change, and the Queensland Government has a Climate Action Plan based on the 2017 Queensland Climate Transition Strategy
- The character, resilience and values of the receiving environment – Given the project's contribution to an increase in greenhouse gas emissions, the resilience and values of the receiving environment may be impacted due to long-term and cumulative impacts of climate change
- The public interest – Whilst the activity represents potential positive social and economicimpacts, the irreversible risks to the environment may outweigh these. The department'spreliminary view is that an approval may not be in the public interest in that it may be inconsistent with public commitments made by the Queensland Government.

2.2 Action

Provide further information to address the standard criteria to demonstrate these requirements are satisfied in the proposal.

2.3 Response

"The precautionary principle – Environmental authorities cannot be conditioned to avoid serious or irreversible damage to the environment which climate change represents"

The Precautionary Principle states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Applications should propose actions to prevent or minimise serious harm even though there may not be full scientific certainty about the scale or causes of the harm.

However, with reference to the scientific uncertainty regarding the impacts of climate change as a result of GHG emissions, the proponent's response is in keeping with the precautionary principle as all emissions from the project will be offset with carbon credits or carbon capture and storage (see Section 1). Therefore, actions will be taken to prevent environmental harm as a result of climate change although there is not full certainty of its scale.

If the project results in the displacement of an older power station, such as Callide B, then the Galilee Power Station is capable of providing for a reduction in Australia's national CO_2 emissions of approximately 11 M tonnes CO_2-e annually, compared with the current situation (on the basis of the displacement of a less efficient power station emitting 0.9 tonnes CO_2-e per MWh over 1400 MW at base load).

Waratah Coal acknowledges that environmental authorities cannot condition proponents to provide carbon offsets. Waratah's view is that carbon reduction regulation should be applied at an industry level over all generators in the State rather than at a project level so as to maintain a competitive level playing field and to set clear and achievable industry targets.

"Intergenerational equity – The project does not appear at this stage to be able to maintain or enhance the health, diversity and productivity of the environment for the benefit of future generations"

As described in the application material, the project does maintain and enhance the health, diversity and productivity of the environment for the benefit of future generations. In terms of maintenance, the project has been deliberately located to avoid harm to environmental values and will not result in a significant impact to any Matter of State Environmental Significance. Water usage and waste streams are minimised in comparison with current operating coal fired power stations. The power plant will include low-NOx burners, bag filters and flue gas desulphurisation to minimise emissions rates in comparison with existing coal fired power stations. Waratah Coal intends that, when commissioned, the Galilee Power Project will be the cleanest coal fired power plant in Australia, measured by any metric.

All GHG emissions will be either captured and sequestered or offset via carbon credits as described above (Section 1). Therefore, there will be no net increase in emissions as a result of the project. As such, there will not be any significant negative environmental impacts that would affect the maintenance of 'the health, diversity and productivity of the environment for the benefit of future generations' as a result of the project. In terms of enhancement, if the project results in the displacement of an older power station, such as Callide B, then the Galilee Power Station is capable of providing for a reduction in Australia's national CO_2 emissions of approximately 11 M tonnes CO_2-e annually, compared with the current situation (on the basis of the displacement of a less efficient power station emitting 0.9 tonnes CO_2-e per MWh over 1400 MW at base load).

With reference to carbon offsets, it is also worth noting that as well as providing for maintenance of the health, diversity, and productivity of the environment for the benefit of future generations, carbon offsets also have the potential to enhance these factors. Offsets often have positive second order conservation and employment effects (such as preservation and enhancement of habitat and indigenous employment opportunities). Offsets can be implemented today and do not require significant technology development.

"Conservation of biological diversity and ecological integrity – The project may contribute towards irreversible climate change impacts that will undermine biological diversity and ecological integrity"

The project will not result in an increase in GHG emissions, as they will be offset via carbon credits and/or carbon capture and storage as described above in Section 1. Therefore, the project will not 'contribute towards irreversible climate change impacts that will undermine biological diversity and ecological integrity'. In many cases, the use of carbon offsets will in fact represent environmental benefits, including habitat revegetation, development of regional communities, indigenous employment, etc.

If the project results in the displacement of an older power station, such as Callide B, then the Galilee Power Station is capable of providing for a reduction in Australia's national CO_2 emissions of approximately 11 M tonnes CO_2-e annually, compared with the current situation (on the basis of the displacement of a less efficient power station emitting 0.9 tonnes CO_2-e per MWh over 1400 MW at base load).

"Any Commonwealth or State Government plans, standards, agreements or requirements about environmental protection or ecologically sustainable development –Australia is a signatory to the Paris Agreement and has federal obligations to address climate change, and the Queensland Government has a Climate Action Plan based on the 2017 Queensland Climate Transition Strategy"

The project is consistent with the Commonwealth and State plans, agreements and requirements regarding environmental protection and ecologically sustainable development.

Commonwealth Agreements

Paris Agreement

The Paris Agreement is a global agreement to limit global warming to well below two degrees Celsius (2°C) above pre-industrial times, and as close to 1.5°C as possible. Australia announced its ratification of the Paris Agreement on 10 November 2016. Other international treaties of relevance are the United Nations Framework Convention on Climate Change (UNFCCC), the 26th Glasgow Conference of the Parties (COP26) and the Australia-Singapore Low Emissions Memorandum of Understanding (MoU).

United Nations Framework Convention on Climate Change (UNFCCC)

Under the Paris Agreement, Australia must submit emissions reduction commitments known as Nationally Determined Contributions (NDCs). These include our national target.

Australia's first NDC is on the UNFCCC registry:

- 2015 NDC: committed to reduce emissions by 26 to 28% below 2005 levels by 2030.
- 2020 NDC update: affirmed the 2030 target, outlined Australia's practical, technology-led approach to emission reductions, include new actions and measures since 2015.
- 2021 NDC update: committed to net zero emissions by 2050, inscribed low emissions technology stretch goals, affirmed the 2030 target, and reported 2021 projections results showing Australia is on track to exceed this target by up to 9 percentage points.

- Australia will submit its second NDC to the UNFCCC in 2025.

As explained below, the Galilee Power Station is consistent with the Australia's NDCs.

Glasgow COP26

At COP26 Australia updated and enhanced our NDC under the Paris Agreement to include a target of net zero emissions by 2050, the latest emissions projections to 2030 that will see Australia achieve up to a 35% reduction by 2030, and seven new targets in the form of low emissions technology stretch goals, which will be critical to achieving the 2030 and 2050 targets through a "technology not taxes" strategy.

Australia-Singapore MoU

The MoU will support the development and uptake of new and emerging low emissions technologies with practical collaboration on:

- hydrogen
- carbon capture utilisation and storage (CCUS)
- renewable energy trade
- measurement, reporting and verification (MRV) of emissions.

The Galilee Power Station is aligned with the Australia-Singapore MoU through the development of CCUS technologies.

Queensland Government Climate Action Plan and Climate Transition Strategy

According to the DES website (About climate action | Queensland Climate Action (des.qld.gov.au)):

The Queensland Government has set bold but achievable targets for reducing our emissions while creating jobs.

- *50% renewable energy target by 2030*
- *30% emissions reduction below 2005 levels by 2030*
- *zero net emissions by 2050.*

The Queensland Climate Transition Strategy outlines how Queensland proposes to prepare for the transition to these targets and set pathways to meet these targets. The project is wholly consistent with these targets. The 2030 target of 50% will easily be achieved and is expected as early as 2027/28.

The Galilee Power Station will provide net-zero power from its first commissioning and supports the Queensland State Government's 50% renewable target by providing the 50% of energy that is not renewable, as efficiently as possible and with the lowest possible carbon footprint. Compared with plant currently operating in Queensland, the Galilee Power Station will provide reductions in carbon emissions of 100%, utilising a combination of carbon offsets and carbon capture and storage.

Cleanest and most efficient power station in Australia

The Galilee Power Project will utilise the most efficient technology available at the time of design. If designed today, the plant's characteristics would be:

- Very high steam temperatures (650°C)
- Very high pressure (33,000 kPa)

- Dual re-heat cycles
- Feedwater heaters and air heaters.

Modelling indicates that the above characteristics would achieve net efficiency of 42% (LHV) and a carbon intensity of 0.79 t(CO2e)/MWh; therefore, we are targeting between 0.75 and 0.81 (CO2e)/MWh gross emissions (pre-offset, pre-capture). As shown in Figure 2-1 and Figure 2-2 below, this gross carbon intensity is substantially lower than incumbent plant burning lower quality fuels (e.g. Callide, Yallourn, Loy Yang) or operating with lower thermal efficiencies (e.g. Gladstone, Callide B, Tarong, Stanwell).

Our estimates indicate that if the Galilee Power Project were to displace the Gladstone Power Station (which we understand is partially traded by the State Government) in the market, approximately 10.6 million tonnes per annum of gross emissions (at 90% capacity factor, 0.96 tonnes/MWh and 1,400 MW) would be saved.

If the Galilee Power Project were to displace Yallourn Power Station, we estimate that (even allowing for an additional 10% transmission network losses), approximately 12.8 million tonnes per annum would be saved (90% capacity factor, 1.29 tonnes/MWh and 1,400 MW).

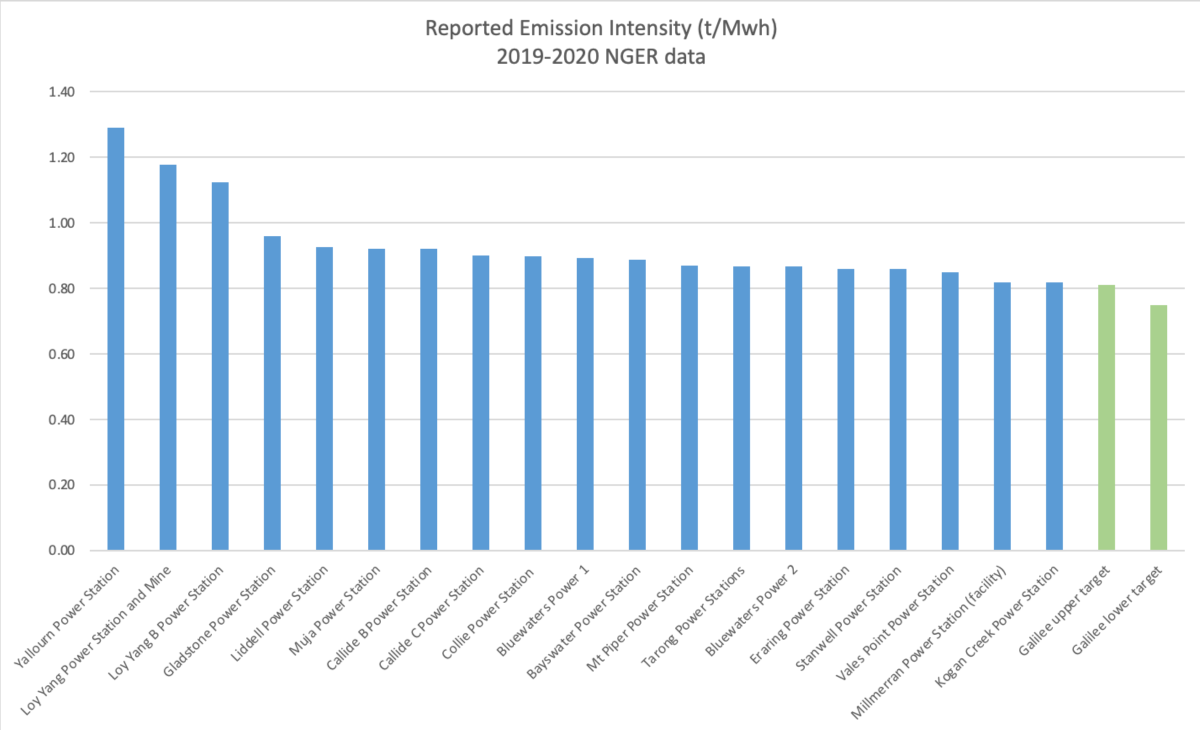

Figure 2-1: Carbon intensity of all Australian Coal Fired Power Stations[1]

[1] Source: NGER data 2019-2020. Note that Hazelwood (now decommissioned) has been excluded.

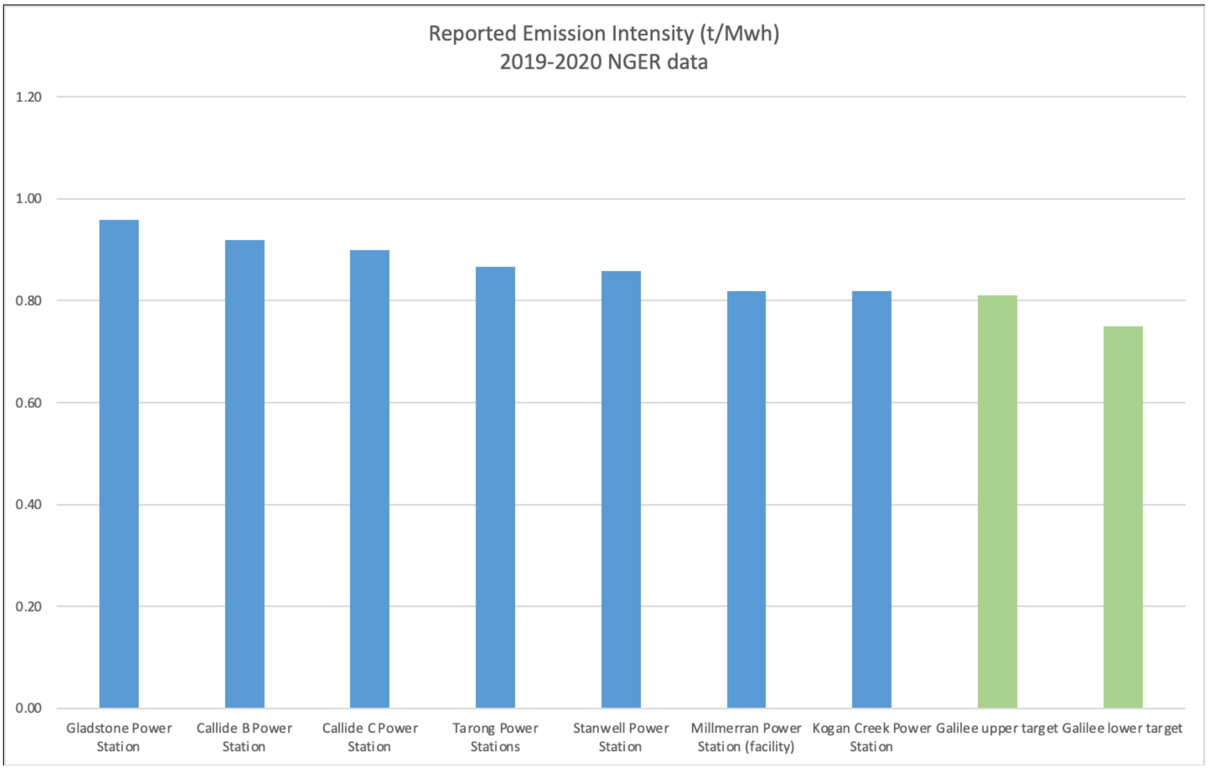

Figure 2-2: Carbon intensity of all Queensland Coal Fired Power Stations[2]

> *"The character, resilience and values of the receiving environment – Given the project's contribution to an increase in greenhouse gas emissions, the resilience and values of the receiving environment may be impacted due to long-term and cumulative impacts of climate change"*

As described above, the project will not result in an increase in greenhouse gas emissions, as the emissions will be offset via carbon credits and/or CCS as described above in Section 1. Therefore, there is no risk to the "resilience and values of the receiving environment … due to long-term and cumulative impacts of climate change". In many cases, the use of carbon offsets will in fact represent environmental benefits, including habitat revegetation, development of regional communities, indigenous employment, etc.

If the project results in the displacement of an older power station, such as Callide B, then the Galilee Power Station is capable of providing for a reduction in Australia's national CO_2 emissions of approximately 11 M tonnes CO_2-e annually, compared with the current situation (on the basis of the displacement of a less efficient power station emitting 0.9 tonnes CO_2-e per MWh over 1400 MW at base load).

> *"The public interest – Whilst the activity represents potential positive social and economic impacts, the irreversible risks to the environment may outweigh these. The department's preliminary view is that an approval may not be in the public interest in that it may be inconsistent with public commitments made by the Queensland Government."*

[2] Source: NGER data 2019-2020

The risks to the environment have been thoroughly assessed and the information has been provided in the application material and subsequent four responses to information requests. The material demonstrates that there will be no significant impact to any Matter of State Environmental Significance. With reference to GHG emissions, the Project will not result in an increase, as the emissions will be offset via carbon credits and/or carbon capture and storage as described above in Section 1.

Furthermore, the public commitments made by the Queensland Government regarding GHG are targets consisting of:

- 50% renewable energy target by 2030
- 30% emissions reduction below 2005 levels by 2030
- zero net emissions by 2050.

The project is consistent with these public commitments. We reiterate, the 2030 target of 50% will easily be achieved and is expected as early as 2027/28. If 50% of energy is renewable, it makes sense that the remaining 50%, derived from non-renewable energy sources, be as energy efficient as possible. The Galilee Power Station will be the most energy efficient coal fired power station in Australia due to the ultra-supercritical technology, and will operate with net-zero GHG emissions through a combination of offsets and CCS. Waratah Coal consider this a win-win scenario which preserves the employment and revenue benefits of coal mining, without the negative environmental impacts from GHG emissions.

This project also addresses the public interest issue of the right of the public to access continuous and affordable power. As existing coal plants continue to get older, the risk of outages will continue to increase. Currently Queensland has very little surplus baseload capacity and this capacity will only decrease over time without intervention. The applicant for this action is prepared to fund this power station development without any financial assistance from government, and hence this project represents a net benefit to the community in terms of improved access to continuous and affordable power without any taxpayer contributions.

3 Human Rights

3.1 Issue

Section 58(1) of the *Human Rights Act 2019* requires public entities to make decisions in a way that is compatible with human rights and to give proper consideration to human rights when making those decisions.

DES has identified concerns regarding the following human rights:

- s15(2) and s15(4) the right to recognition and equality before the law – in relation to age discrimination and treatment of younger people who may not be afforded the same opportunities older generations currently have due to climate change
- s16 the right to life – a person's ability to live their life and quality of life may be impacted due to climate change
- s19 freedom of movement – in that climate change may impact where a person can live and work
- s20 freedom of thought, conscience, religion and belief AND s27 cultural rights – in that climate change can contribute to the loss of fish and other animal habitats which may impact religious or cultural eating customs
- s24 property rights – in that climate change may impact where a person can live or work
- s25 the right to privacy and reputation – in that a person's physical and integrity may be impacted by climate change impacts
- s26(2) right to protection of families and children – in that climate change may restrict a child's right to the protection that is in the children's best interest
- s28 cultural rights of Aboriginal and Torres Strait Islander peoples – in that climate change may deny Aboriginal and Torres Strait Islander peoples the right to maintain and strengthen their relationship to the land and their ability to conserve and protect the environment
- s29(1) right to liberty and security of person – in that a person's physical and integrity may be impacted by climate change impacts.

3.2 Action

Provide further information to address the project's compatibility with the abovementioned human rights.

3.3 Response

As outlined above, DES's concerns regarding human rights being impacted by climate change are unfounded as the project will not result in an increase in a net increase in greenhouse gas emissions. As described above, Waratah Coal has committed to the power station producing carbon neutral (net-zero) power from commencement of operations; that is, the GHG operational emissions as a result of the project will be 100% offset by carbon credits and/or carbon capture and storage. Therefore, there will not be a net increase in GHG emissions as a result of the project, and in fact, there will be significant reductions in GHG emission reductions if older, less efficient power stations are displaced by the Galilee Power Station.

The project will confer many positive social and economic impacts at the local, regional, state and national scales and these should also be taken into account. Offset projects will further enhance human rights through reforestation and the provision of employment opportunities for regional and indigenous communities.

Local and regional

A Social Impact Assessment Report for the project was prepared in 2020 to support the Material Change of Use application for the project. This report drew on social research conducted between May and July 2020[3].

The power station is proposed to be located in a rural and remote area that is characterised by cattle grazing and some tourism. The nearby communities of Alpha and Jericho are small towns which are characterised by their friendly and community-oriented lifestyle and resourceful populations. The towns and the broader region have suffered population decline for some time. Persistent themes in the consultation undertaken for the social impact assessment were the community aspirations for reversing the population decline, more employment opportunities for residents and young people, and more vibrant community organisations. An initial stakeholder list was prepared during the scoping phase of the social impact assessment, and feedback sought from Barcaldine Regional Council. Consultation meetings then took place in Alpha, Jericho, Barcaldine and Longreach[4].

The most pertinent theme that emerged during the consultation was community support for the project. None of the respondents mentioned that they or the broader community did not want the project to proceed. On the contrary, several respondents commented that they would like to see it developed sooner. However, some residents expressed concerns that some challenges may come with the associated resident and non-resident population growth.

Likely significant impacts arising from the project, both positive and negative, are:

- A stable power supply will be provided to Alpha as part of Waratah's Coal commitment to the Alpha and Jericho communities
- Population growth and associated opportunities for revitalisation of the community
- Growth in employment, training and business opportunities
- Risk of investor driven housing market speculation impacting vulnerable populations
- More school students to prevent decline in schooling and teaching numbers and potential for additional health and community services
- Increased competition for labour impacting existing businesses
- Changing community dynamics, feelings of insecurity and uncertainty about the project.

The Social Impact Assessment Report also contains a Social Impact Management Plan that is designed for the project to contribute to meeting community aspirations of population growth and community revitalisation, while avoiding negative impacts associated with too rapid or too large growth.

Key mitigation measures include:

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[3] The methodology for the SIA was developed taking into account good practice guidance (Vanclay, Esteves, Aucamp, & Franks, 2015), the project scope (which was prepared with input from BRC and generally in accordance with the Queensland Governments' Social Impact Assessment Guideline [State of Queensland, 2018]), and community particulars identified during the scoping phase. Importantly, the methodology was tailored to the Project approvals pathway which does not ordinarily require an SIA being conducted.

[4] An overview of the engagement process can be found in Section 4.2 of the Social Impact Assessment report. Table 7 of the Social Impact Assessment report provides a list of the consultation events and the stakeholders consulted.

- Ensuring non-resident workers are housed in a dedicated accommodation village
- Encouraging in-migration of permanent, operational workers and their families to the focus communities and the broader Barcaldine Regional Council area
- Providing training and employment opportunities for local and regional residents
- Working with local council and organisations to manage impacts to services and facilities
- Managing the changing community dynamics and potential for disturbances to landholders and neighbours
- Engaging and consulting respectfully and meaningfully with local community members.

Overall, it is considered that the potential local and regional negative impacts of the project can be successfully managed.

State and national

At a state and national level, the project will contribute to maintaining the standard of living in a net-zero world by providing low cost, net-zero, dispatchable power using clean coal technologies. This means being able to supply competitive base load power (on a 24/7 basis) to industrial processes such as aluminium refining and copper production and to preserve the value of Australia’s mineral wealth in a changing world.

In addition, carbon reuse presents opportunities to create new industries in regional Northern Australia. While most opportunities are in their infancy, Waratah Coal intends to work with developers of potential technologies to grow a carbon re-use industry in regional Northern Australia. Potential opportunities include high value products manufactured from algae and concrete-like products manufactured through the mineralisation of materials such as ash, slag and minerals.

4 Hazardous Chemical Facility

4.1 Issue

The Preliminary Hazard Analysis Report does not specify the type and capacity of the ammonia storage arrangement.

4.2 Action

- Model the following scenarios:

  - a chlorine full drum rupture
  - a loss of containment from the 20 mm inspection port (recessed valve on a drum with no valve cover- size may vary in various drum designs)
  - a loss of containment from the chlorine manifold (if more than one drum is connected to chlorination unit)

  to demonstrate that any offside impact from a chlorine loss of containment AEGL-2 (60 minutes) (from the scenarios listed above) will not reach land use receptors as per State Code 21 requirements. The vulnerable, sensitive, commercial or community activity, open spaces and industrial land uses should be identified (if any) and marked on the above overlayed consequence maps as defined in the State Code 21.

- Confirm the ammonia storage type and the capacity of each containment e.g., storing in a tank(s) or cylinders.

4.3 Response

4.3.1 Chlorine Containment

Refer to the attached Prudentia report (Appendix C) for the modelling and assessment that demonstrates any offside impact per the scenarios listed will not reach land use receptors per AEGL-2 and State Code 21 requirements.

4.3.2 Ammonia Storage

Refer to attached Prudentia report (Appendix C) for expected ammonia storage type and capacity.

In all cases the storage and handling of hazardous materials will be implemented according to the relevant regulatory requirements and Australian Standards and appropriate risk control measures will be in place to appropriately mitigate the risk.

5 References

The Department of State Development, Manufacturing, Infrastructure and Planning. 2018. Social Impact Assessment Guideline. https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0017/17405/social-impact-assessment-guideline.pdf

Vanclay, F., Esteves, A. M., Aucamp, I., & Franks, D. M. (2015). Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects.

Appendix A: Offset Market Sounding Report

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Galilee Project
Carbon Offset Market Sounding Summary

Prepared for Waratah Coal by Arche Energy

June 2022

Acknowledgement of Country

The Galilee Power Project is on the land of the Clermont-Belyando Area Native Title claim group, formerly known as the Wangan and Jagalingou people.

Arche Energy acknowledges and pays respect to the Traditional Custodians and Elders of the nations on which we work and the continuation of cultural, spiritual and educational practices of Aboriginal and Torres Strait Islander peoples.

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Any capital and operating cost estimates rely on heuristics and assumptions and are provided as indicative, concept level estimates.

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1. the depreciation of, or any loss in respect of, an investment or the value of an investment, or the failure of an investment or the value of an investment to appreciate, including but not limited to any:
    1. securities, commodities, currencies, options and futures transactions;
    2. real estate investment, including but not limited to any related return on investment, capital appreciation or tax benefits; or
    3. leased equipment or any other goods; or
2. any actual or alleged representation, advice, forecast or guarantee, whether express or inferred as to the performance of any investment.

This document is confidential and may contain market-sensitive information.

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1 Introduction

Waratah Coal is developing the Galilee Coal Project in Central Queensland. The project will be developed as a conventional mine, exporting thermal coal through the seaborne market and providing coal to a new, clean coal power station, the Galilee Power Project. The Galilee Power Project will generate baseload power for sale on the National Electricity Market (NEM).

The Galilee Power Project will comprise a 1,400MW ultra-supercritical power station. This industry-leading high-efficiency, low-emissions (HELE) power station will provide affordable, reliable, efficient, lower carbon, baseload power around the clock.

Carbon capture and storage (CCS) technology is intended to be the mainstay of the Galilee Coal Project's carbon emissions abatement strategy in the medium and long term, in addition to the high-efficiency and low-emissions design of the ultra-supercritical power station. However, given the expected timing of environmental review and approvals required for commercial-scale CCS projects in Australia, in the short-term Waratah Coal intends to use carbon offsets as the primary abatement mechanism to maintain a net zero emissions profile over the project lifespan. Offsets will also be used to address residual carbon emissions that cannot be economically captured with CCS in service.

Waratah Coal commissioned Arche Energy to perform a market sounding for carbon offsets, including Australian carbon credit units (ACCUs) to understand the market's ability to support the short-term and long-term carbon abatement requirements for the Galilee Power Project.

In this report, Arche Energy provides a summary of the market sounding exercise.

2 Abatement Need and Assumptions

2.1 Project Parameters

The Galilee Power Project is expected to have the following carbon emission parameters.

Table 1. Galilee Power Project expected carbon emission parameters

Parameter	Value	Unit
Total power station power output (2 modules)	1400	MW
CO_2 production (upper bound) per annum (2 modules)	9.43[1]	Million tonnes CO_2 per annum (Mt CO_2 pa)
Project life	50	years

Table 1 shows that the total upper bound CO_2 production from the project is approximately 9.43Mt CO_2 pa. This represents the total emissions produced from two power modules, that for a net-zero carbon emissions profile would need to be captured or offset.

2.2 Net-zero Emissions Approach

While regulatory and market demands may not mandate that the Galilee Power Project adopts a net-zero emissions profile, for the purposes of this report, it has been assumed that the project is intended to have a net-zero carbon emissions profile over the life of the project.

2.3 Sequencing of Key Infrastructure

The timing of key milestones of the project is critical to establishing the maximum carbon offset requirement. For instance, the CCS infrastructure intended for the project would capture between 90% and 95% of emissions, leaving between 5% and 10% of emissions to be offset. However, the timing of the CCS infrastructure may leave

[1] Waratah Power Station Development Application LGA DA_191219 Appendix A, p.47

a gap between commissioning the power plant and commissioning the CCS infrastructure and this would require an offset of 100% of the project's emissions for this period.

It should be noted that there is significant international interest in ensuring that CCS projects are successfully delivered at a scale suitable to meet international climate targets. For example, the IEA Executive Director Fatih Birol said recently: "Our numbers show that reaching net-zero goals without CCS will be almost impossible."[2]

If there is a slow ramp-up of power plant output, e.g. a number of years between the commissioning of the first and second 700MW power station modules, this would halve the expected emissions required for abatement for this period, i.e. a maximum of 4.72Mt CO_2 produced per annum for a single 700MW power station module operating.

2.4 Short-term and long-term carbon offset requirements

For the purposes of the market sounding exercise, it was assumed that the maximum short-term carbon offset requirement is 9.43Mt CO_2 pa, which is the upper-bound emissions rate as calculated.

The long-term carbon offset was assumed to be required to offset the residual emissions produced after CCS is operational, that is 10% of the total CO_2 production per annum, or 0.94Mt CO_2 pa. This offset requirement was assumed to be required until the decommissioning of the project, i.e. for the full project duration of 50 years.

Table 2 shows the assumed project timing and carbon abatement approach that was used as the basis for the market sounding exercise.

Table 2. Assumed project timing and abatement approach

Year	Project milestone	CO_2 generated (Mtpa)	CO_2 captured assuming 90% capture rate (Mtpa)	Residual carbon emissions (Mtpa)	Carbon offsets used (Mtpa)	Net carbon emissions (Mtpa)	Primary carbon emission abatement method	Comment
2028	First 700MW power station module operational	4.72	0	4.72	4.72	0.00	Offsets	Offsets used to achieve net zero emissions
2032	CCS infrastructure approved and operational	4.72	4.24	0.47	0.47	0.00	CCS	Offsets used for residual carbon emissions
2033	Second 700MW power station module operational	9.43	8.49	0.47	0.47	0.00	CCS	Offsets used for residual carbon emissions

[2] https://www.afr.com/policy/energy-and-climate/iea-chief-rebukes-australia-over-emissions-net-zero-20210924-p58ufm

Year	Project milestone	CO_2 generated (Mtpa)	CO_2 captured assuming 90% capture rate (Mtpa)	Residual carbon emissions (Mtpa)	Carbon offsets used (Mtpa)	Net carbon emissions (Mtpa)	Primary carbon emission abatement method	Comment
2058	Project completion	9.43	8.49	0.94	0.94	0.00	CCS	Offsets used for residual carbon emissions

It should be noted that the project will consider the use of biomass firing (e.g. using prickly acacia as a fuel source). This could represent a reduction in coal usage of up to 10%. In this case, this would have a corresponding reduction on the emissions figures above.

3 Market Assessment

3.1 International Carbon Markets

Globally there are a number of carbon markets, all designed to facilitate the reduction of carbon emissions overall via market mechanisms. The size of global carbon markets grew by over 20% in 2020, with a value of over US$100 billion and an annual trading turnover of more than US$250 billion.[3] Major carbon markets have been established in several jurisdictions, including the European Union (EU), United Kingdom (UK), the United States (US) and China.

The EU Emissions Trading System (EU ETS) is in Phase 4 of its operation, which concludes in 2030. The total cap on emissions began at 1,720 million tonnes in 2020 and reduces by 2.2% annually.[4]

The UK Emissions Trading Scheme (UK ETS) is in Phase 1, running from 2021 to 2025, with the initial cap on allowances set at 155.7 million tonnes, decreasing over time.[5]

The US currently has no federal emissions trading scheme. However, two of its notable regional schemes are the Regional Greenhouse Gas Initiative (RGGI), which is a cap-and-trade regime that covers CO_2 emissions from a group of New England and Mid-Atlantic states; and California, which has its own trading regime.[6]

China launched its national ETS in 2021 after several delays, becoming the world's largest ETS and covering 12% of global CO_2 emissions, or approximately 4.5 billion tonnes.[7] This scheme currently has a flexible emissions cap that can go up or down from year to year, depending on the output of regulated sites. The lack of a firm cap makes it unclear if the ETS will cut emissions under its current design in the short term.[8]

Abatement projects that are part of these international schemes have a varied level of reputability, and therefore industry confidence is mixed. Main areas of concern are around internationally sourced carbon abatement certificates as a reliable and authentic representation of actual carbon abatement. The reputation of Australia's Emissions Reduction Fund (ERF) as a source of reputable carbon abatement is strong (as is the EU and UK scheme), as discussed in Section 3.2.

For the purposes of this assessment, the Australian carbon market has been assessed as the primary target for carbon offsets (although the volume of offsets required for the project is likely to necessitate procurement of offsets internationally).

[3] https://www.mckinsey.com/business-functions/sustainability/our-insights/putting-carbon-markets-to-work-on-the-path-to-net-zero

[4] https://www.gtlaw.com.au/insights/carbon-markets-australia-overseas-2021

[5] Ibid

[6] Ibid

[7] https://chinadialogue.net/en/climate/the-first-year-of-chinas-national-carbon-market-reviewed/

[8] https://www.carbonbrief.org/in-depth-qa-will-chinas-emissions-trading-scheme-help-tackle-climate-change/

3.2 Australian carbon credit units (ACCUs)

3.2.1 Regulator

Australia's Clean Energy Regulator (CER) is an independent statutory authority that administers Australia's ERF. The ERF is a voluntary scheme that provides incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions.[9]

Along with the ERF, which issues ACCUs, the CER also administers the Renewable Energy Target's two schemes: the Large-scale Renewable Energy Target (LRET), and the Small-scale Renewable Energy Scheme. The LRET incentivises the development of renewable energy power stations in Australia through a market for the creation and sale of certificates called large-scale generation certificates (LGCs).[10] These LGCs are then sold to wholesale purchasers of electricity to meet their renewable obligations.

LGCs were not considered to be an appropriate method of carbon abatement for the Galilee Power Project as this project is neither a renewable power station nor a wholesale purchaser of electricity. Therefore, the focus of the assessment centred on ACCUs as the primary source of carbon offsets.

3.2.2 Perceived Integrity

According to the CER Quarterly Carbon Market Report for December 2021, the integrity of ACCUs is high[11], which increases their attractiveness as a source of carbon offsets in both the domestic and international markets.

3.2.3 Abatement Projects

Several activities are eligible under the scheme and participants can earn ACCUs for emissions reductions. One ACCU is earned for each tonne of CO_2 equivalent (tCO_2-e) stored or avoided by a project. A company seeking to offset its emissions can voluntarily surrender ACCUs to represent an equivalent emissions reduction of one tonne of CO_2 per credit certificate surrendered.

The CER maintains a public register of projects registered under the ERF[12]. This register contains all nationally approved abatement projects, including certificates awarded and proponent details.

3.2.4 Structure of Market

The CER conducts an annual reverse auction for the ERF, where the CER acts as the buyer. Proponents of carbon abatement projects bid to enter contracts with the CER to transfer ownership of ACCUs to the CER as they will be generated. The schedule of ACCU contract deliveries extends 10 years into the future. At these auctions, sellers of ACCUs submit a price they are willing to sell ACCUs at to the CER. The CER then chooses the lowest cost offered ACCUs to offer contracts to in turn. The number reported as the price of the auction is the highest price offered to the CER that is accepted.[13]

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[9] http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund

[10] http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Large-scale-Renewable-Energy-Target

[11] Clean Energy Regulator, Quarterly Carbon Market Report – December Quarter 2021, p.6.
http://www.cleanenergyregulator.gov.au/Infohub/Markets/quarterly-carbon-market-reports/quarterly-carbon-market-report-%E2%80%93-december-quarter-2021

[12] http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register

[13] https://www2.greenbase.com.au/what-you-need-to-know-about-erf-auctions/

3.2.5 Safeguard Mechanism

The safeguard mechanism is a key element of the ERF as it signals to business to avoid emissions increases beyond business-as-usual. It does so by placing a legislated obligation on large emitters to keep net emissions below an emissions limit or baseline. The safeguard mechanism applies to facilities with direct Scope 1 emissions of more than 100,000 tCO_2/y. Responsible emitters that exceed the mechanism's baseline are required to manage the situation by either purchasing and surrendering ACCUs or by applying for a calculated baseline, a variation to their baseline, a multi-year monitoring period, or an exemption due to exceptional circumstances.[14,15]

Grid-connected electricity generators are subject to a "sectoral baseline", currently set at 198 $MtCO_2$-e/y. This is considerably higher than the total reported Scope 1 emissions from grid-connected generators in 2015/16, which was 179.1 $MtCO_2$/y. The government has acknowledged that it does not expect the electricity sector baseline to be breached before 2030.[16]

The sectoral baseline will be in place until the sector's aggregated emissions exceed the baseline. After this point, facilities would be required to comply with their own individual facility baseline, which would apply in the financial year after which the CER publishes the reported exceedance.[17]

The total volume of this sectoral baseline could change over time, depending on the potential for political policies to be revised due to climate change. The effect of a reduced sectoral baseline would likely impact the least efficient emitters first, obliging them to purchase and surrender ACCUs before less efficient emitters.

3.3 Size of Market

In 2021, 16.5 million ACCUs were issued, an increase of 6% from 2020.[18] The use or voluntary surrender of ACCUs grew by 13% to 950,000 ACCUs in 2021, which is a new record for the scheme. The total ACCUs issued over the life of the scheme to 2021 is approximately 108 million certificates[19], representing 108Mt of CO_2 emissions reduced or avoided.

The yearly volume of offsets required by the Galilee Power Project is over 50% of the annual quantity of ACCUs issued nationally in 2021. Therefore, even assuming a healthy growth of the ACCU market over the next six to eight years, it is likely that the carbon offsets required for the project once operational would greatly exceed the volume that would be available through either the spot market or through direct commercial negotiation.

Therefore, it is assumed that a significant portion of carbon offsets would need to be sourced from outside the ACCU market. As such, it is likely that the project's offset portfolio would comprise a mix of domestic and internationally sourced credits and that Galilee would require new offset projects to enter the market. The project's offset portfolio would also include long-term carbon offset projects that would allow the cost per tonne of

[14] http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism

[15] https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1819/Australias_climate_safeguard_mechanism

[16] https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1819/Australias_climate_safeguard_mechanism

[17] http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines/Sectoral-baseline

[18] http://www.cleanenergyregulator.gov.au/Infohub/Markets/quarterly-carbon-market-reports/quarterly-carbon-market-report-%E2%80%93-december-quarter-2021

[19] http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register

carbon paid by Waratah Coal to approach the long-term cost of abatement, and reduce its exposure to the offset spot price.

3.4 Spot Market Price Fluctuation

The ACCU spot price underwent an unprecedented price surge in Q4 2021, increasing from $26.50 to $51.00, a rise of 92%.[20] Sharp peaks in the spot price of any commodity market indicate a supply-demand imbalance; in the case of the late 2021 rally, a sudden increase in demand following the 26th United Nations Climate Change Conference of the Parties (COP26) that was held in Glasgow on 31 October to 13 November 2021 (and various corporate and government declarations of net-zero target) led to spot prices exceeding the cost of supply.

ACCU prices softened significantly in Q1 2022, following the Federal Government's changes announced on 4 March 2022 to fixed-delivery ACCU contracts. This change allows holders to pay an exit fee and be released from their fixed obligations to the government, releasing more liquidity into the market.[21]

Figure 1 shows the spot prices of ACCUs to 20 May 2022.

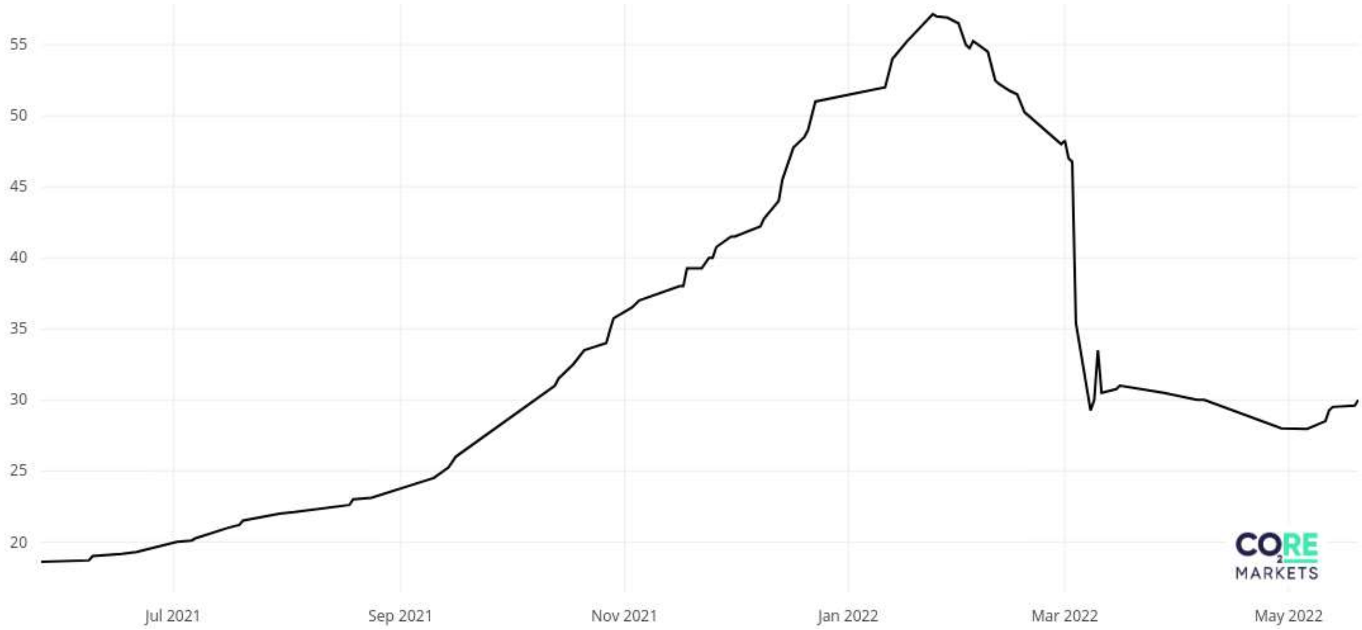

Figure 1. ACCU spot prices to 20/05/2022. Source: Renewable Energy Hub[22]

The most recent ACCU auction result (April 2022) produced an average result of $17.35/tonne[23]. This indicates that the spot price is still trading well above the competitive cost of supply and that there is currently opportunity to develop new offset projects at costs below the current spot price.

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[20] http://www.cleanenergyregulator.gov.au/Infohub/Markets/quarterly-carbon-market-reports/quarterly-carbon-market-report-%E2%80%93-december-quarter-2021

[21] https://www.jonesday.com/en/insights/2022/04/australian-carbon-credit-units

[22] https://www.renewableenergyhub.com.au/market-prices/

[23] http://www.cleanenergyregulator.gov.au/ERF/auctions-results/april-2022 accessed 19 May 2022.

3.5 Future Market Development

The CER intends to commence operation of the Australian Carbon Exchange in 2023. This online carbon exchange is expected to increase market transparency for ACCUs and potentially other types of carbon units and certificates.[24] This exchange should simplify the trading of ACCUs, supporting an increasing demand from the corporate sector. This will facilitate the voluntary trading market for ACCUs that currently has a low level of transparency.

The ongoing buoyancy in the market price for ACCUs is also expected to support the development of abatement projects, and, like international carbon markets, to attract investment in new technologies to achieve low-cost carbon abatement.

[24] http://www.cleanenergyregulator.gov.au/Infohub/Markets/australian-carbon-exchange

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4 Abatement Cost

4.1 Costs by CO_2 Emission Volume

The costs for the expected required amount of offsets are shown in Table 3. A range of offset prices has been shown to cover a market price fluctuating between $15/t to $100/t (current spot price $30.00 as at 20 May 2022).

For completeness, the full, unabated volume of CO_2 emissions for both power station modules of 9.43Mtpa has been shown also.

Table 3. Range of carbon offset costs for expected project emission volumes

		Offset price (million AUD$ per annum)				
Carbon offsets (Mtpa)	Comment	15/tCO_2	20/tCO_2	30/tCO_2	50/tCO_2	100/tCO_2
4.72	1 x 700MW module, CCS not operational	$70.7	$94.3	$141.5	$235.8	$471.5
0.47	1 x 700MW module, CCS operational	$7.1	$9.4	$14.1	$23.6	$47.2
0.94	2 x 700MW modules, CCS operational	$14.1	$18.9	$28.3	$47.2	$94.3
9.43	2 x 700MW modules, CCS not operational (worst case assumption)	$141.5	$188.6	$282.9	$471.5	$943.0

Based on the most recent ACCU auction price of $17.35/t$CO_2$, and assuming the project timing from Table 2, a single power station module would incur offset costs of $81.9M pa before CCS infrastructure is operational, dropping to $8.2M afterwards. Once the second power station module is operational with CCS, the offset costs would be $16.4M pa. At a carbon intensity of 0.81 tonnes per MWh, an offset cost of $17.35/tonne would influence power prices by $14.05/MWh.

Based on a spot price of $100/t, and a worst-case assumption that both power station modules are in operation and no CCS infrastructure is operational, the offset costs would be $943M pa. This would give significant incentive for the CCS infrastructure to be commissioned as soon as possible in the project lifespan.

4.2 Long-term Offtakes

While the ACCU spot price reflects a relatively volatile market, there is an opportunity to achieve greater certainty on ACCU pricing via long-term agreements. These agreements would reduce risk for buyers by providing improved cost certainty and for sellers by providing improved volume certainty, while the seller may forgo opportunities (and risks) on the spot market.

It is expected that long-term agreements for offsets would be priced closer to cost of supply due to the ability of the project to underwrite development costs for new projects and to provide sales volume certainty, thus improving an offset project's bankability. The power project owner may also choose to invest directly into the offset project, thereby creating a vertically integrated supply chain.

The other benefit of a long-term agreement is that it would facilitate the development of other carbon abatement projects that would require relatively long-term commitments to be feasible. The addition of new carbon abatement projects would increase the overall ACCU supply available and stabilise long-term ACCU prices.

The size of the Galilee Project warrants the development of specific offset projects that will be underwritten by a long-term offtake (over many decades). This long-term offtake approach will give the project access to offsets at a price that is closer to a competitive cost of supply rather than exposing the project to an illiquid market.

A number of the industry participants indicated a willingness to develop a portfolio of offset projects to specifically cater for the needs of the power project.

The ERF's most recent auction results provide a reasonable indication of the long-term cost of supply for new projects. The most recent (April 2022) average price was $17.35/tonne.

5 Parties of Interest

5.1 Major Certificate Recipients

The following ACCU certificate recipients were contacted regarding their interest in long-term offset agreements.

Table 4. Correspondence with major ACCU certificate recipients

Name	ACCU certificate volume received to 2021[25]	Comment
Party 1	16,656,936	Meeting held. Refer Section 5.3.
Party 2	4,189,429	Spoke 4/4/22 to CEO. No interest indicated in large, long-term agreements. Indicated preference for the spot market in coming years.
Party 3	2,234,133	Contacted regarding interest, no interest indicated
Party 4	1,679,396	Contacted regarding interest, no response back
Party 5	1,677,354	Contacted regarding interest, no response back
Party 6	1,504,614	Meeting held. Refer Section 5.3

Interest in long-term agreements directly with ACCU recipients appeared to be limited judging from the responses received; therefore discussions were extended to include project developers traders and brokers.

5.2 Project Developers, Traders and Brokers

From the Quarterly Carbon Market Report:

> *in 2021, total ACCUs held in the accounts of intermediaries (brokers, traders and financial institutions) tripled to 3 million... The share of ACCUs held by intermediaries as a proportion of total ANREU holdings doubled from 13% to 26% during 2021... The growth of ACCU holdings by intermediaries reflects greater interest from traders, aggregators and financial institutions.*[26]

Arche's discussions with ACCU traders and project developers reflected a far greater interest in long-term agreements than from ACCU recipients directly. The outcomes of these discussions are listed in Section 5.3.

[25] http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register

[26] http://www.cleanenergyregulator.gov.au/Infohub/Markets/quarterly-carbon-market-reports/quarterly-carbon-market-report-%E2%80%93-december-quarter-2021

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5.3 Initial Discussions

Initial discussions were held with the following parties on their interest in engaging in long-term carbon offset agreements.

Table 5. Discussions regarding long-term carbon offset agreements

Name	Category	Comment
Party 1	ACCU recipient / Project Developer	Meeting held with Chief Investment Officer. Party 1 is largest carbon abatement project developer in Australia, involved with ~200 abatement projects across the country. Party 1 expects to receive over 126M ACCUs over life of projects in hand. Also developing water quality market and plastics offset market. Interested in long-term offset agreement.
Party 7	ACCU recipient	Meeting held with BD manager and CFO. Interested in discussions on long-term agreement, indicated preference to deal with partners with "similar values". Project scale of abatement probably too large for them but interested in smaller scale discussions for what they could provide.
Party 8	Broker	Meeting held with BD Manager and CEO Corporate. Purportedly largest buyer of voluntary ACCUs in Australia. Interested in long-term offset agreements. Indicated need to find offtakers (i.e. ACCU buyers). They develop international offset projects also and can access large volumes of international units. Financing for TEM projects generally available.
Party 9	Broker	Meeting held with BD Manager and GM Energy Solutions. Purportedly largest trader of environmental products globally. Interested in long-term offset agreements. Propose to meet the project demand with mix of local (likely land-based) offsets and internationally-sourced certificates. International projects need to go through internal Shell integrity review for reliability and credibility.

All parties in Table 5 indicated a willingness to progress these initial discussions to more detailed discussions on long-term offset arrangements. The suggested next steps are discussed in Section 6.

6 Next Steps

The suggested next steps to advance the current long-term offset discussions are:

- Non-disclosure agreement (NDA) to be put in place with potential partners
- ensure alignment of values (e.g. with LGI Limited) will be conducive to a long-term agreement
- establish parameters with brokers to determine the mix of offset certificates that would best suit the project requirements
- define supply timeframe to align with project emissions profile
- vendor quotations
- commercial negotiations
- execute agreement/s.

These steps are subject to approval by Waratah Coal before they are finalised.

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Appendix B: Carbon Capture and Storage Technical Report

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Galilee Power Project CCS Technical Summary

Prepared for Waratah Coal by Arche Energy

June 2022

Acknowledgement of Country

The Galilee Power Project is on the land of the Clermont-Belyando Area Native Title claim group, formerly known as the Wangan and Jagalingou people.

Arche Energy acknowledges and pays respect to the Traditional Custodians and Elders of the nations on which we work and the continuation of cultural, spiritual and educational practices of Aboriginal and Torres Strait Islander peoples.

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Any capital and operating cost estimates rely on heuristics and assumptions and are provided as indicative, concept level estimates.

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    a. securities, commodities, currencies, options and futures transactions;
    b. real estate investment, including but not limited to any related return on investment, capital appreciation or tax benefits; or
    c. leased equipment or any other goods; or
2. any actual or alleged representation, advice, forecast or guarantee, whether express or inferred as to the performance of any investment.

This document is confidential and may contain market-sensitive information.

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1 Introduction

Waratah Coal is developing the Galilee Coal Project in Central Queensland. The project will be developed as a conventional mine, exporting thermal coal through the seaborne market and providing coal to a new, clean coal power station, the Galilee Power Project. The Galilee Power Project will generate baseload power for sale on the National Electricity Market (NEM).

The Galilee Power Project will comprise a 1,400MW ultra-supercritical power station. This industry-leading high efficiency, low emissions (HELE) power station will provide affordable, reliable, efficient, lower carbon, baseload power on a 24/7 basis.

Carbon capture and storage (CCS) technology is intended to be the mainstay of the Galilee Coal Project's carbon emissions abatement strategy in the medium and long term, in addition to the high-efficiency and low emissions design of the ultra-supercritical power station, with the balance of carbon emissions (occurring either before commissioning of the CCS plant or as residual emissions) being addressed through offsets.

It is acknowledged within industry that CCS as a later "add-on" module to an existing power station is inefficient and relatively ineffective. This will not be the case for this project, where CCS will be an integral part of the power station design from the inception of the project.

In 2021 Waratah Coal commissioned Arche Energy to develop a concept for a post-combustion carbon capture and storage facility. This report is a high-level summary of that concept as well as an update of opportunities and actions that have occurred since 2021.

2 Project summary

2.1 Overview

The proposed CCS plant will consist of:

- a post-combustion capture plant that will scrub CO_2 from the power station's flue gas stream, purify the CO_2 stream and compress it for transportation and storage
- a pipeline system transporting the CO_2 to the storage field
- a CO_2 storage field complete with distribution pipelines, injection wells and monitoring systems.

2.2 Project parameters

The Galilee Power Project is expected to have the carbon emission parameters shown in Table 1 They show that the total upper bound CO_2 production from the project is approximately 9.43Mt CO_2 pa. This represents the total emissions produced from two power modules, that for a net-zero carbon emissions profile would need to be captured or offset.

Table 1. Galilee Power Project expected carbon emission parameters

Parameter	Value	Unit
Total power station power output (2 modules)	1400	MW
CO_2 production (upper bound) per annum (2 modules)	9.43[1]	Million tonnes of CO_2 per annum (Mt CO_2 pa)
Project life	50	years

2.3 Net-zero emissions approach

While regulatory and market demands may not mandate that the Galilee Power Project adopts a net-zero emissions profile, for the purposes of this report, it has been assumed that the project is intended to have a net-zero carbon emissions profile over the life of the project.

[1] Waratah Power Station Development Application LGA DA_191219 Appendix A, p.47

2.4 Sequencing of key infrastructure

The timing of the project's key milestones is critical to establishing its maximum carbon offset requirement. For instance, the CCS infrastructure intended for the project would capture between 90% and 95% of emissions, leaving between 5% and 10% of emissions to be offset. (Where applicable, this project has assumed a 90% carbon capture rate as a conservative approach, which excludes other opportunities for emissions reduction that may be included in the project, like renewable biomass firing). However, the timing of the CCS infrastructure being constructed may leave a gap between commissioning the power plant and commissioning the CCS infrastructure. This situation would require an offset of 100% of the project's emissions for the gap period.

Similarly, if power plant output is slow, for example if there is a number of years between the commissioning of the first and second 700MW power station modules, this would halve the expected emissions required for abatement for this period, producing only a maximum of 4.72Mt CO_2 produced per annum for a single 700MW power station module operating.

3 CCS in summary

3.1 CCS process

The CCS process involves underground sequestration of CO_2 and is conceptually depicted in Figure 1. It involves the following plant and processes:

1. CO_2 / NOx / SOx removal
2. Capture / separation of CO_2 at the power plant and pipeline compression
3. CO_2 transmission (pipeline) infrastructure
4. CO_2 injection facilities (wells).

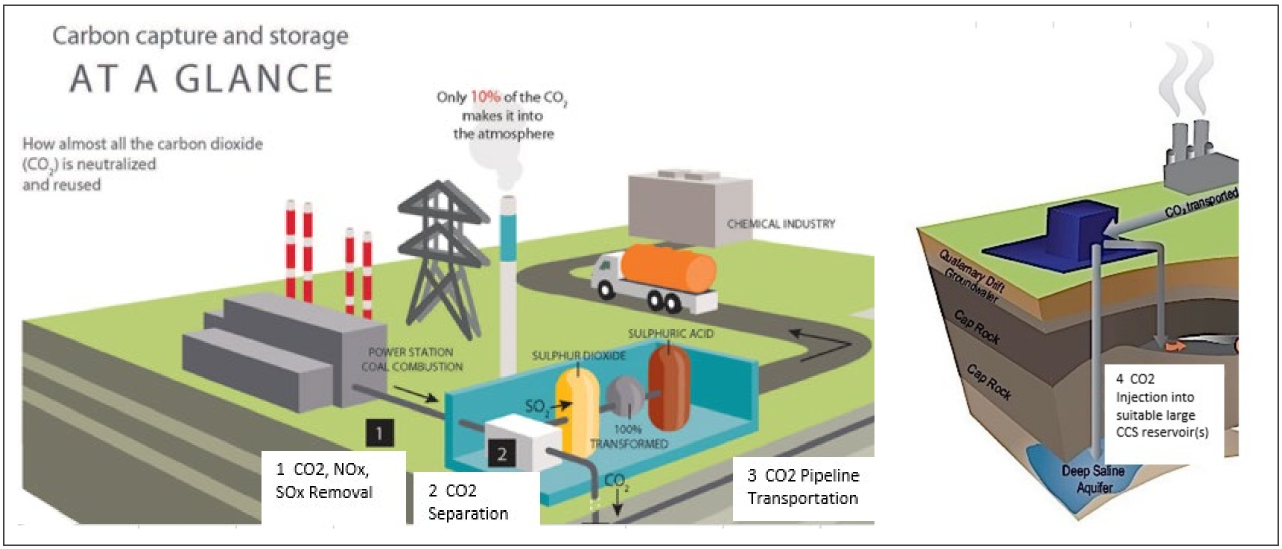

Figure 1: CCS Process [2] [3]

These stages of the CCS process for the Galilee Power Project will be described Sections 4 to 6.

[2] http://www.mining.com/canada-launches-1-25bn-large-scale-carbon-capture-and-storage-plant-35547/

[3] https://www.ediweekly.com/technology-help-save-earth-carbon-capture-storage-ccs/

3.2 Feasibility of CCS

CO_2 sequestration has been proven technically feasible and is already performed in Australia and in other parts of the world. Examples of sequestration include the below projects.[4,5,6,7,8]

- Gorgon Gas Project: An offshore Australian gas development on Barrow Island, Western Australia[7], with onshore gas processing on the environmentally sensitive Barrow Island in Western Australia. Natural gas streams are processed from the Gorgon and Jansz Fields (15% and 1% CO_2 in the gas stream respectively), and the CO_2 by-product is injected into the Dupuy Formation via four onshore wells.
- Sleipner Project: A Norwegian (North Sea) gas development where the CO_2 by-product (9% CO_2 in the gas stream) is separated from the sales gas stream (< 2.5% CO_2 specification) on an offshore production platform and injected for long-term storage in a thick, high permeability reservoir between 800 and 1000m below the seabed.
- Snohvit Project: A Norwegian (Barents Sea) gas development where produced gas from the Snohvit-Albatross-Askeladd fields (about 6% CO_2 in comingled gas stream) is transported by pipeline to an onshore terminal for gas treatment. The CO_2 by-product is separated and transported back to the production area for injection into a suitable (Jurassic) formation.
- In Salah Project: An Algerian onshore gas development treating production from the Krechba field. The natural gas stream (10% CO_2 in the gas stream) is processed locally to the field, and the CO_2 by-product is injected back into the same reservoir.
- Boundary Dam Coal CCS Project: A 139 MW coal-fired power station in Saskatchewan, Canada, operated by SaskPower since 2014. CO_2 nameplate capture rate of 1 Mt per annum, used for enhanced oil recovery.
- Petra Nova - A 240 MW coal-fired power station operated by NRG and JX Nippon in Texas, USA, commenced CCS operation in 2016 (placed on hold in 2021). 1.4Mt CO_2/y capture capacity, used for enhanced oil recovery.
- Yanchang – A coal-to-chemical plant in Shaanxi Province in China, commenced operations in 2014 at 0.05Mt/y CO2 capture rate, expanded CO_2 capture rate 0.36 Mt/y commenced operations in 2020. Used for enhanced oil recovery.

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4 Carbon Storage Taskforce, "National Carbon Mapping and Infrastructure Plan – Australia" Sept 2009 [p21, 33/136]

5 A. Chadwick, O. Eiken, "Offshore CO_2 Storage: Sleipner natural gas field beneath the North Sea", 2013 [p1-2/23]

6 Statoil, "Snohvit: The history of injecting and storing 1Mt CO_2 in the fluvial Tubaen Fm", 2013 [p1-2/9]

7 S. Ryan, "The Gorgon CO_2 Injection Project", 2010

8 https://en.wikipedia.org/wiki/List_of_carbon_capture_and_storage_projects

4 Galilee Power Project CCS — overview

4.1 Summary

The CCS system will receive compressed CO_2 from the proposed Galilee Power Project, transport it to the CCS field, distribute the CO_2 to the Colinlea Sandstone Formation in the Southern Galilee Basin (discussed in Section 6.4) and sequester it underground.

4.2 Site Location

The Power Station will be located immediately to the east of the Galilee Coal Project mining lease, in a location known as "Monkland", on Monklands Road, Hobartville (see Figure 2). The real property description is Part of Lot 2 on SP136836.

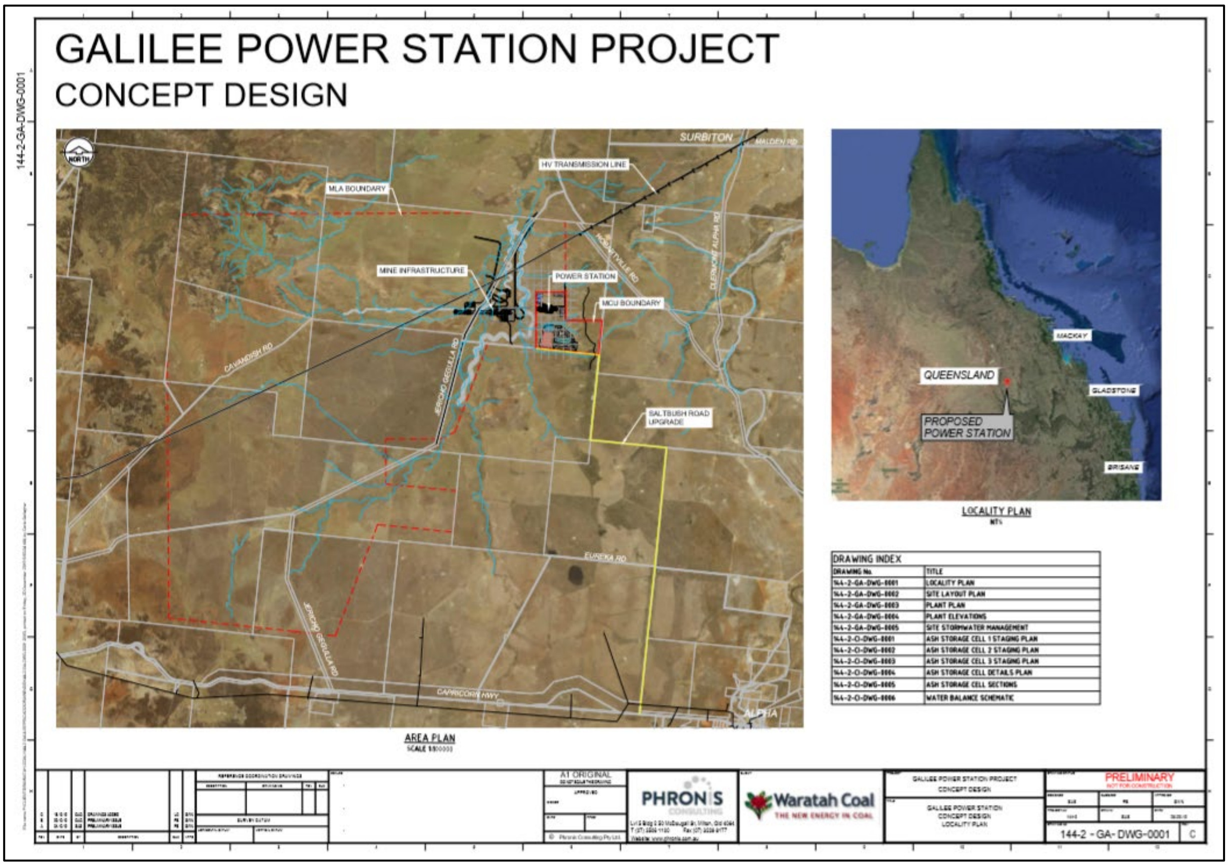


Figure 2: Site Location Plan

5 Post combustion capture plant

5.1 Location

The Galilee Carbon Capture Plant is proposed to be located at the nearest location to stack position (Item 23). It is proposed to utilise an outcrop of laydown area (Item 13) as shown in Site Plan mark-up (in yellow) in Figure 3.

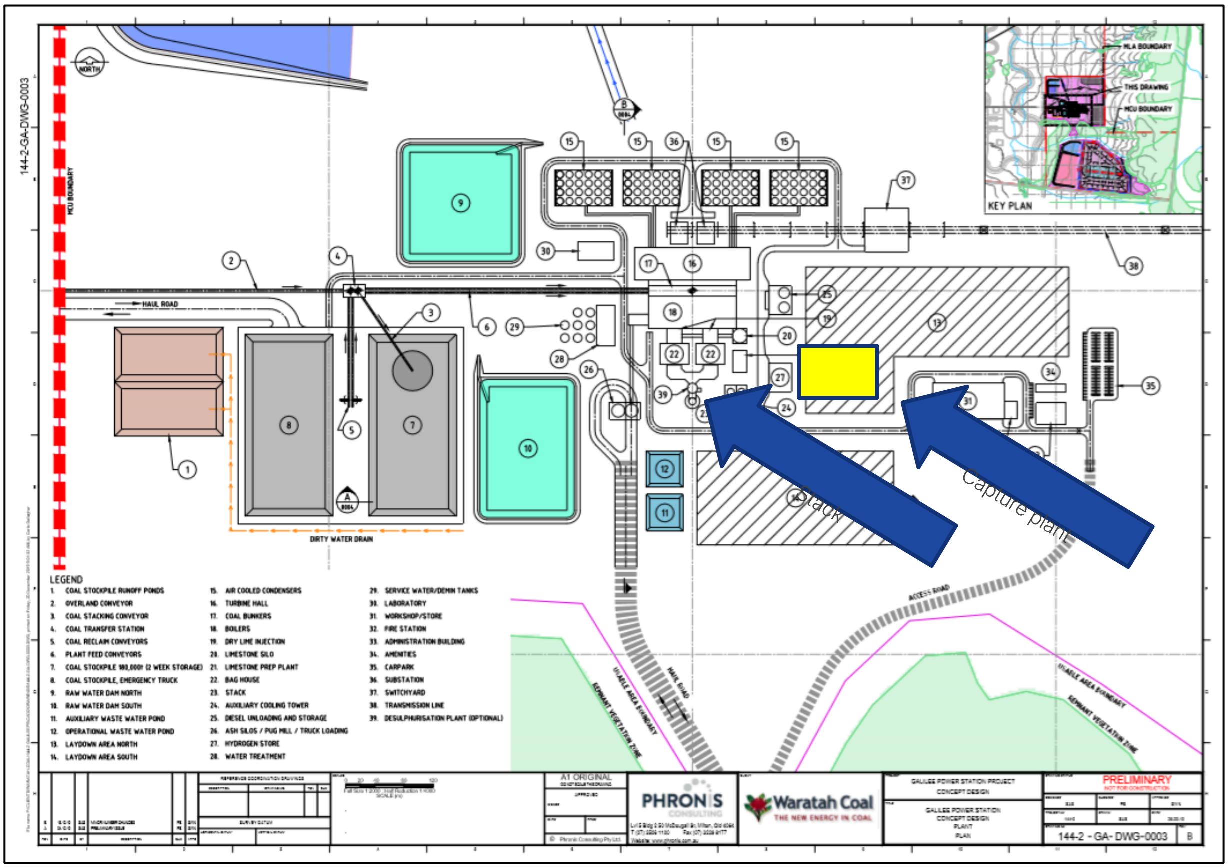


Figure 3: Galilee Power Project Site Plan

5.2 Post-combustion CO_2 capture and compression

The Galilee power station combustion process will be a typical negative pressure furnace consuming pulverised coal (and possibly blends of woody biomass such as prickly acacia). The flue gas stream will comprise of combustion products along with nitrogen and residual (excess) air.

To capture and compress the CO_2 from the flue gases produced by the plant combustion process, it is proposed to use a post-combustion capture technology. The post-combustion process captures and compresses CO_2 after combustion, electricity generation and NOx/SOx removal processes.

Post-combustion CO_2 capture involves capture of the CO_2 from flue gases, resulting in:

- a treated flue gas stream, and
- a concentrated CO_2 stream for beneficial use.

Compression of the CO_2 stream is then required to boost its pressure to facilitate storage nearby, or for transportation (potentially over long distances) to a suitable storage location. A diagram of the carbon capture process is shown in Figure 4.

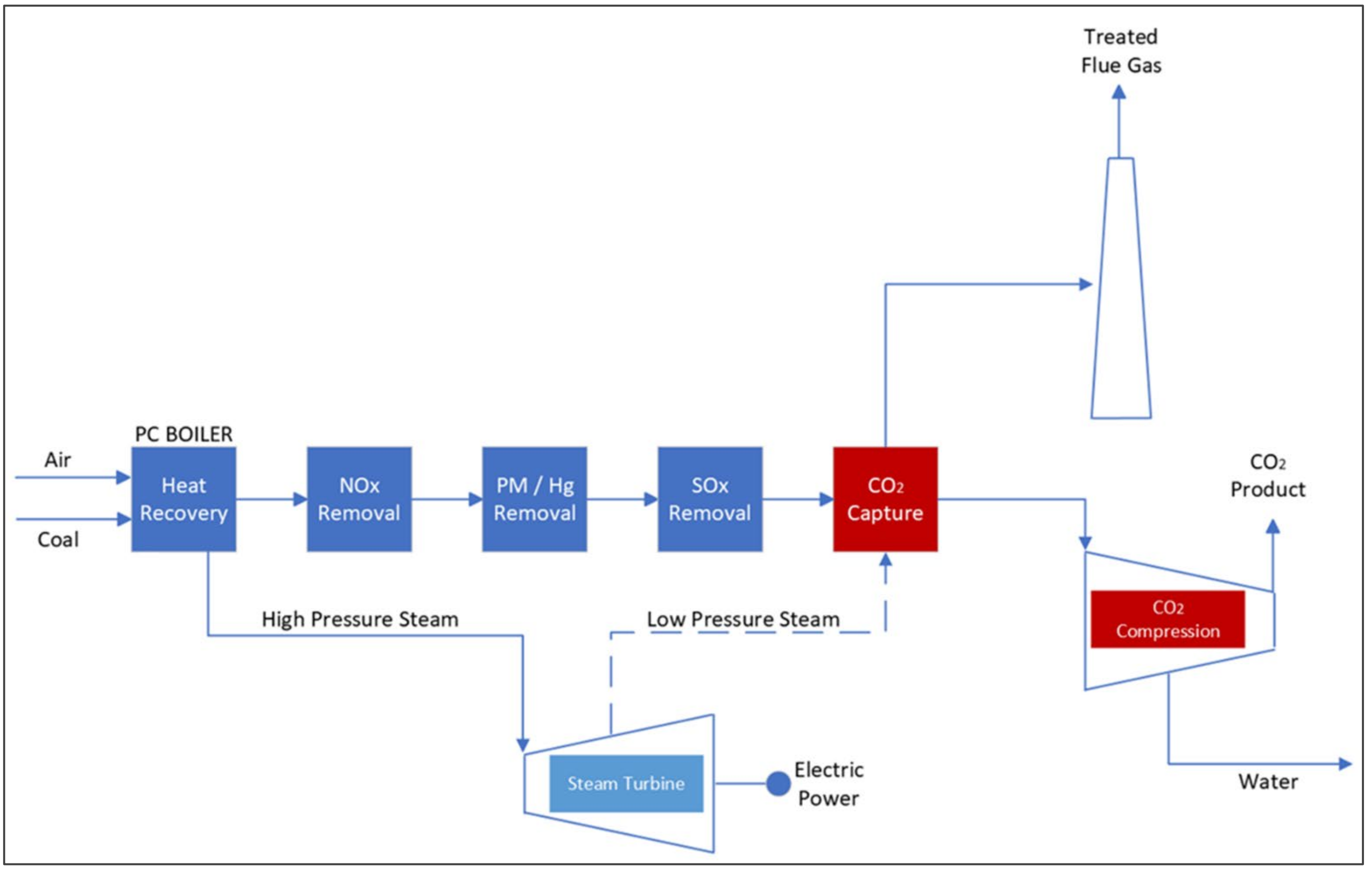


Figure 4. Process diagram of carbon capture and compression in a coal-fired power plant[9]

Where used in coal-fired power generation applications, post-combustion CO_2 capture and compression can be applied to any combustion-based technology (such as USC) and can either be designed into a new plant or retro-fitted to an existing plant.

[9] https://netl.doe.gov/coal/carbon-capture/post-combustion

Typically, CO_2 concentration in flue gases is 10–15% for coal-fired USC power plants, and 4–5% for gas fired power plants.[10] This relatively high CO_2 concentration makes post-combustion capture far more efficient and cost-effective than direct air capture of CO_2, which separates CO_2 at atmospheric concentrations of 412 ppm (0.0412% CO_2).

5.3 Post-combustion capture in commercial use

Examples of where post-combustion capture has been commercially applied in coal-fired plants are shown in Table 2.

Table 2: Global commercialised coal fed CCS Projects [11] [12] [13]

Project	Location	Operator	Commencement Date of Project	Production Rate CO_2 (Mt/y)	Application
Boundary Dam (139 MW)	Saskatchewan, Canada	SaskPower	2014	1.0	Enhanced oil recovery
Petra Nova (240 MW)	Texas, USA	US DoE, NRG, JX Nippon, MHI	2016	1.4	Enhanced oil recovery
Yanchang (Coal to chemical plant)	Shaanxi Province, China	Yanchang Petroleum	2020	0.36	Enhanced oil recovery

5.4 CO_2 removal system

The capture process will typically remove about 90%–95% of the CO_2 by mass[14, 15] from the flue gas stream, so there will be some residual CO_2 in the treated flue gases that is released to atmosphere (which will be addressed by offsets). Where applicable, this project has assumed a 90% carbon capture rate as a conservative approach.

CO_2 is extracted from the flue gas stream through absorption or adsorption using a chemical or physical process.

The most common process for post-combustion CO_2 capture is CO_2 removal by an amine chemical solvent process, typically using monoethanolamine or MEA.[16]

[10] Global CCS Institute, "CO_2 Capture Technologies – Post Combustion Capture (PCC)", Jan 2012 [4/17]

[11] https://en.wikipedia.org/wiki/Carbon_capture_and_storage#By_country

[12] M. Oettinger (IEAGHG), "Post-Combustion Capture", Dec 2015 [p18/38]

[13] GPAC/PJVA Joint Conference Presentation, "The Alberta Carbon Trunk Line", Oct 2013 [p10/27]

[14] Global CCS Institute, "CO_2 Capture Technologies – Post Combustion Capture (PCC)", Jan 2012 [6/17]

[15] M. Oettinger (IEAGHG), "Post-Combustion Capture", Dec 2015 [p17/38]

[16] Y. Wang, L. Zhao, A. Otto, M. Robinius, D. Stolten, " A Review of Post-combustion CO_2 Capture Technologies from Coal-fired Power Plants", Nov 2016 [p2/16]

The MEA chemical solvent process is shown in Figure 5, with description of the process provided below.

The flue gas stream enters an absorber column (1) where the CO_2 is selectively absorbed by the MEA stream. The CO_2-rich MEA stream proceeds to the regenerator (or stripper) column (2), where the stream is heated, and then a concentrated CO_2 stream is released from the MEA liquid.

The regenerated (or lean) solvent is then recycled through to the absorber (3) to allow re-use in the absorber column. The separated CO_2 stream can then be used in a beneficial CCS process (4).

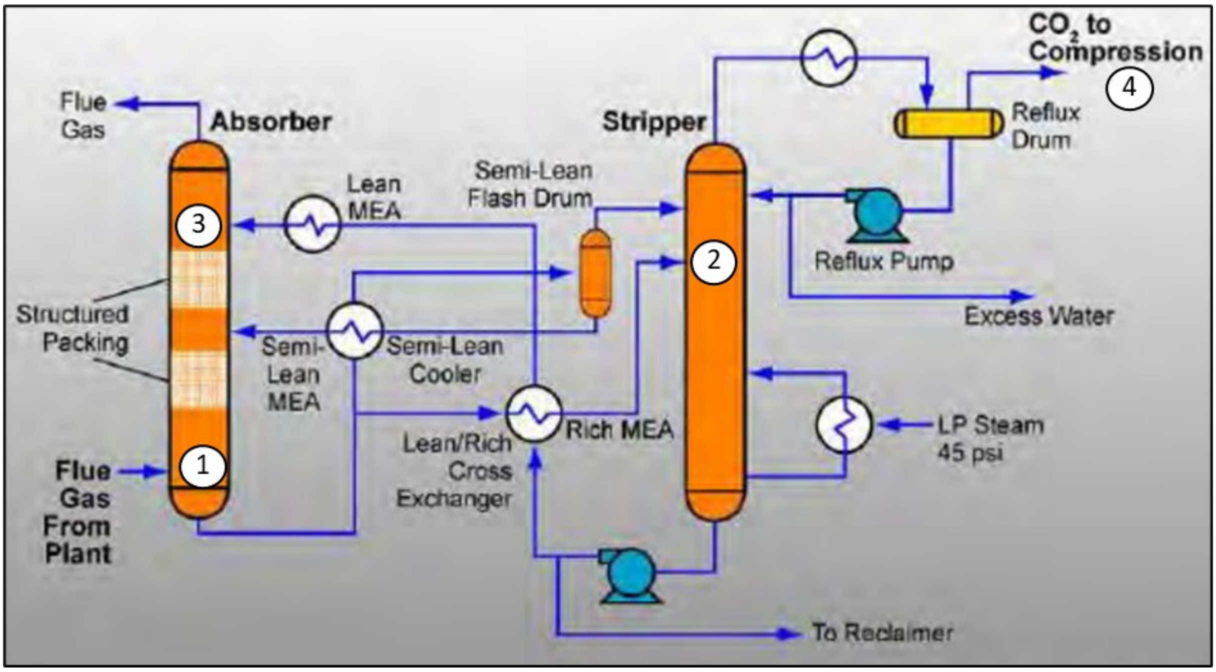


Figure 5: Chemical Amine Absorption Process (MEA)[17]

Data sources suggest that unit sizes of 7.2 million Nm^3/day are feasible for CO_2 removal units (including MDEA, MEA and amine chemical solvent types); although it is understood that larger bespoke plant may be more capital efficient than modular plant (this capital reduction opportunity will be explored in subsequent development phases).

5.5 CO_2 compression

CO_2 would be compressed to 12.5MPa for transportation and storage as a supercritical fluid.

A supercritical fluid is a substance that is held at a pressure above its critical point. At these pressures, there is no distinct phase change between gas and liquid phases and so the substance has properties of both, i.e. compressible like a gas, but high density like a liquid, creating optimal conditions for CO_2 transportation and storage.[18]

Electric-motor-driven multi-stage centrifugal compressors with high-flow, high-head characteristics are required for this application. Compression sizing assumes a discharge pressure of 12.5MPa.

[17] M. Oettinger (IEAGHG), "Post-Combustion Capture", Dec 2015 [p11/38]

[18] https://en.wikipedia.org/wiki/Supercritical_carbon_dioxide

6 CO_2 storage prospectivity

6.1 Galilee Basin

Figure 6 shows the extent of the Galilee Basin, which covers an area of approximately 247,000km^2.

It spans a geographical region from Hughenden and Winton in the north to Charleville in the south and includes the towns of Barcaldine and Alpha.

The larger Eromanga Basin is located to the west and the oil and gas producing Cooper Basin to the south-west.

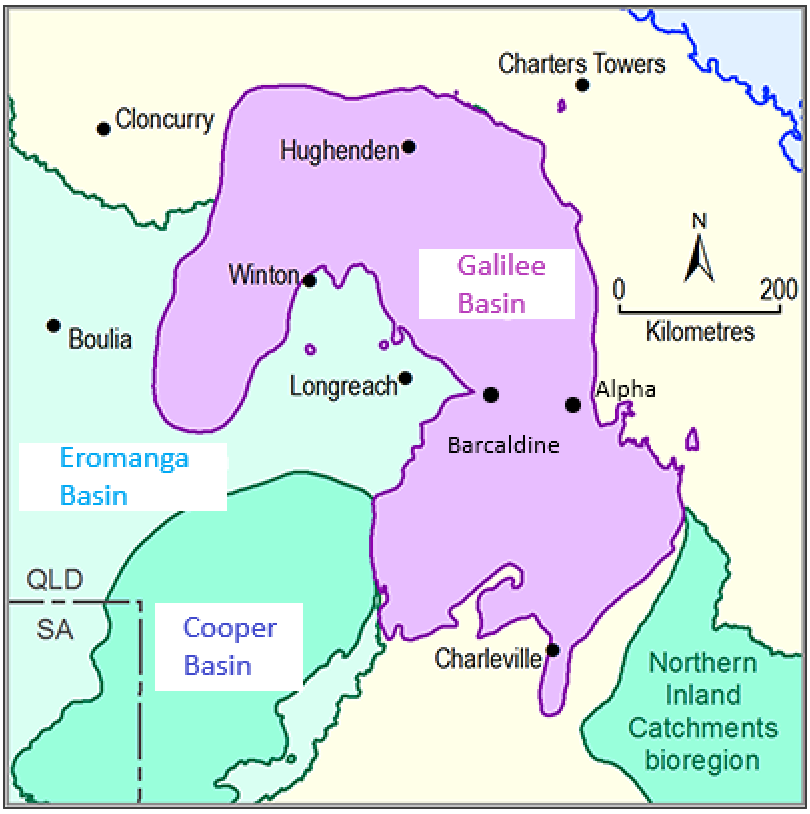


Figure 6: Southwest Queensland Basins Map19

Further details regarding the geographical region and the resources and projects in the area is presented in Figure 7.

[19] Based on mapping from https://www.bioregionalassessments.gov.au/assessments/11-context-statement-galilee-subregion/113-geology

Despite large coal deposits having been discovered, in 2011 it was reported there had been no commercial oil and gas discoveries made in the Galilee Basin[20]. However, an initial desktop analysis review[21] found that there is a substantial amount of 2D seismic in the area of interest, with processed images and original data readily available. There are several wells around the area of interest, most having downhole geophysics and well completion reports.

It is known that both of the two major seismic surveys were designed in such a way that the respective companies were able to produce time-structure maps of the Jurassic, Triassic, Permian and older formations from the seismic data. Geological modelling of the Colinlea Sandstone can then be refined by re-processing the available data, and surfaces made that depict the Top and Base of the Colinlea, as well as other formations that may be necessary for planning and good well control during drilling of any well.

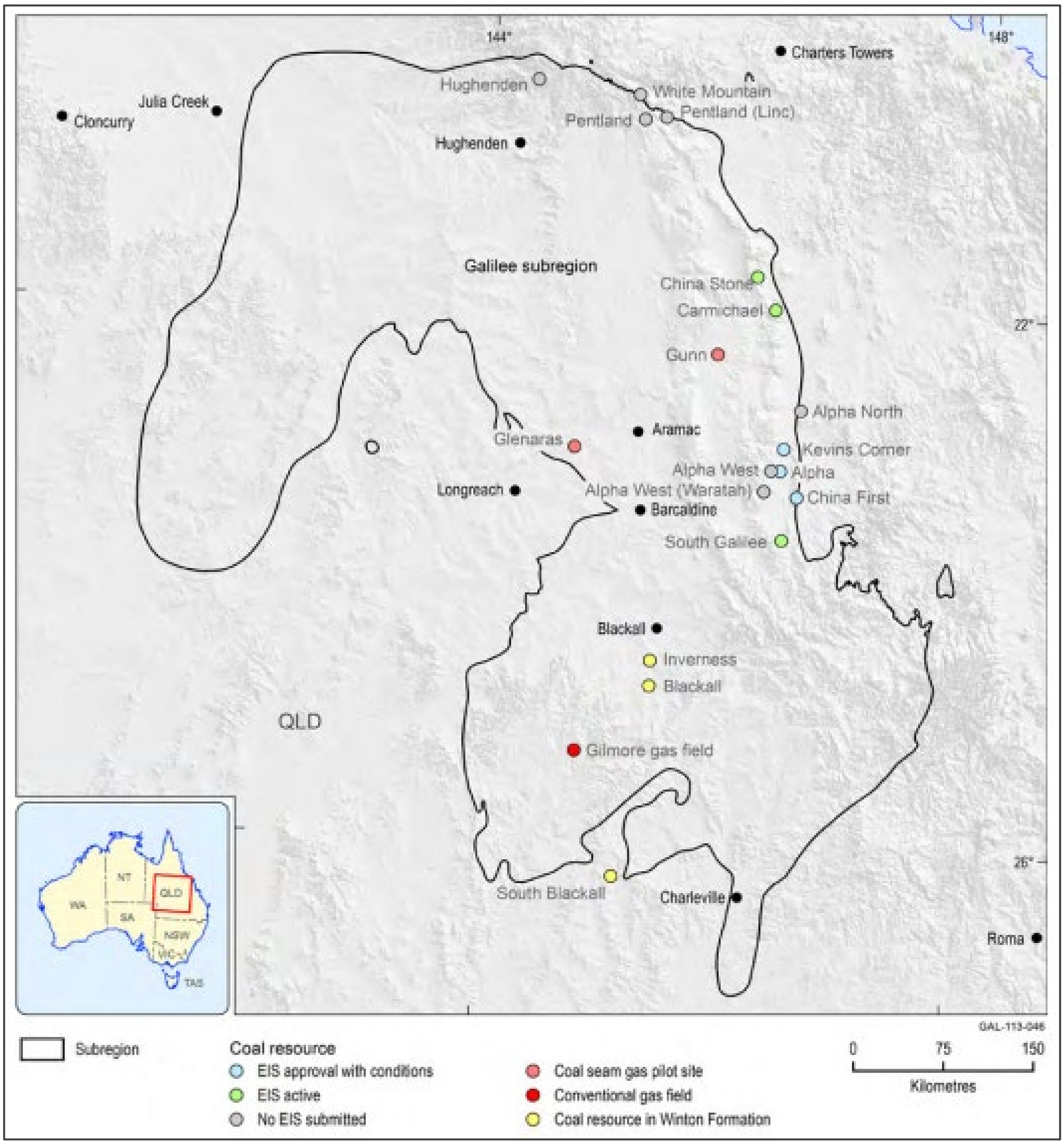


Figure 7: Galilee Basin geography and significant resources and projects[22]

[20] CO_2 Geological Storage Solutions (CGSS), "An assessment of Queensland's CO_2 geological storage prospectivity – the Queensland CO_2 Geological Storage Atlas", 2011 [p3/8]

[21] Waratah Coal, 2021, Review of Data Relevant to Sequestration Trial

[22] Australian Government, Lake Eyre Basin Bioregional Assessment, Product 1.1 "Context statement for the Galilee subregion", May 2014 [p68/167]

6.2 CO_2 trapping and MAS

A fundamental concept assumed in the Queensland CO_2 Geological Storage Atlas[23] is that the bulk of the prospect storage capacity potential is achieved by a mechanism known as Migration Assisted Storage (MAS) — a process that physically traps and immobilises CO_2 within the pore space of a formation.

Geology and reservoir configuration are primary factors in determining whether MAS trapping is viable in a particular prospect. There are four MAS trapping mechanisms in operation in reservoir formations during CO_2 re-injection (refer to Figure 8):

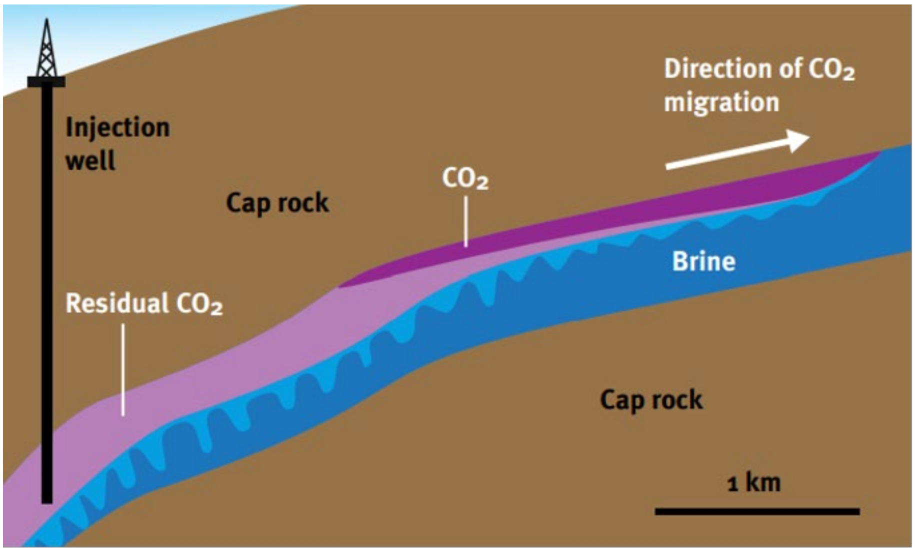
- CO_2 trapping below sealing rock: through buoyancy forces, the CO_2 plume migrates from the injection well up-dip (displacing brine within the saline aquifer) and is trapped against reservoir sealing rock above. This is known as a drainage process. It should be noted that buoyancy is the result of supercritical CO_2 being less dense than the saline aquifer fluids it displaces, and hence the supercritical CO_2 moves upward.
- Residual CO_2 immobilisation: CO_2 moving in the trailing edge of the CO_2 plume is “snapped off” and trapped within the pore spaces of the reservoir rock. This is known as an imbibition process.[24]
- Gas dissolution: this is a slow process where some CO_2 from the plume is absorbed by the unsaturated brine during migration. This denser CO_2/brine mix sinks slowly through the aquifer. Referring to the Queensland CO_2 Geological Storage Atlas, the study did not consider the contribution from this mechanism to CO_2 storage, but it may contribute to an additional 20% CO_2 storage capacity than quoted in Queensland CO_2 Geological Storage Atlas estimates.[25]
- Formation reaction: some CO_2 from the plume reacts with the reservoir rock and mineralises forming solids.[26]

[23] CO2 Geological Storage Solutions (CGSS), “An assessment of Queensland’s CO2 geological storage prospectivity – the Queensland CO2 Geological Storage Atlas”, 2011 [p3/8]

[24] CO_2 Geological Storage Solutions (CGSS), “Regional Storage Capacity Estimates: Prospectivity not Statistics”, Aug 2010 [p7/10]

[25] CO_2 Geological Storage Solutions (CGSS), “Regional Storage Capacity Estimates: Prospectivity not Statistics”, Aug 2010 [p6/10]

[26] https://www.globalccsinstitute.com/news-media/insights/migration-assisted-storage-opportunities-are-almost-endless/



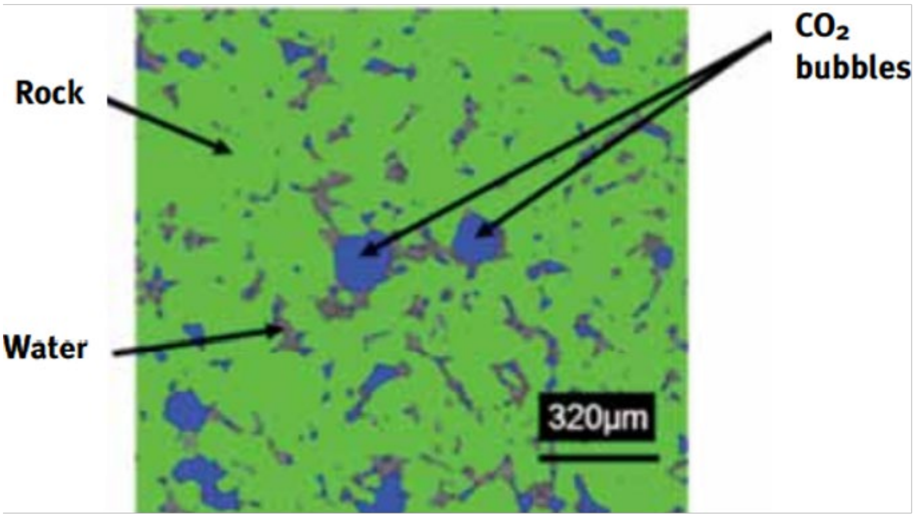


Figure 8: MAS (migration assisted storage) CO_2 trapping mechanisms[27]

The MAS trapping mechanism enables many sedimentary reservoirs to become prospects for CO_2 storage, not just those with large structural anti-clines. The potential storage capacity also greatly increases, as gas saturation of the reservoir rock pore space under up-dip sealing structures is contributory.

[27] Prof M. Blunt, Imperial College London, "Carbon Dioxide Storage", Dec 2010 [p8/14] https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Carbon-dioxide-storage----Grantham-BP-4.pdf

6.3 Estimation of CO_2 storage capacity

CO_2 Storage capacity (CO_2 mass) has been quantified in the CGSS Study using the following equation:

$mCO_2 = RV * Ø * Sg * δ(CO_2)$

Where:

- $m(CO_2)$ = mass of CO_2 (kg)
- RV = reservoir rock volume (m^3)
- Ø = total effective pore space as a fraction of reservoir rock volume (RV)
- Sg = gas saturation of pore space (Ø)
- $δ(CO_2)$ = density of CO_2 at reservoir conditions (kg/m^3)

The CGSS study methodology for determination of CO_2 storage capacity is an approach driven by formation geology and reservoir engineering rather than rules-of-thumb frequently adopted in prospectivity assessments. Often such assessments use regional formation storage efficiency (SE) factors (typically around 4% SE for an entire reservoir RV), rather than a more rigorous geological modelling approach.

In addition, generic CO_2 density assumptions, typically of 700kg/m^3, are often made, meaning the effect of reservoir parameters such as formation depth and salinity, and consequently reservoir pressure and temperature gradients as discussed earlier, on density are not considered.

It should be noted that, due to the above factors, storage capacity estimates can differ significantly between methodologies assumed in different CO_2 storage literature sources.[28] The CGSS study methodology is considered a more rigorous approach but is likely to result in more conservative (i.e. lower) CO_2 storage estimates.

6.4 Prospectivity review

Waratah Coal commissioned a review into the prospectivity of CCS in the Galilee Basin.[29] Based on this review, the most prospective areas in the Galilee Basin were identified from the Queensland Cabon Dioxide Geological Storage Atlas[30], as follows:

- Colinlea Sandstone (southern Galilee Basin) with storage potential of 1,320Mt
- Clematis Sandstone/Rewan Formation (southern Galilee Basin) with storage potential of 982Mt
- Clematis Sandstone/Rewan Formation (northern Galilee Basin) with storage potential of 534Mt
- Betts Creek beds (northern Galilee Basin) with storage potential of 594Mt.

Of these areas, the best prospect was identified as the Colinlea Sandstone Formation. It was identified as suitable to the needs of the Galilee Power Project, due to the below characteristics.

- 100km distance to the Galilee Coal project site.
- Large total storage capacity estimated at 1,320Mt CO_2, representing nearly 200 years of storage capacity at the project's proposed injection rates.

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[28] CRCGHGT, CSIRO, IEA Cooperative Research, "Injection Strategies for large-scale CO_2 storage sites, 2011 [p7/8]

[29] Arche Energy, "Galilee Basin CO_2 Storage Prospectivity", 2nd February 2021

[30] DEEDI, 2009, Queensland Carbon Dioxide Geological Storage Solutions, p. 316.

- Mid-depth aquifer with reservoir depth of over 800m, which is sufficient to maintain CO_2 in a supercritical (i.e. dense, fluid-like) state.
- Reservoir properties are satisfactory, with formation thickness and permeability adequate to support commercial CO_2 injection rates. In this case, the constraint on rate is the formation thickness, which is relatively thin at 20m.
- Colinlea formation is below, and sealed from, the formations that feed the Great Artesian Basin (GAB).

6.5 CO_2 injection

Understanding CO_2 physical properties is important in determining how best to inject and store CO_2. Below is a brief overview of the salient characteristics.

6.5.1 CO_2 Storage Phase

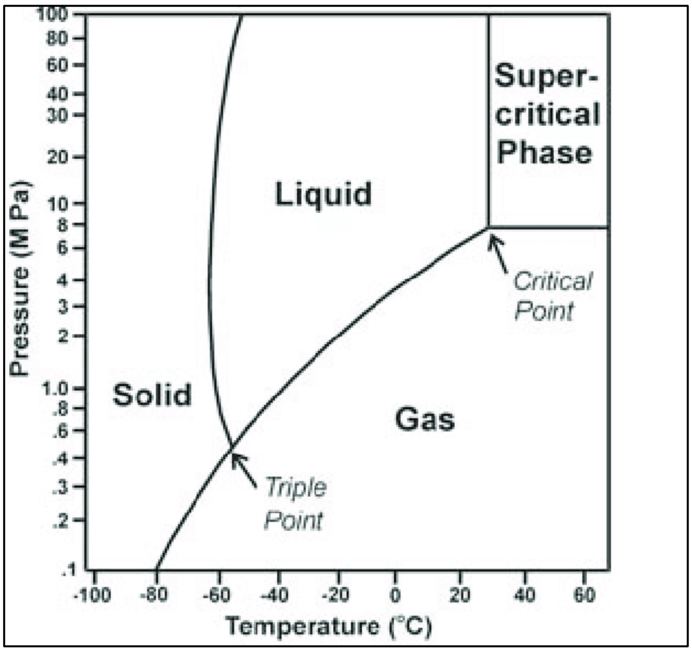

Figure 9: CO_2 Phase Diagram[31]

CO_2 will exist in solid (dry ice), liquid or gaseous phase at pressure at temperature conditions below the critical point. The critical point for CO_2 (when it reaches supercritical state) is at 31.1°C and 7.38 MPa. Above this point, CO_2 can be compressed like a gas, but has density like a liquid, which is optimal for transportation and storage.[32]

CO_2 injection conditions will need to:

- exceed current reservoir pressures to permit CO_2 to be re-injected
- exceed critical point conditions to ensure CO_2 is maintained in supercritical state.

[31] D. Voormuij, G. Simandl, "Geological and Mineral CO_2 Sequestration Options", 2003 [p3/14]

[32] https://en.wikipedia.org/wiki/Supercritical_carbon_dioxide

6.5.2 CO_2 density

Generally, injected CO_2 density increases as the reservoir depth increases and the reservoir's hydrostatic pressure also increases.

As CO_2 must be injected and maintained in storage in a supercritical state, it must be stored in aquifers with reservoir conditions exceeding the critical point, or typically reservoirs with a minimum depth of 800m.[33]

At conditions necessary for CO_2 injection in the Galilee South reservoir depths (described in Section 6.4), the supercritical CO_2 density is typically above 250kg/m^3. This density is still lower than that of the saline aquifer water, which provides buoyancy for the plume migration.

6.5.3 Key CO_2 injection prerequisites

The following reservoir characteristics are key impactors on the viability of large-scale CCS.

- Reservoir suitability
    - The reservoir must have good sealing to ensure that the CO_2 does not migrate upward and permeate vertically through the capping rock. This will ensure viability of long-term storage. For the Galilee Basin, sealing effectiveness has yet to be fully verified due to the lack of historical oil and gas activity and associated data. More seismic data acquisition and drilling activities will need to be done to confirm the Basin's sealing effectiveness.[34][35]
    - The reservoir must have a continuous rise to support CO_2 trapping and MAS mechanisms.
- Reservoir depth
    - As mentioned previously, injection into an aquifer of sufficient depth to maintain the CO_2 in a supercritical state is vital. As reservoir depth increases, both reservoir pressure and temperature progressively increase. With changing reservoir conditions and increased volume of sequestered CO_2 over time, the density of the CO_2 increases comparatively rapidly, which will enable increasingly greater volumes of CO_2 to be stored in a given pore space.
- Reservoir integrity — injection pressure management
    - CO_2 injection conditions will need to exceed initial reservoir pressures to permit CO_2 to be injected. However, CO_2 pressure must be maintained below reservoir fracture conditions. Typically, risk of fracture pressure being reached is close to the well bore.

[33] D. Voormuij, G. Simandl, "Geological and Mineral CO_2 Sequestration Options", 2003 [p6/14]

[34] CO_2 Geological Storage Solutions (CGSS), "An assessment of Queensland's CO_2 geological storage prospectivity – the Queensland CO_2 Geological Storage Atlas", 2011 [p5/8]

[35] B. Bradshaw, CAGS Technical Workshop, "Queensland's CO_2 Geological Storage Atlas – Results", Jan 2010 [p18/30]

6.5.4 CO_2 injection rate and CCS viability

Predicting well CO_2 injection rate is a complex subject. Some literature suggests injection of up to 1 Mt CO_2 per year is readily achievable; however, the determination of a realistic well injection rate depends on understanding the impact of a variety of reservoir properties.[36]

A summary of how impactors influence reinjection rate (and thus sub-surface costs) is shown in Table 3.

Table 3: CCS Cost Impactors[37]

Impactors	Causes
Reservoir permeability	Higher reservoir permeability will reduce the number of wells required.
Formation thickness	Larger pay (productive reservoir) thickness will reduce the number of wells required.
Formation depth	With increased formation depth, there is typically a greater differential between virgin reservoir and fracture pressures. This permits greater storage of CO_2 in deeper reservoirs, but the benefit is typically partially offset by the increased well cost.
Well type	The choice of well type is likely to increase possible injection rate (dependent on formation permeability and thickness). However, well type selection can substantially increase the cost per well. Vertical wells are generally significantly cheaper and are often a preferred onshore solution, particularly where reservoir layer thickness is low to medium.
Fracture stimulation	Fracture stimulation of wells can increase the injection rate per well and reduce number of wells required. However, it is likely to increase the cost per well and is most beneficial for very low permeability wells (1mD). For Galilee wells (which have permeabilities typically significantly greater than 10mD), fracture stimulation is unlikely to positively impact number of wells required[38].

6.5.5 CCS injection infrastructure

From previous work commissioned by Waratah[39], development of the CCS infrastructure for the Colinlea Sandstone prospect would require the following infrastructure:

- 100km trunkline to connect the Galilee Power Plant with the Colinlea Sandstone prospect in the mid-south of the Galilee Basin
- 120km of pipeline to connect Main Hub and Level 1 hubs
- 140km of pipeline to connect Level 1 and Level 2 hubs
- 160km of flowline to connect hubs with spoked wellhead configuration.

[36] Prof M. Blunt, Imperial College London, "Carbon Dioxide Storage", Dec 2010 [p10/14] https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Carbon-dioxide-storage----Grantham-BP-4.pdf

[37] CRCGHGT, CSIRO, IEA Cooperative Research, "Injection Strategies for large-scale CO_2 storage sites, 2011 [p7/8]

[38] CRCGHGT, CSIRO, IEA Cooperative Research, "Injection Strategies for large-scale CO_2 storage sites, 2011 [p6/8]

[39] Arche Energy, "Galilee Basin CO_2 Storage Prospectivity", 2nd February 2021

The Colinlea Formation prospect CAPEX is estimated at AU$1,567 million (excluding uncertainty allowances or contingency).

The Colinlea Formation prospect OPEX is estimated at AU$24.4 million per annum excluding seismic monitoring. An additional AU$167 million per survey will be required for seismic survey works to be conducted over the life of the CO_2 injection project. Seismic surveys are recommended prior to construction and in years 2, 7, 12, 17 and 22.

If a fee of $26 per tonne (real) of CO_2 stored is received by the project (as a standalone business), the project internal rate of return (IRR) would be 6.2% (real) on a pre-tax unlevered basis or 9.1% (real) on a post-tax levered basis.

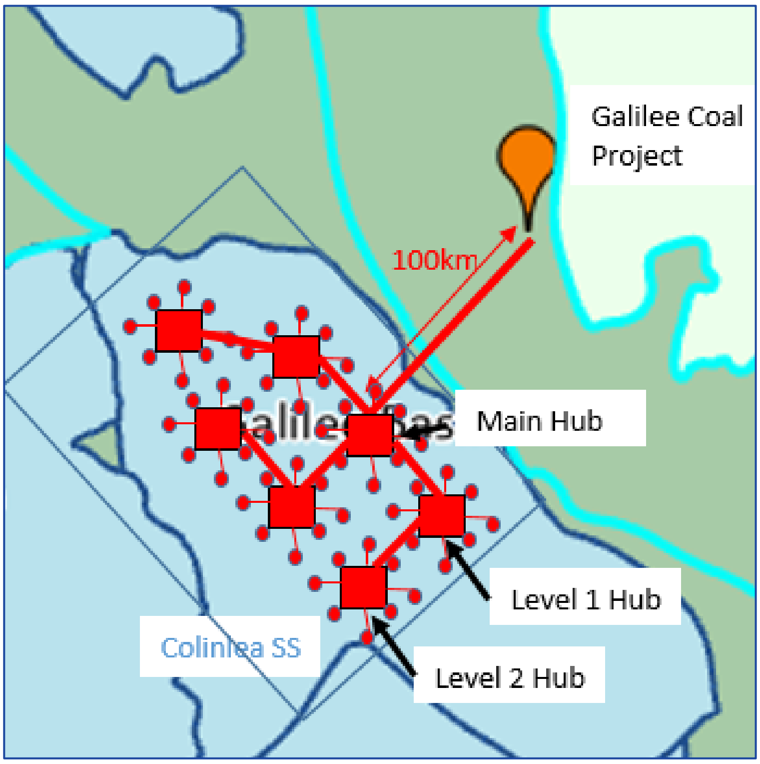

Figure 10: Recommended Colinlea Sandstone Prospect Development (not to scale)

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6.6 Galilee Power Project CCS Tenure

6.6.1 Preferred injection field

In May 2021 Waratah Coal lodged an expression of interest for the exploration of the above tenure. The acreage was not included in the Queensland Government's exploration tenure tender process for 2021; however, the feedback was that the acreage may be included in future years' tender programs.

6.6.2 2022 Exploration Tenure Tender

Waratah Coal has recently tendered on a GHG Exploration Permit, including an Authority to Prospect, for Tender Area QLR2021-1-1 and QLR2021-1-4. This permit would allow Waratah Coal to investigate in detail the suitability of these areas for CCS and progress them if suitable to the environmental and regulatory permitting stage.

While these two tenure areas are further away from the proposed Power Station than the preferred storage areas, the additional pipe length required to reach these fields does not make these areas unfeasible as options.

Details of this tender are as follows:

- Tender submitted on 3/3/2022
- Tender area QLR2021-1-1:
  - Permit name: Roma North
  - Locality: 80km NNE of Roma, Surat/Bowen Basin
- Tender area QLR2021-1-4:
  - Permit name: Quilpie
  - Locality: 40km NNW of Quilpie, Galilee/Eromanga Basin
- Tender status: tender is currently in the process of being reviewed by the Qld Government

6.6.3 Other options for CCS storage fields

In the absence of acquiring its own tenure, Waratah Coal may choose to negotiate access to storage fields developed by the successful tenderers from the 2022 exploration tenure tender program. This approach will provide these tenderers with revenue certainty and possibly finance to progress their exploration programs. Waratah Coal may also choose to negotiate supply of CO_2 to enhanced oil and/or gas recovery projects in the Galilee, Surat, Moonie or Cooper Basins.

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Appendix C: Prudentia Report

MEMORANDUM				
PPC Project No	OC22010			
To	Matthew Richards - Arche Energy			
By	AD	AD	AD	
Check	MA	MA	MA	
Revision	A	B	0	
Date	09/05/22	11/05/22	16/05/22	
RE:	**Galilee Power Station - Cl_2 Dispersion Modelling and Ammonia Storage**			

The Galilee Power Station Project is required to respond to ministerial queries related to the proposed "Hazardous Chemical Facility" for the site. The ministerial queries are related to Cl_2 storage and ammonia storage, specifically:

1. Review additional scenarios for Cl_2 loss of containment to determine whether AEGL-2 (3600s) is reached at any offsite receptors. The scenarios specified were:

- Cl_2 full drum rupture
- Loss of containment from the 20mm inspection port on the drum
- Loss of containment from Cl_2 manifold where more than one drum is connected

2. Confirm ammonia storage type and capacity

Prudentia has been engaged to assist with background information to assist with responding to the above.

Note that the project has previously performed a preliminary hazard assessment (*Reference 1*) and the ministerial queries were in response to this report. Importantly, the design is conceptual only and no detailed design has been performed. Therefore, this analysis is performed on a conceptual design only and values may be subject to change as design develops.

1. Cl_2 Dispersion Modelling

Cl_2 is required for water treatment of the auxiliary cooling tower. The previous hazard study investigated the release of Cl_2 from a 10mm offtake valve located on the Cl_2 drum and determined that the distance to the AEGL-2 was 4.2km.

1.1 Inputs and Assumptions

The following summarises the inputs and assumptions for this study:

- The preliminary hazard analysis assumed that Cl_2 would be supplied as a 1tonne cylinder of liquid chlorine. This is consistent with PPC's understanding for local (QLD) supply and storage in water treatment facilities and was maintained as the basis for this study. It was assumed that the drum contents are 100% Cl_2 and stored at 880 kPaa and 30°C.
- Release elevation 1m for all scenarios
- Horizontal release direction with no impingement

- 2m height of interest
- Surface roughness 100mm
- Weather conditions (central QLD):

	air velocity (max)	*air velocity (min)*	*Previous Study*
Wind speed	3.1	1.1	2
Pasquill Stability Factor	A/B	F	E
Relative humidity (%)	65	40	50
Air temperature (°C)	1	40	20
Surface temperature °C)	as above	as above	-

- For the manifold release case with more than one Cl_2 drum connected, it was assumed that 2 drums were open to the manifold. The previous study noted up to 5t of Cl_2 on site however it is assumed that only one cylinder is typically lined up for operation i.e. two drums online is considered conservative as site operation would be designed to empty dedicated drums for replacement rather than all of the drums at the same time. This case did not take credit for pressure reduction at the drum and the release was determined for the drum conditions above i.e. 880kPaa and 30°C. It was assumed that the release size was a 10mm diameter hole which is consistent with the assumption that the manifold is constructed from ½" tubing.

1.2 Results & Conclusion

For the assumptions above, the following summarises the Phast modelling performed for the Cl_2 release scenarios noted previously. Note that the previous hazard study investigated a release from a 10 mm opening on the drum and arrived at a distance of 4.2km to AEGL-2 (3600s). It was noted the closest receptor was 11km away.

Case	*Distance to 2ppm[1, 2, 3] (m)*
Full drum rupture	5100
20 mm diameter inspection port on drum	4100
10 mm diameter release from manifold with 2 drums online	6500

Notes:
1. AEGL-2 corresponds to 2ppm Cl_2
2. The distance provided is rounded up to the next 100m
3. The distance provided is the largest distance for the weather cases examined

Assuming that the closest sensitive receptor is unchanged from the previous hazard assessment, the latest modelling undertaken *"demonstrates that any offside impact from a chlorine loss of containment AEGL-2 (60 minutes) (from the scenarios listed above) will not reach land use receptors per State Code 21 requirements"*.

2. NH_3 Storage, Type and Capacity

Note that at this stage of the project it is not possible to "confirm" NH3 storage capacity or type since sufficient design has not been completed i.e. confirmation of feedwater quality, confirmation of boiler materials and selection of the boiler water treatment regime. However, based on reasonable assumptions, the following comments are made:

- The previous hazard study did note that storage of <50wt% aqueous ammonia would not exceed 5tonnes. It is PPC's understanding that the >50wt% nominated in Table 4.1 is in error. The previous hazard assessment assumed a 30wt% ammonia solution for the Aloha dispersion modelling for the spill event.
- It is suggested that it would be preferable to use a ~20wt% ammonia solution as this permits the use of IBCs i.e. vapour pressure at this concentration is within IBC pressure rating.
- 1000L IBCs are a typical container type for the supply of water treatment chemicals, including NH_3 solutions, in central Queensland.
- Ammonia solution is used to maintain the boiler pH at a sufficient value to minimise corrosion. For the expected steam capacity of the Galilee boiler (once-through) and assuming operation at a pH of around 9, the estimated consumption[1] of 20wt% ammonia solution is less than a single IBC every 3 weeks. Therefore, PPC consider that the 5t storage noted in the previous hazard assessment is acceptable i.e. delivery every 18 weeks.
- Note that the consumption noted above does not consider first fill requirements.

In summary, 1000L IBCs are typical for chemical storage of water treatment chemicals and are considered an adequate NH_3 solution transport and storage assumption for Galilee. It is recommended that a lower strength solution is used, <20wt% to stay within the IBC design pressure. In relation to the quantities noted in the previous hazard study, around 5 IBCs would be located on site. The dispersion modelling performed for the NH_3 spill case[2] in the previous hazard assessment is conservative in relation to the storage quantity and concentration noted here.

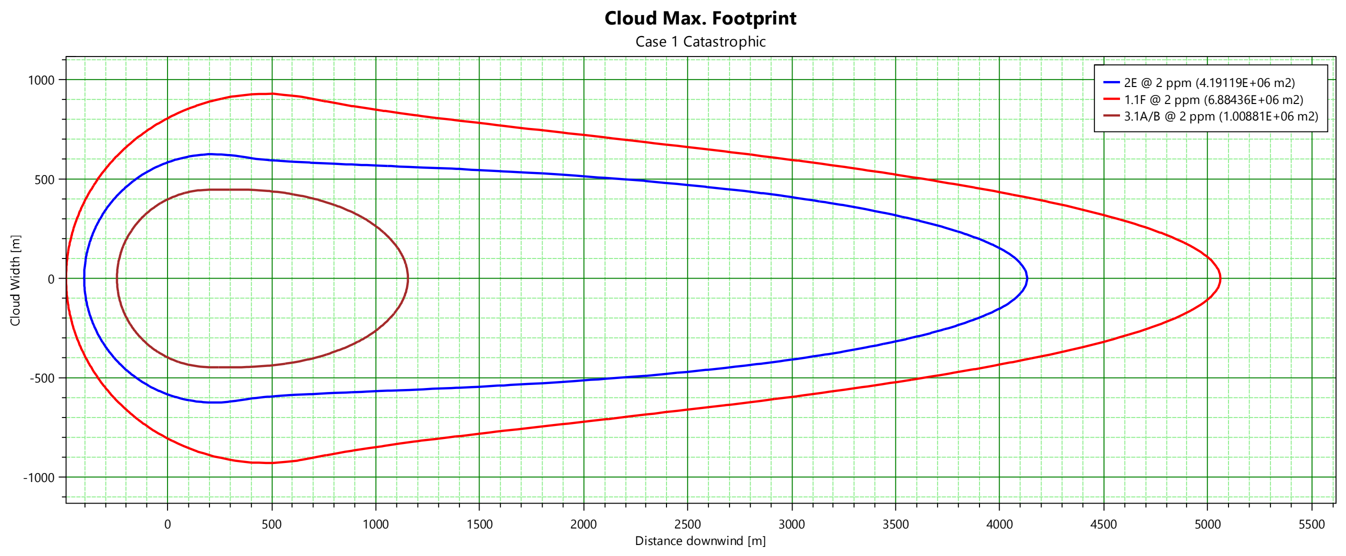
[1] *Consumption is based on a loss of 7.5% steam losses. This is considered a high value for a process plant with multiple end users and is considered conservative in this instance.*
[2] *Previous hazard assessment considered 1-2 tonnes of spilled NH_3 solution so the complete contents of up to 2 IBCs.*

3. References

1. *Waratah Coal, Galilee Power Station, Preliminary Hazard Assessment_B, 28/11/19, by Phronis Consulting*

Attachment 1 – PHAST Concentration Profiles to 2ppm Cl_2

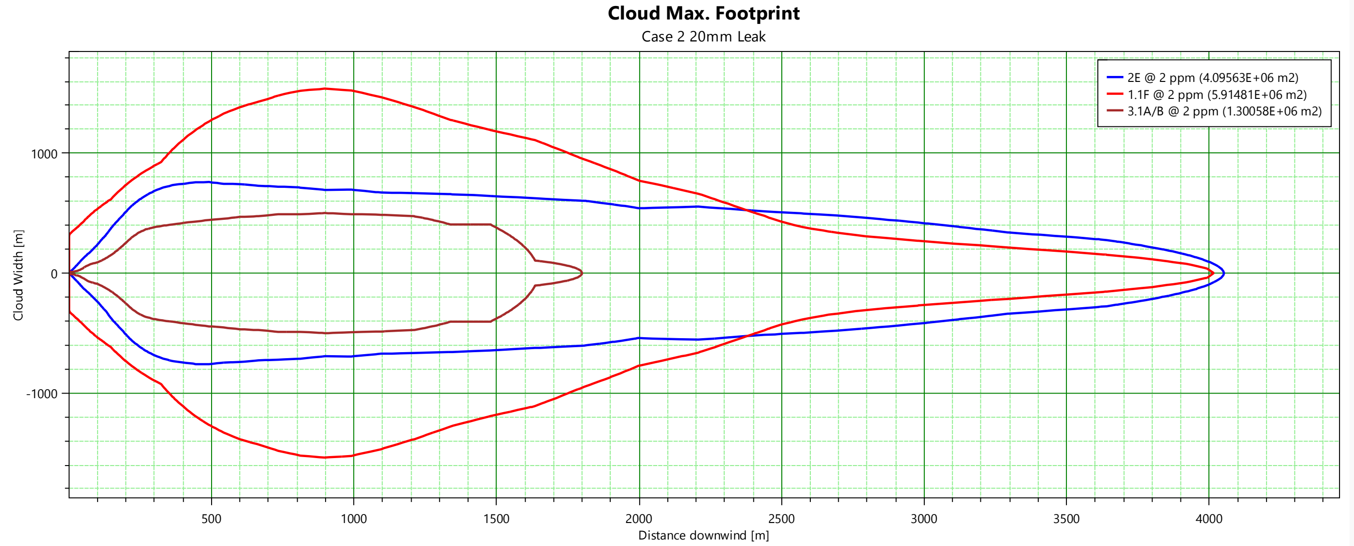
Audit Number	1303
Averaging time	ERPG (3600 s)
Equipment	Pressure vessel - 30/8.8
Height of Interest	2 m
Spacing parameter for the grid in the x dimension	0.1
Material	CHLORINE
Material to track	CHLORINE
Program	Phast 8.4
Scenario	Case 1 Catastrophic
Weather	Multiple Weather
Workspace	AD



Mass rate | Max Conc vs Distance | Conc. vs Time | Conc vs Dist. at Height | Footprint | Max Footprint | Side View

Pool Vaporisation | Dispersion | Toxic

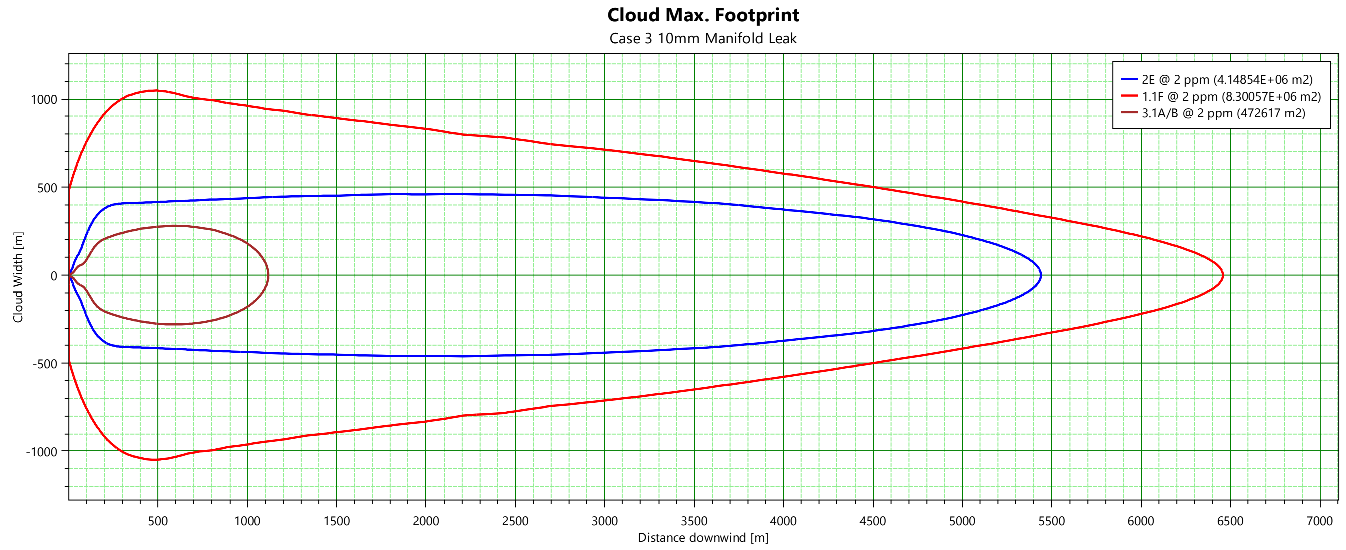
Audit Number	1303
Averaging time	ERPG (3600 s)
Equipment	Pressure vessel - 30/8.8
Height of Interest	2 m
Spacing parameter for the grid in the x dimension	0.1
Material	CHLORINE
Material to track	CHLORINE
Program	Phast 8.4
Scenario	Case 2 20mm Leak
Weather	Multiple Weather
Workspace	AD



Mass rate | Max Conc vs Distance | Conc. vs Time | Conc vs Dist. at Height | Footprint | Max Footprint | Side View

Pool Vaporisation | Dispersion | Toxic

Audit Number	1303
Averaging time	ERPG (3600 s)
Equipment	Pressure vessel - 30/8.8 (1)
Height of Interest	2 m
Spacing parameter for the grid in the x dimension	0.1
Material	CHLORINE
Material to track	CHLORINE
Program	Phast 8.4
Scenario	Case 3 10mm Manifold Leak
Weather	Multiple Weather
Workspace	AD



Mass rate | Max Conc vs Distance | Conc. vs Time | Conc vs Dist. at Height | Footprint | Max Footprint | Side View

Pool Vaporisation | Dispersion | Toxic