CO_2 Storage Resource Catalogue

Cycle 3 Report

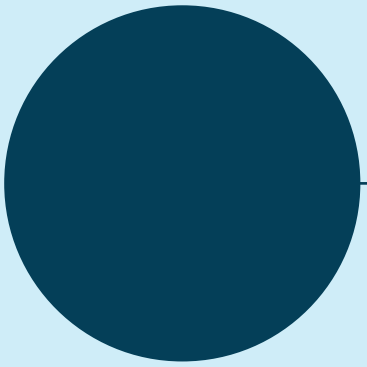
March 2022

Amounts of CO_2

Stored
0.006 Gigatonnes

Commercial
0.1 Gigatonnes

Sub-commercial
31 Gigatonnes



Undiscovered
471 Gigatonnes

Appendix E : Oceania

Australia

Contents

Change record for STOR-SW-RP-0001-A01/Appendix-E

Document Summary			
Client	Oil and Gas Climate Initiative (OGCI)		
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Important notice

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1.0 Australia

1.1.1 Summary

Australia was assessed during Cycle 1 and updated during Cycle 2 and Cycle 3. The CSRC has identified a CO_2 storage resource for Australia as follows:

Classification	CO_2 storage resource (Gt) Project and no project	CO_2 storage resource (Gt) Project specified only
Stored	0.006	0.006
Capacity	0.11	0.11
Sub-Commercial	31.4	1.11
Undiscovered	471.0	0.36
Aggregated*	502.4	1.59

* The aggregated resource represents the summed storage resource across all maturity classes and as such should not be viewed as representative of the potential of the country.

Table 1-1: Storage resource classification summary for Australia

- There are currently 69 sites at both a local and regional scale, located across a minimum of 14 basins, both onshore and offshore. 13 of these evaluations have a project defined.
- As of February 2021, over 1.8 Mt of CO_2 has been injected to deep geological storage. 1 Mt (published data) in the Chevron-operated Gorgon project and 0.8 Mt in the CO_2CRC Otway Research Facility.
- Australia remains the most highly ranked country in the world for CCS specific legislation, according to the GCCSI Legal and Regulatory Indicator

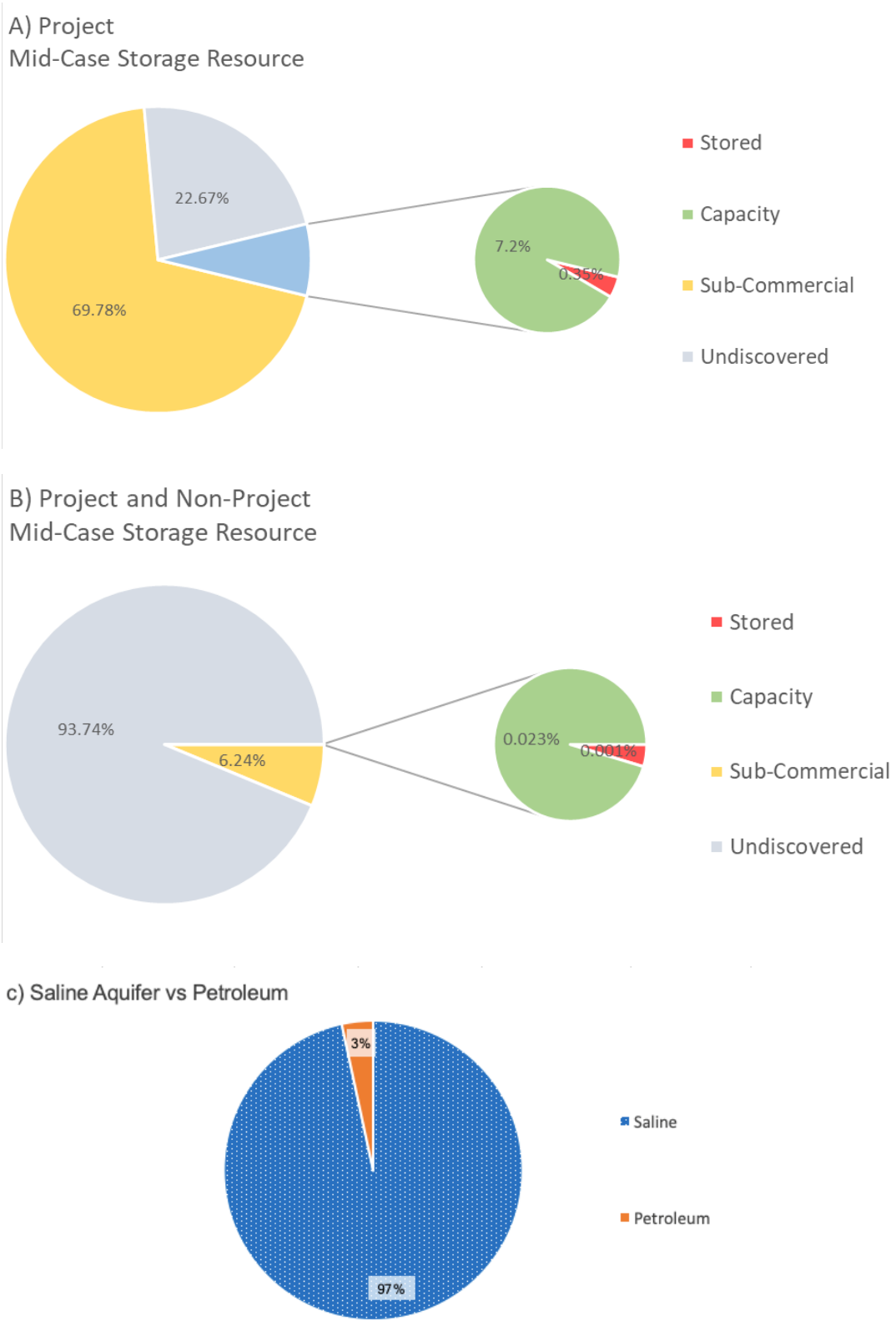

Figure 1-1: a) Spread of storage resource in Australian sites (69) across SRMS classifications, where a project has been specified. b) Spread of storage resource in all Australian sites across SRMS classifications; both project specified and not. c) Split of Australian storage resource between saline aquifers and hydrocarbon fields, both project specified and not.

1.1.2 Resource Statement

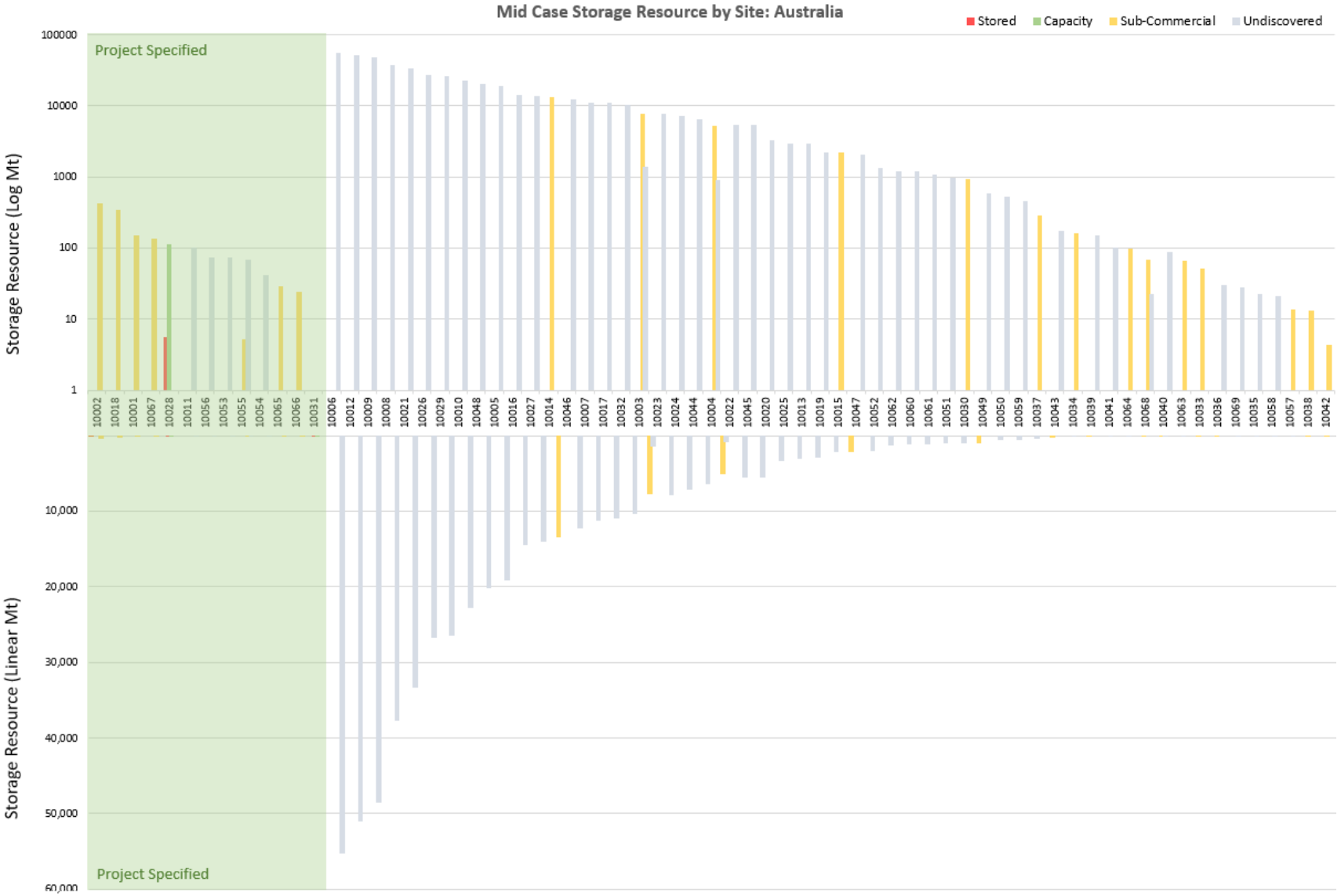

Figure 1-2: Storage resource summary for Australia compiled in the CSRC. Graph above is log scale and graph below is linear. Green box highlights sites where a project has been specified.

1.1.3 Evaluation History

The potential CO_2 storage resources of Australia were initially summarised as part of the GEODISC programme of research completed by the Australian Petroleum Cooperative Research Centre, Geoscience Australia and the University of New South Wales in 2004 [1]. The project screened over 300 geological basins down to 48 before some 65 "potentially environmentally sustainable sites for CO_2 injection" (ESSCIs) were identified. This report was at the time a ground-breaking piece of work and one of the first attempts at a regional CO_2 resource evaluation. To navigate the lack of globally published reservoir simulation studies at the time, a "risked based" calculation method was developed. A chance factor was assigned to each potential ESSCI, describing its chance of being capable to deliver a viable development. This ESSCI chance accounted for storage resource, injectivity potential, site details, containment, and existing natural resources. In general, depleted fields had the highest ESSCI chance, followed by structural traps with no hydrocarbons and finally hydrodynamic systems with no structures.

The study concluded that Australia has a potential risked storage resource (ESCCI storage potential x ESCCI Chance factor) of 720 Gt. Whilst the evaluation included the identification of specific formation and seal pairs through regional review and highlighted the significant potential available, the document does not support a useful classification against the SRMS system. Furthermore, the CO_2 storage resource was presented as "Risked Resource" rather than the un-risked resource required by the SRMS.

In 2009, the Carbon Storage Taskforce (CST) compiled the National Carbon Mapping and Infrastructure Plan – Australia on behalf of the Australian Government, which provided the storage resource estimations included in this report [2]. The Taskforce is composed of members from key industry sectors and Governments which have an expertise or interest in CCS. The Plan aims to map both the potential storage resource and carbon sources in Australia to accelerate industrial CCS development. The report considered the storage resource within saline aquifers, petroleum fields and EOR projects. Theoretical, probabilistic storage capacities were calculated for saline aquifers, based on the probability of the resource being able to be utilised. The reported results used a storage efficiency factor (E) of 4%.

The methodology to evaluate the storage within hydrocarbon fields was not defined in the CST report.

Since 2009, the Australian Government has undertaken several research projects on specific sites or basins that are considered priority areas for CCS development in Australia. Of these, two provide storage resource estimations, one for the Gippsland Basin and one for the Petrel Sub-basin [3] [4]. Both these reports use simulation modelling to prove CO_2 containment, built using well and seismic data from nearby hydrocarbon exploration activity. As such, they provide project-based evaluations.

The storage resource potential for Australia was updated in Cycle 2. Cycle 1 data was a limited update of the Cycle 0 dataset which was used to test the SRMS classification process and create the initial version of the CSRC. As much of the data included in this early version was from country-wide and regional basin scale evaluations dated from the Geodisc 2003 [7] and the National Carbon Storage Taskforce 2009 [2] studies, much of the original data have been superseded by studies carried out in the subsequent decade.

The major changes to the resource entries and classification are:

- Refinement of the 'undiscovered' resource in eight basins resulting in a re-classification of 49% of the Basin Play resource to Sequence Play and Lead most of this data was published in Bradshaw et al [5].
- Overall, 40 new sites have been added to the Catalogue, ranging from Sequence Play to Development Unclarified on the SRMS classification. This includes six sites which changed classification and six new Projects.
- 15 new Sub-commercial (Discovered) sites (10 new saline aquifer sites and five new depleted fields).
- Most sites sit within the onshore basins (Bowen, Eromanga, Surat, Galilee, and Perth basins, including depleted fields in Queensland), with the Gippsland, Browse and Bonaparte basins containing offshore potential opportunities.
- Volumes of Stored CO_2 have been updated at the Otway facility and at the large-scale, commercial Gorgon project.

Cycle 2 updated the resource review of Australia using the detailed evaluations of the Queensland-based Zerogen project which looked at storage potential in the Bowen and Surat basins, and the Wandoan project which also evaluated the Surat Basin [6]. Additional studies also evaluated the Eromanga Cooper and Galilee basins. In the North West Shelf area, evaluations of the opportunities in the saline aquifers of the Browse and Bonaparte basins offer potential support for the development of the high CO_2 gas field sin that area. The SW Hub project has evolved over the past decade and provides refinement of the Perth Basin area resource potential. Resource potential of the onshore and offshore Gippsland Basin and Otway Basin was also updated.

1.1.4 Resource Review

1.1.4.1 Major Projects

The Australian commercial storage resource documented in this report is sourced from two projects: Chevron's Gorgon LNG project and the CO_2CRC Otway Research Facility.

Operating since 2009, Gorgon is an LNG site where naturally occurring CO_2 is separated from the natural gas before compression. Up to 3.8 Mt/yr is expected to be injected over a 25-year period, and in February 2020, the project surpassed 1 Mt CO_2 injected. A total CO_2 volume of 120 Mt has been approved for injection (M. Trupp, Chevron, *pers. comm*), representing the expected volume of captured CO_2. A suite of CO_2 injection, water injection and surveillance wells are used in the project to manage CO_2 containment in the Jurassic-age reservoir [7].

The Otway Research Facility was established in 2008 by the Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC) under the Australian Government's Cooperative Research Centres (CRC) program. Following the cessation of funding in 2014, the facility now operates as a not-for-profit research centre with the aim of developing CCS injection and monitoring techniques to lower industrial GHG emissions. It has successfully stored 80,000 tonnes of CO_2 and aims to drill up to 5 injection and/or monitoring wells from 2017 onwards [8].

No estimations for the total storage resource potential at either site could be found within the published literature.

The Global CCS Institute has provided updates on several CCS projects in Australia (Global CCS Institute, 2020):

- The Cooper Basin Project has commenced FEED for the 1.7 Mtpa CCS project taking CO_2 produced from the Moomba natural gas processing plant to depleted hydrocarbon fields (via a 50 km pipeline) for storage.
- The Carbon Transport and Storage Company (CTSCo) is planning a demonstration project capturing up to 120,000 T/y CO_2 from a coal-fired power station with storage in the Surat Basin.

- The CarbonNet project (Victoria) has completed appraisal drilling and is developing plans with stakeholders for commercialisation in the future.

1.1.4.2 Depleted Oil & Gas Fields

The CST [2] reports a total of 16.5 Gt storage potential within Australian depleted hydrocarbon fields. The report does not, however, note the methodology used to calculate this resource.

By definition, all hydrocarbon fields can be classified as discovered. The CST Report [2] notes that in the NW shelf, petroleum activity is currently forecasted to extend beyond 2050 and are therefore considered Discovered Inaccessible storage resources at this time. This holds a total of 13.4 Gt of storage resource.

Outside the NW Shelf, in both offshore and onshore locations, the aggregated storage resource is 3.1 Gt. This portion has been classified as Discovered Development Not Viable, as the resource is not constrained by the Australian regulatory system, however while the storage resource is accessible before the AED of 2050, no sites currently undergoing appraisal were found during the CSRC Cycle 1.

1.1.4.3 Saline Aquifers

The saline aquifer resource comprises the largest proportion of potential storage resource in Australia. The majority, 485 Gt of this resource lies at the 'Undiscovered Basin Play' level as no formation has been specified for many of the basin-level evaluations [2]. In the recent projects undertaken by the Australian Government, where a formation was specified, the resource was classified as 'Undiscovered Sequence Play', however this only accounts for 0.4 Gt, highlighting the overall low maturity of the saline aquifer resource [4], [3].

In areas where the reservoir had been discovered through the drilling and logging of hydrocarbon wells, a portion of the site could be classified as 'Discovered Not Viable', calculated as a proportion to the well density.

The total 'Stored' saline aquifer resource is 2 Mt, from the Gorgon and CO_2CRC projects, as detailed in 1.1.4.1.

1.1.5 Regulatory Framework

CCS legislation in Australia is defined either by the state, or by the Commonwealth, when in Commonwealth Marine Protection Zones. There is currently legislation established covering a number of states and areas in the Commonwealth waters, giving Australia the highest global Legal and Regulatory Indicator rating from the GCCSI [9]. In 2020 the Offshore Petroleum and Greenhouse Storage Act 2006 (OPGGSA) was updated to allow cross-boundary CO_2 injection (i.e., between Commonwealth and state/Territory jurisdictions; [10]. The CST Report notes, however, that the regulation is not consistent between states, particularly in the areas surrounding long-term liability and any pre-existing rights for resource exploitation of specific sites [2].

The CCS-supportive legislation and policy framework in Australia has led to industry CCS operations at Gorgon, in addition to numerous government-backed research facilities and pilot-projects [11]. [10].

1.1.6 Issues for the Assessment

While the National Carbon and Infrastructure Mapping Plan made significant progress in identifying and quantifying CO_2 storage resource in Australia, the report is now more than a decade old and would benefit from modern evaluation, accounting for the significant changes in the CCS industry over the last 10 years and also learnings from the petroleum industry.

There is a risk of double counting in the Bonaparte and Gippsland Basins between the regional, theoretical evaluation made in the National Carbon Mapping and Infrastructure Plan [2] and later studies that considers injection on a local scale into the basins [4] [3]. In accordance with the SRMS guidelines on aggregation of resources, the double counting cannot be avoided as due to the different maturity of the sites against the SRMS classification system [12].

1.1.7 Future Updates

1.1.7.1 Future evaluations

Further work should also focus on evaluation at a site or even formation level, to progress the maturity of the Australian resource along the SRMS classification system.

1.1.8 Resources booked using SRMS

On 8th Feb 2022 Santos announced that it had booked 100 Mt of CO2 storage resource in the Cooper Basin in South Australia in its end 2021 reserves statement [13]. The announcement highlighted that it is "a subset of the total prospective storage resource in the Cooper Basin" and noted that it "follows the final investment decision on the 1.7 million tonne per annum Moomba carbon capture and storage (CCS) project in November 2021". (Note: The Moomba project is not included as a site in the catalogue because insufficient technical data have been published.)

Resource Class	End 2021 Resource Booking
Proved capacity (1P)	6 $MtCO_2$
Proved plus probable capacity (2P)	9 $MtCO_2$
Contingent resources (2C)	91 $MtCO_2$

Table 1-2: Santos Capacity and 2C contingent CO_2 Storage resources as at 31 December 2021 [13]

2.0 Bibliography

[1] J. Bradshaw, G. Allinson, B. Bradshaw, V. Nguyen, A. Rigg, L. Spencer and P. Wilson, "Australia's CO2 geological storage potential and matching of emission sources to potential sinks," *Energy 29,* pp. 1623-1631, 2004.

[2] Australian Government, "National Carbon Mapping and Infrastructure Plan," 2009.

[3] Australian Government: Geoscience Australia, "Carbon dioxide storage potential of the Gippsland Basin," 2016.

[4] Australian Government: Geoscience Australia, "Regional assessment of the CO2 storage potential of the Mesozoic succession in the Petrel Sub-basin, Northern Territory, Australia," 2014.

[5] B. Bradshaw, K. Spencer L, A. Lahtinen, K. Khider, D. Ryan, J. Colwell, A. Chirinos, J. Bradshaw, J. Draper, Hodgkinson and MCKillop, "An Assessment of Queensland'sCO2 Geological Storage Prospectivity - The Queensland CO2 Geological Storage Atlas," *Energy Procedia,* vol. 4, pp. 4583-4590, 2011.

[6] S. Hurter, N. Marmin, P. Probst and A. Garnett, "Probabilistic Estimates of Injectivity and Capacity for Large Scale CO2 Storage in teh Gippsland Basin, Victoria, Australia.," *Energy Procedia,* vol. 37, pp. 3602-3609, 2013.

[7] A. Macdonald-Smith, "Chevron injects one millionth tonne of carbon at Gorgon," 2020. [Online]. Available: https://www.afr.com/policy/energy-and-climate/chevron-injects-one-millionth-tonne-of-carbon-at-gorgon-20200214-p540xv. [Accessed 09 03 2020].

[8] CO2CRC, "Our History," [Online]. Available: http://www.co2crc.com.au/our-history/.

[9] Global CCS Institute, "CCS Legal and Regulatory Indicator (CCS-LRI)," 2018.

[10] Global CCS Institute, "The Global Status of CCS: 2020," Global CCS Institute, Australia, 2020.

[11] Global CCS Institute, "CCS Policy Indicator (CCS-PI)," 2018.

[12] Society of Petroleum Engineers (SPE), "CO2 Storage Resources Management System," SPE, 2017.

[13] Santos, "Santos announces booking of CO2 storage capacity," 2022. [Online]. Available: https://www.santos.com/wp-content/uploads/2022/02/220208_2021-Reserves-Statement.pdf. [Accessed 28 February 2022].