CAPTURING OUR FUTURE

Why Carbon Capture is critical to Australia's Energy Transition

Chamber of Commerce and Industry WA

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Summary

Humanity is in a race against time to reconfigure almost everything we do – how we move around, feed ourselves, and how we power production. To maintain a liveable climate, the leading authority on climate change, the Intergovernmental Panel on Climate Change (IPCC), suggests that we need to not only limit the release of carbon dioxide into the environment, we need to also remove billions of tonnes of carbon dioxide from the atmosphere by 2050.

Despite the enormity of the challenge, global pressure to decarbonise is building. From governments to employees, to financial markets, insurers, and customers, businesses, large and small, are expected to do more to dramatically cut their emissions.

Globally, there has been a raft of new legislative instruments designed to encourage low emissions footprints, and simultaneously drive investment in low emissions technologies. And policy responses are increasingly permeating across international borders. In Australia, there is more stringent climate change requirements, with legislated 2030 and net zero targets, new climate-related financial disclosures, and a strengthened Safeguard Mechanism with declining emissions baselines mandated for Australia's 218 biggest emitters.

With calls for rapid acceleration of progress this decade, all options to reduce emissions need to be on the table. Transitioning energy systems to renewables will play a key role, yet this alone is not a panacea; the business community knows that to achieve Australia's climate targets, we will require multiple technologies working in tandem.

There are many tools in the decarbonisation toolbox, but in this report, we focus on carbon capture, which is used in this report as a catch all term for carbon capture and storage (CCS) and carbon capture, utilisation and storage (CCUS).

Carbon capture is a critical area for ongoing global research, development and deployment. Its appeal lies not only in its ability to prevent the release of large amounts of carbon dioxide into the atmosphere, and remove existing atmospheric emissions, but also in making carbon dioxide a valuable commodity to be used as a feedstock or a component in other industrial processes or products.

For this reason, it not only serves as an opportunity to decarbonise our own industries, and support our regional neighbours to do the same, it serves also as a catalyst for developing new areas of industrial and economic opportunity.

And Australia, particularly Western Australia, is uniquely positioned to capitalise on this triple dividend. Our modelling, which builds on WA Government predictions, demonstrates that carbon capture presents a minimum $79.5 billion in baseline economic benefits from 2030-50, with additional income from future projects, tax revenue, construction, and future utilisation opportunities.

It should come as no surprise that carbon capture is a key strategy underpinning countries leading the energy transition, from green powerhouses such as the US and Norway, through to countries you might not expect, such as Kenya and Italy. Carbon capture is supported by leading research bodies, including Australia's own Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the IPCC, which states that carbon capture is essential to meet existing global commitments such as the Paris Agreement.[1] This is because carbon capture has been proven safe, technologically sound and effective in reducing and extracting emissions through several decades of research and technological development.

Yet despite this, it remains politically contentious in Australia.

Seizing the carbon capture opportunity – and the benefits that it yields in terms of mitigation and in building economic opportunity – largely depends on it being recognised and given full support by governments and the community as a pivotal and legitimate part of Australia's decarbonisation strategy. It needs significant investment, funding certainty, the right regulatory levers, and political will to ensure it achieves wide-scale adoption and deployment. Importantly, it also needs the backing of the community.

This policy paper demonstrates why carbon capture is central to true decarbonisation and unpacks the barriers to greater uptake. Case studies are used to showcase how it's being deployed across the world. We also make recommendations on how State and Federal Governments can better support carbon capture to support global decarbonisation efforts.

[1] Intergovernmental Panel on Climate Change. AR6 Synthesis Report: Climate Change 2023. March 2023

Carbon Capture: the fundamentals

As a basic premise, carbon capture removes carbon dioxide from the air or prevents it from entering the atmosphere via technological applications. Once removed, the carbon dioxide can be stored in geological formations for permanent *storage* or stored and used for alternative purposes, known as *utilisation*.

Carbon capture is not new – the practice became widespread in the 1970s within the oil and gas sector. Carbon dioxide was captured and then re-injected in the oil fields to boost oil production outputs - a process known as enhanced oil recovery. This process has resulted in millions of tonnes of carbon dioxide separated, then piped and injected into oil and gas reservoirs globally.

Today, there is much more to carbon capture than enhanced oil recovery. **Table 1** highlights the two broad types of carbon capture: Point Source Capture and Direct Air Capture (DAC). Due mainly to cost and technology readiness, Point Source Capture is more commonly found in industrial sites, while DAC is currently considered cost-prohibitive for large scale adoption, due to the high energy requirements. Despite this, an estimated 130 DAC facilities are in various stages of planning and development across the world.

Table 1: Types of carbon capture

Point Source Capture	Direct Air Capture
	
Emissions are captured, either pre-combustion or post-combustion, via a binding agent placed. This is beneficial for capturing emissions at the source.	A machine-driven process where large fans draw in air and the carbon dioxide is captured in a binding agent. This is beneficial for capturing existing emissions in the atmosphere.

Once captured, carbon dioxide is compressed and stored. From here, it can continue to be either stored permanently or used. Geological storage is the most common type of storage, where compressed carbon dioxide is piped underground into geological basins. A similar concept, deep ocean storage, is currently being investigated for feasibility. Geological storage can result in mineralisation, which permanently captures carbon dioxide as limestone.

An emerging type of carbon capture, particularly in Europe, is Bio-Energy CCS (BECCS). This process sees carbon dioxide added to an environment to turbocharge growth of plants or algae. The plants or algae absorb carbon dioxide and are harvested and dried, before being either burnt for energy, buried, or used as an input for other processes. Waste from agriculture or forestry sectors can also be used as an input for BECCS.

In addition to storage, captured carbon dioxide can be used in multiple ways. Some of the current industrial uses of carbon dioxide include the production of urea, fire suppressants, food and drink preservation, biochar and refrigeration. **Table 2** provides an overview of both common uses of, and storage for, carbon dioxide.

Carbon capture, therefore, offers immense potential in creating new streams of economic opportunity. Other emerging utilisation opportunities, which require further research and development to achieve commerciality, are explored later in this paper.

Table 2: Common types of carbon dioxide storage and utilisation

Storage		
Geological storage	**Enhanced Weathering**	**Bio-Energy CCS (BECCS)**
Carbon dioxide is pumped into a reservoir in rock, where carbon dioxide is stored indefinitely.	Crushed minerals are spread across a large land mass or in the ocean. These minerals draw down carbon dioxide naturally, and can help improve soil quality.	Plants or algae are grown, sometimes in high-carbon dioxide environments, and are usually dried. The organic matter is then used as a feedstock to generate energy, directly as a fertiliser, or for pyrolysis.
Utilisation		
Refrigeration	**Fire Suppressant**	**Food and Drink uses**
Carbon dioxide absorbs heat, and has been used historically as a gas for refrigeration under the code ArcTick R744.	Carbon dioxide can be used in fire extinguisher units, as a fire suppressant.	Food-grade carbon dioxide can be use in carbonated drink production, and to preserve food by preventing or limiting the risk of bacteria.
Urea Production		**Pyrolysis / Biochar**
Carbon dioxide is produced as an ammonia by-product, but can also be used to create urea. Urea has many applications, notably AdBlue to reduce emissions from diesel.		Pyrolysis burns waste and plant material with no oxygen, creating biochar. This can then be used to improve soil, or as an input into water treatment or road construction.

Why carbon capture underpins our decarbonisation efforts?

It is widely acknowledged that carbon capture is critical to global efforts to reduce emissions and achieve the ambitious target set in the Paris Agreement. Its critical role is underscored by a convergence of evidence from reputable organisations, such as academic institutions, research bodies and think tanks. For example, carbon capture features prominently as a cornerstone of mitigation pathways outlined within the IPCC *Special Report on Global Warming of 1.5°C*, the International Energy Agency's (IEA) *Sustainable Development Scenario*; and the landmark *Net Zero Australia* report.

> The next decade will be critical to the prospects for CCUS and for putting the global energy system on a path to net-zero emissions... Without a sharp acceleration in CCUS innovation and deployment over the next few years, meeting net-zero emissions targets will be all but impossible.[2]

Much of the modelling and research has also underscored the importance of carbon capture for addressing hard-to-abate emissions, facilitating the transition to low-carbon electricity and hydrogen production, and for removing carbon from the atmosphere. Each of these are discussed below.

#1: Removing carbon dioxide we've created

Despite efforts to reduce carbon emissions, there is still significant amounts of emissions in the atmosphere. Carbon capture provides a means to capture these existing emissions, helping to mitigate their impact on the climate. For example, by using a range of existing and new and emerging technologies, such as BECCS and DAC, carbon capture can directly, and substantially, reduce atmospheric carbon dioxide levels.

The significance of atmospheric carbon dioxide removal is underscored by the latest IPCC assessment report, which emphasises the inevitability of deploying carbon dioxide removal technologies to achieve net-zero emissions globally.

This not only enables the achievement of the objectives of the Paris Agreement but also addresses the urgent need to counteract the legacy emissions accumulated over decades of industrial activity. Ultimately, the desired aim here is to achieve negative emissions, where more carbon dioxide is removed from the atmosphere than is emitted.

> Strong and urgent emissions cuts, together with the growth in carbon sequestration, are critical if the world is to achieve its net zero goals by mid-century.[3]

[2] International Energy Agency. *Special report on carbon capture utilisation and storage*, 2020 updated 2023
[3] Media release Minister M. King. *New offshore greenhouse gas storage acreage to help cut emissions*, 2023

According to the IEA[4], carbon capture is expected to transition through **three phases**:

Phase 1 (now to 2030): the focus is on capturing emissions from existing power plants and factories. It is envisaged that over 85 per cent of all carbon dioxide emissions captured this decade will come from plants retrofitted with carbon capture technological solutions.

Phase 2 (2030 to 2050): over these decades, the contribution of carbon capture in terms of cumulative emissions reduction is expected to grow 12 per cent through deployment within high-priority industries, namely cement, steel and chemical sectors. The application of BECCS is also seen to expand significantly in these areas, as well as in the power sector, due to economies of scale and cost reductions.

Phase 3 (2050 to 2070): the amount of carbon dioxide captured is expected to increase significantly due to the use of technologies, with a heavy reliance on BECCS, and to a lesser extent DAC. Under these scenarios, the carbon dioxide captured from bioenergy, or directly from the air, is used in combination with clean hydrogen to produce synthetic hydrocarbon fuels, notably for use in aviation.

#2: Enabling industries with hard-to-abate emissions to survive and thrive

It is widely recognised that carbon capture offers a viable pathway for reducing emissions in industries that have proven notoriously challenging to decarbonise. These sectors include iron, steel, cement, alumina, aluminium, chemicals processing, aviation and agriculture, and represent about 20 percent of our total greenhouse gas. Typically, these sectors face significant barriers in applying carbon capture. Some may not have the relevant expertise, while other facilities are not expected to produce the volume of carbon dioxide needed to underpin the business case for their business. As a result, carbon capture hubs are integral for broadscale adoption of carbon capture in hard-to-abate sectors.

The IEA suggests that carbon capture, at present, accounts for nearly 40 per cent of the total global cumulative reduction in carbon dioxide emissions in the steel, cement and chemicals sectors combined.[5] This demonstrates the proposed role carbon capture should play in addressing emissions from hard-to-abate industries and emphasises the urgency of scaling up its deployment.

[4] International Energy Agency. CCUS in the transition to net-zero emissions. September 2020
[5] Ibid.

> Carbon dioxide removal cannot substitute deep emissions reductions, but it is part of all modelled scenarios that limit global warming to 2 degrees or lower by 2100... [it] is needed to counter-balance emissions from difficult-to-decarbonise sectors, such as industry, long-distance transportation, and agriculture.[6]

These industries also produce products that play a highly significant role in our society, particularly in underpinning our economic and social fabric. Carbon capture is hugely significant to ensure these industries remain competitive in a rapidly changing market, however, these sectors need adequate support to develop the skills and capabilities necessary.

#3: Powering the transition to low-carbon electricity and hydrogen

The electricity sector is one of the largest emitters of carbon dioxide, accounting for approximately 40 per cent of global energy-related carbon dioxide emissions. While shifting to renewables will reduce emissions, carbon capture could offer a solution to help decarbonise this sector overall. This is achieved by creating low-carbon electricity, where gas or coal, remains the major input to energy production.

According to the IEA, power plants equipped with carbon capture technologies are projected to contribute around 5 per cent of global power generation by 2040, up from 1.5 per cent in 2030. This significant increase underscores the growing importance of carbon capture in supporting the transition to low-carbon energy systems.

Carbon capture also acts as a catalyst for the production of hydrogen. While green hydrogen as an energy source has great merit, most hydrogen in production currently is made using natural gas and splitting gas molecules into hydrogen and carbon dioxide. When the carbon dioxide is vented into the air, this is termed grey hydrogen, alternatively, when carbon capture is used to capture these emissions, this is termed blue hydrogen. Regardless of its source, hydrogen will be crucial for decarbonising hard-to-abate industries.

With the use of hydrogen globally projected to increase seven-fold by 2070, carbon capture will play a crucial role in producing low carbon hydrogen at scale, further advancing the goals of climate mitigation and decarbonisation.

[6] Intergovernmental Panel on Climate Change. IPCC Arg WGIII: CDR Factsheet: Carbon dioxide removal, 2022

How Carbon Capture is growing globally

Given its significance, it's not surprising there is significant global momentum surrounding carbon capture. From Scandinavian countries in the northern hemisphere to Africa in the southern hemisphere, there are novel examples of pilots and technological demonstrations rapidly being developed, largely with backing and support of national governments.

Scandinavia and Iceland

The Nordic countries of Norway, Denmark, Sweden, Iceland and Finland are all heavily invested in carbon capture. Finland and Denmark, for example, aim to be the first countries to achieve negative emissions by pursuing an aggressive carbon capture strategy by 2040.[7]

Norway is a first mover and continues to cement itself as one of the leaders in this space. Beginning with Sleipner, Norway created the first large-scale carbon capture project in the world, in 1996, followed by Snøhvit in 2008. Combined, these facilities capture 1.7 million tonnes of carbon dioxide each year

With the support of the national government, the Nordic countries are rapidly advancing their carbon capture credentials, including:

- *Norway:* Norway is also leading the development of Europe's first cross-jurisdictional carbon capture initiative, known as Longship, which will be a new hub-type model. The Norwegian Government is contributing 66 per cent of the cost for this project. The first commercial project under Longship is the Northern Lights project, which is planned to start storing carbon in 2025.
- *Denmark:* The Danish Government and Denmark Chamber of Commerce is co-funding State of Green, a thinktank promoting renewables and carbon capture. The Government has three subsidy pool schemes, based on length of time for a project rather than methods used. The Government has also backed experimental carbon capture projects, such as the Amager waste centre, by providing funding and establishing regulatory sandboxes for long-term certainty.
- *Sweden:* As part of the Swedish *Circular Economy Act*, storing and utilising carbon dioxide in product manufacturing earns significant tax breaks for manufacturers. Sweden also opened a National Centre for CCS in June 2023, and is focusing on research opportunities for carbon capture and storage.
- *Iceland:* The Orca Project **[Case study 1]** in Iceland is the world's current largest DAC plant, which is powered by geothermal energy. The proponents have started work on a second facility, Mammoth, expected to capture up to 36,000 tonnes of carbon dioxide each year.

[7] Associated Press, Keyton D. *Some nations want to remove more pollution than they produce. That will take giving nature a boost*, 2023

CASE STUDY 1

Orca Direct Air Capture Project

Status:	Operational
Operator:	Carbfix and Climeworks
Location:	Hengill, Þingvellir, Iceland

Co-located with the Hellisheiði Power Station, the Orca Project, which is powered by geothermal energy, is currently the largest operational DAC facility in the world. It was officially opened in 2021 and is a large-scale implementation of Carbfix's mineralisation technology and Climeworks' DAC technology.

Given that both Carbfix and Climeworks had only been able to trial their technology, the Orca Project has been highly significant in proving their respective capability at scale. Each of Climeworks DAC 'collectors' can capture 500 tonnes of carbon dioxide per annum, and with 8 of these collectors within the Orca Project, 4,000 tonnes of carbon dioxide are removed from the atmosphere each year, and mineralised underground, deep in volcanic basalt.

Orca, not only absorbs carbon dioxide from the atmosphere, but it also filters sulphur dioxide, which may, in the future, become subject to emissions restrictions.

IMAGE CREDIT: Climeworks, photograph taken from initial construction of the collectors. Pictured are the first four collectors that were installed.

The Americas

The United States of America is also a strong supporter of carbon capture, through incentives, advocacy, and research. Recent legislative changes have delivered even more attractive credits for both traditional carbon capture and emerging DAC technologies that are stored in saline geologic formations, including significant increases in credits for both Point Source Capture and DAC.

One project capitalising on these incentives is STRATOS in Texas, which has received the financial backing of investment firms Blackrock and Occidental **[Case study 2]**.

To promote the development and investment of carbon capture projects in the US, a range of other policy and legislative changes have been provided. This includes relaxing the legislative requirements that surround the development of pipelines to promote diversification of gas and liquid transport and the uptake of common user infrastructure. The aim is to de-risk projects, making them more attractive for investment. The $100 million Advanced Carbon Dioxide Removal Technologies Program, for example, exists to assist small pilot projects to become commercially viable.

To position themselves as a leader and influence global change, particularly across the Asia-Pacific, the US Department of Commerce recently released the *Carbon Capture, Utilization (sic), and Storage Handbook for Policymakers* (2024), translated into various languages, including Bahasa Indonesia, Malay, Thai, and Vietnamese. The handbook identifies barriers to CCUS adoption, with policy levers to address them. The US Department of Energy is also undertaking the first direct government procurement program for carbon removal, through a prize competition model.[8] The US Department of Energy has a long history of carbon capture research and development, with the US Gulf Coast considered one of the most active carbon capture regions in the world.

Canada, also, has a long history of supporting carbon capture, often through public-private partnerships for carbon capture projects or public outreach. For example, the International CCS Knowledge Centre is co-funded by BHP and a local energy company, while the Quest carbon capture project received C$865 million in start-up support from the State of Alberta and the Canadian Government **[Case Study 3]**.

In 2023, the Canadian Government also announced legislation to subsidise carbon capture and net-zero energy projects to the value of C$20 billion over five years. This was in response to industry concerns that C$50 billion worth of investments were at risk due to lack of government funding and support.

In South America, the Brazilian state-controlled utilities company, Petrobras, is pursing commercial opportunities, with carbon dioxide injections occurring at their Santos Pre-Salt project in 2023. Discussions are underway to proceed with hub models across Colombia and Brazil.

[8] US Department of Energy, Office of Fossil Energy and Carbon Management. Funding Notice: Carbon Dioxide Removal Purchase Pilot Prize, May 2024.

CASE STUDY 2

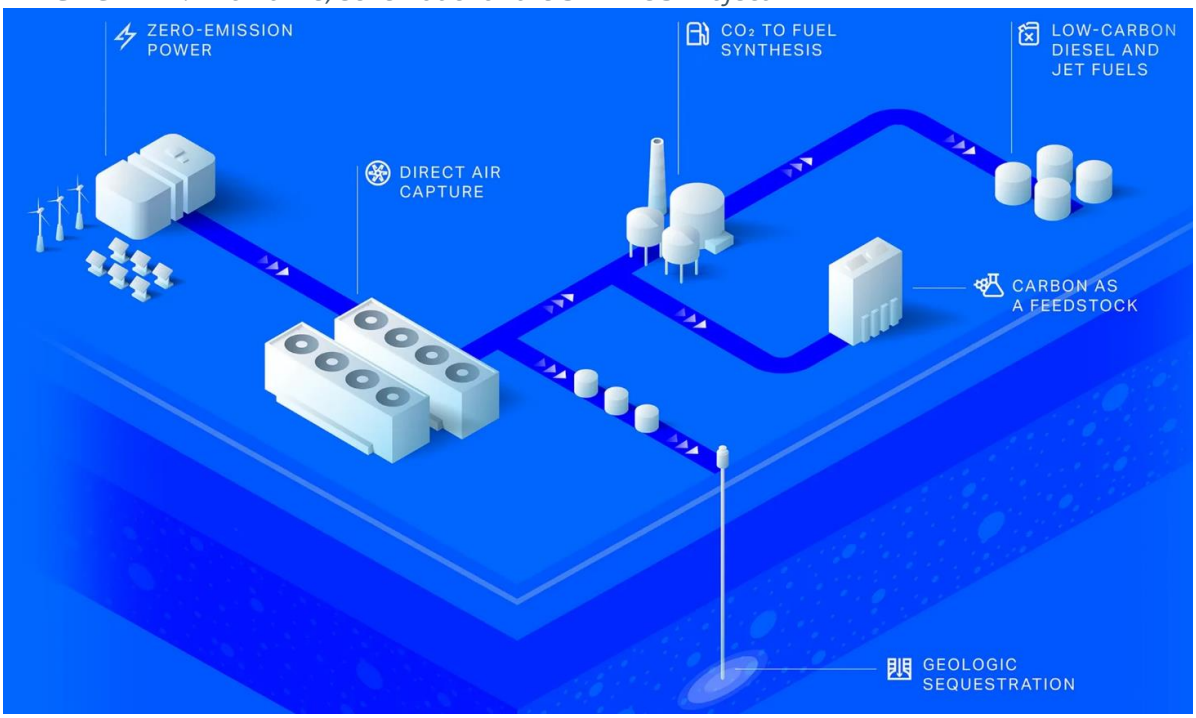
STRATOS	
Status:	In development
Proponent:	1PointFive, Occidental and BlackRock
Location:	Ector County, Texas, USA

STRATOS is on track to be the world's largest Direct Air Capture facility, with the aim to capture up to 500,000 tonnes of carbon dioxide each year by 2025. Investment powerhouses, Occidental and BlackRock, have agreed to invest $550 million into the project, which is being built in Ector County, Texas.

The groundwork for construction began in November 2023 and the project is around one third complete.

Once captured, the carbon dioxide will be stored before being used as a feedstock to create low-carbon diesel and jet fuels, or for chemical processes. Emissions will also be stored in saline aquifers, so the project is eligible for incentives under the *US Inflation Reduction Act.* Carbon credits from STRATOS have already been marketed to and purchased by US companies, such as Microsoft and Amazon.

IMAGE CREDIT: 1PointFive, schematic for the STRATOS Project



CASE STUDY 3

Quest	
Status:	In operation
Operator:	Canadian Natural Resource Limited, State of Alberta, Shell, Chevron
Location:	Scotford, Alberta, Canada

Quest is a 9-year old carbon capture site located in the locality of Scotford, approximately 50 kilometres from the City of Edmonton, Alberta.

The facility is operated by Shell, and owned by a consortium consisting of Canadian Natural Resource Limited, Shell, and Chevron Canada. It is co-located with the Scotford Energy and Chemicals Park, home to a bitumen upgrader, oil refinery, and chemicals plant.

Quest was the first Canadian carbon capture project to capture 1 million tonnes of carbon dioxide each year, and continues to do so, while lowering the cost profile. This is the result of an excellent storage reservoir with significant capacity for carbon dioxide injection, and strong capture reliability with less than 1% of downtime annually.

IMAGE CREDIT: Shell, aerial view of Quest carbon capture facility.

Europe and Britain, Middle East and Africa (EMEA)

The European Commission (EU) actively supports carbon capture projects in Europe since it was identified within the *European Union Net-Zero Industry Act* as a key decarbonisation strategy across the EU. The EU has a target of storing 50 million tonnes by 2030, a substantial shift from their previous capture target of 5 million tonnes.

These targets are underpinned by a suite of policy and legislative instruments, including:

- categorising certain carbon capture projects as 'net-zero strategic projects', providing a range of benefits for proponents, including faster approvals.
- a CCUS Forum, supported by three working groups, to deliver advice on key policy drivers, infrastructure requirements, and how industry can be supported in the development and deployment of technological innovations.
- identifying CCUS as a key objective of the *EU Innovation Fund*, one of the largest funding programmes in the world to support the development of innovative low-carbon technologies and flagship projects.[9] There are two other notable funding programmes: the *Connecting Europe Facility* supports cross-border carbon dioxide transport networks, and *Horizon Europe* supports research, pilots, and small-scale demonstration projects.

Across Europe and Britain, there are several key projects focused on reusing depleted gas fields in the North and Mediterranean Seas for carbon capture. Of note are:

- the Ravenna Hub operated by Italian energy giant, ENI, which seeks to support industrial users in southern Europe.
- Scotland's Energy Transition Zone and Acorn Project. Both projects leverage existing oil and gas infrastructure for carbon capture and hydrogen production.
- Aramis, a public-private partnership through the Port of Rotterdam in the Netherlands, will support industrial areas across the Netherlands, Belgium, France and Germany.
- Antwerp@C, at Port of Antwerp-Bruges, Belgium seeks to not only be a site for CCS, but also plans to reuse carbon dioxide in various ways to create a carbon-neutral port.

Nations in Africa are also long-term supporters of carbon capture. In South Africa, the country's potential for CCS was first mapped back in 2004, which then led to the development of a Centre of Carbon Capture and Storage in 2009.

In Kenya, the second largest DAC pilot is currently underway. Project Hummingbird seeks to trial low-energy DAC through a community-led trial. If successful, Project

[9] The EU Innovation Fund delivers funding for EU's climate policy. It is linked to the EU's Emissions Trading System and expects to invest approximately €40 billion from 2020 to 2030 in five key areas: Energy Intensive Industry, Renewables, Energy Storage, Carbon capture, use and storage and next-zero mobility and buildings.

Hummingbird would provide a scalable DAC model and revenue source for remote economies **[Case Study 4]**.

The flagship project for the Middle East is the United Arab Emirates Al Reyadah Project, which was the world's first steel carbon capture facility. Al Reyadah became operational in 2016 and captures up to 90 per cent of the carbon dioxide from steel production at the Emirates Steel facility in Mussafah. Oman's first DAC project will break ground late 2024, trialling new technology aimed at increasing the rate of mineralisation.

CASE STUDY 4

Project Hummingbird

Status:	**Under construction**
Proponent:	**Octavia Carbon and Cella Mineral Storage**
Location:	**Naivasha, Nakuru County, Kenya**

Project Hummingbird is an experimental pilot project based in Naivasha, Kenya. The time-limited pilot is expected to capture and store roughly 10,000 tonnes of carbon dioxide over 10 years.

Octavia Carbon has built 100 DAC units, which are each capable of capturing 10 tonnes of carbon dioxide each year. They are very low-capacity units on purpose – 85 per cent of the energy required for each unit will be provided by leveraging the waste heat released from a nearby geothermal power plant, rather than directly from the grid.

Each DAC unit is modular, making the technology scalable and repairs relatively easy. The pilot seeks to demonstrate how low-capacity DAC units can make use of waste heat and excess energy in low socio-economic jurisdictions. Validation of the technology, and carbon credit delivery, will occur in the second half of 2024.

IMAGE CREDIT: Octavia Carbon, renderings of Project Hummingbird

Asia-Pacific Region

The Asia-Pacific Region is a key focus for carbon capture investment, given its skilled population, suitable geography, and potential for growth. This was identified by the US Department of Commerce in its CCUS Handbook for Policymakers.[10]

China dominates carbon capture activities in the Asia-Pacific region, with 12 operational CCS facilities. These facilities were co-funded by state-owned oil, gas, cement, and energy production companies, providing the necessary scale to make projects commercially viable.

In late 2021, India announced several 'deep dive' studies into carbon capture, creating a roadmap, and an incentive scheme to encourage private sector investment.

Japan and South Korea are both heavily invested in developing carbon capture agreements with other nations in the Asia-Pacific region, due to the lack of suitable geology. Japan has been very proactive, releasing their *CCS Long-Term Roadmap*, aimed at storing up to 240 million tonnes per annum of carbon dioxide by 2050; developing an Advanced CCS programme;[11] and initiating draft common carbon capture rules for Australia and Southeast Asia to lower costs and cut construction times.

Japan and South Korea's interest in carbon capture and limited geology has not gone unnoticed. The Malaysian Government also strongly supports carbon capture, primarily through its state-owned oil and gas company, Petronas, and majority state-owned utilities company, Tenaga Nasional Berhad (TNB). Petronas has confirmed a final investment decision in Kasawari Petronas, which will turn a depleted gas field into a carbon capture site **[Case Study 5]**.

The Malaysian Government aims to be net zero by 2040. The accelerated use of carbon capture is a key lever to achieve this, and they are providing tax incentives for carbon capture service providers, and for companies seeking to use carbon capture. These incentives provide 100 per cent offsets for capital expenditure, up to 100 per cent of a company's earnings, as well as a full import duty and sales tax exemptions on equipment required for carbon capture.[12] This is aimed at attracting Japanese and Korean investment.

Indonesia is also positioning itself as a carbon capture hub with 15 projects planned, due to come online between 2028 and 2038.[13] The Indonesian Government recently established the *Indonesia Carbon Capture and Storage Centre* to coordinate and drive this vision, and has recently finalised a legal framework for carbon capture use in future oil and gas exploration. State-owned petroleum company, Pertamina, is also actively developing carbon capture technologies.

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[10] Ibid.
[11] This is intended to rapidly roll out carbon capture between 2030 and 2050. A key aspect of the programme is to develop a 'prompt business environment' between now and 2030.
[12] International Energy Agency. *Policy: Tax Incentive for Carbon Capture Storage Malaysia*, 2023
[13] Six of these hubs are identified as being for the purpose of Enhanced Oil Recovery.

CASE STUDY 5

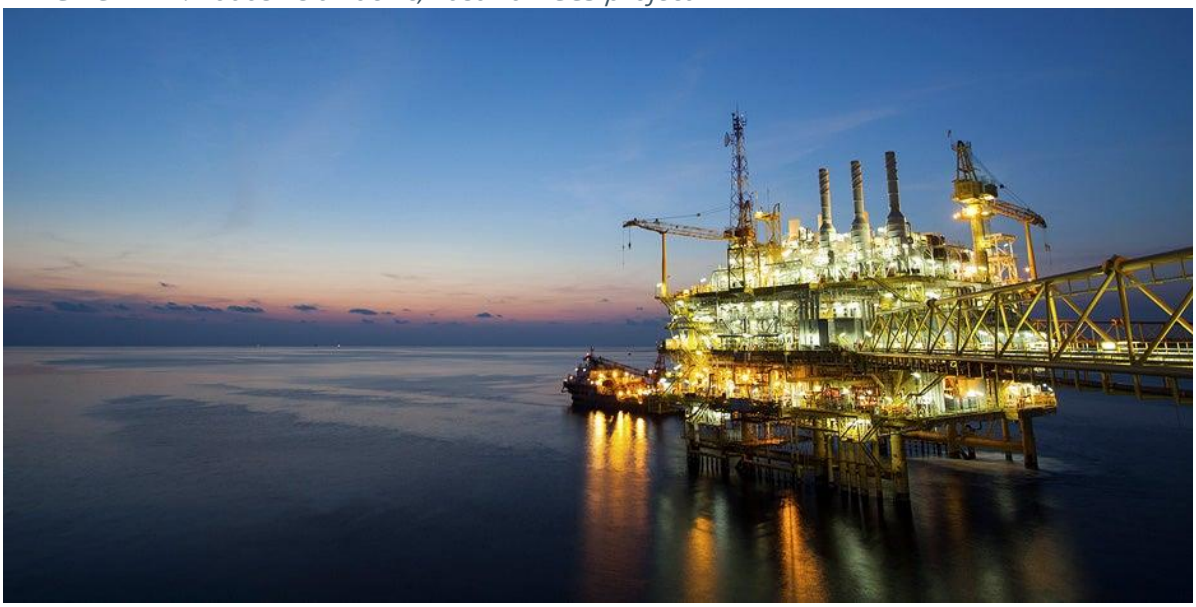
Kasawari Petronas	
Status:	Under construction
Proponent:	Petronas Carigali
Location:	Bintulu, Sarawak, Malaysia

Sarawak's economy is dominated by oil and gas production.

In 2022, Malaysia's public-owned oil and gas company, Petronas, made a final investment decision to proceed with Kasawari. The project is expected to abate 3.3-3.7 million tonnes of carbon dioxide each year and is linked to the Kasawari Central Processing (KCP) Facility.

The KCP facility focuses on gas production, and carbon capture will initially focus on abating the gas flaring that occurs at the facility. However, in the longer term, the intent is for Kasawari to evolve into a regional carbon capture solutions hub. The first injection of carbon dioxide is planned for the end of 2025.

IMAGE CREDIT: Xodus Asia Pacific, Kasawari CCS project



Australia needs to act now, or we'll miss the opportunity

Despite the global momentum, Australia's carbon capture efforts remain relatively limited. There's only one major carbon capture storage project in operation in Australia, the Gorgon carbon capture system at Barrow Island, Western Australia, operated by Chevron Australia **[Case Study 6]**. There are several other storage projects, in advanced development or proposed, across the nation, including:

- Santos' Moomba project (South Australia / Queensland); and Reindeer project (Western Australia)
- ExxonMobil's South East Australia Carbon Capture Hub (Victoria);
- Inpex's Bonaparte project (Northern Territory);
- Wesfarmers' and Mitsui E&P's Cygnus Project (Western Australia)
- Pilot Energy's Cliffhead Project (Western Australia), and
- Woodside's Angel CCS Hub (Western Australia).

These projects offer promising opportunities for emissions reduction, with the eight projects combined expected to reduce Australia's emissions by 8 to 12 per cent annually. However, they represent just a fraction of the global efforts in carbon capture research and innovation. Globally, there are, in fact, 41 projects in operation, 26 projects under construction and 325 in advanced and early development.[14] Since 2022 alone, there has been a 48 per cent increase in carbon capture projects in development, under construction or operating.

Newcastle is also home to one of the world's first mineral carbonation demonstrations, MCi's "Myrtle" plant, which seeks to convert carbon dioxide emissions into building products and other value-deriving materials. It received $14.6 million in Federal Government funding in 2021 to accelerate the development and construction of a mineral carbonation demonstration plant, with construction beginning in 2023. The plant is expected to capture and permanently store over 1000 tonnes of carbon dioxide permanently into building materials and other value-creating products annually.

As other countries accelerate their investments in carbon capture, bolstered by strong government support, Australia must take decisive action now to ensure it remains competitive in the rapidly evolving decarbonisation landscape. With only a handful of projects proposed or underway, Australia risks further falling behind in the race to develop and deploy effective carbon capture technologies.

> We can't afford to bury our heads in the sand... we have to accelerate our activities in this space [Carbon capture and storage] rapidly.[15]

[14] Global Carbon Capture and Storage Institute. *Global Status of CCS Report November update*, 2023
[15] Australian Broadcasting Corporation, McHugh B. *CSIRO scientist says world is burying its "head in the sand" over the need for more carbon capture and storage*, 2016

CASE STUDY 6

Gorgon Carbon Capture and Storage System
Status: Operational
Operator: Chevron Australia
Location: Barrow Island, Western Australia, Australia

Gorgon is a multi-decade natural gas and carbon capture and storage facility located on Barrow Island, off the north-west coast of Western Australia. Gorgon began carbon dioxide injection at the site in 2019, and is currently the world's largest carbon capture and storage project. To date more than 10 million tonnes of carbon dioxide has been dried, compressed and transported, and then injected two kilometres underground into a confined saline aquifer, a naturally occurring and water filled sandstone formation.

To allow for carbon storage, water is removed from the saline aquifer to manage pressure. This water is injected into another formation that is situated above the carbon dioxide storage location.

Like any new technology, Gorgon's carbon capture system has faced challenges – and a unique challenge has been the small amounts of sand which reduced the amount of water flow possible out of the reservoir. This in turn has required a temporary reduction in carbon dioxide storage rate. However, Chevron Australia is committed to increasing carbon dioxide injection rates at Gorgon in accordance with its environmental approvals. A project has commenced that aims to expand the system's capacity to manage water in the reservoir where carbon dioxide is stored, reducing reservoir pressure and enabling increased carbon dioxide injection rates.

Gorgon proves that, like any new technology, initial challenges can be overcome. Learnings from the unique challenges Gorgon has faced have, and are, being applied to newer carbon capture projects around the world.

IMAGE CREDIT: Chevron Australia

Charting the Opportunities

Australia is ideally positioned to leverage its vast resources, innovative capabilities, strong industrial base, geological formations and strategic geographical positioning to become a leader in carbon capture.

> Australia should be positioning itself as a leader in long-term carbon storage, in the first instance, and then look to drive diverse applications of carbon capture across various industries.

Storage – the vision to anchor carbon capture in the Asia-Pacific region

Australia's vast geological formations present significant opportunities for carbon storage, offering the potential to sequester large quantities of captured carbon dioxide underground. The country's geological characteristics, including depleted oil and gas reservoirs, saline aquifers, and stable geological formations, provides the ideal conditions for long-term carbon storage.

Moreover, Australia's commitment to achieving net-zero emissions by 2050 underscores the urgency of developing robust carbon storage infrastructure. The carbon capture 'hub' concept, such as Northern Territory's Middle Arm precinct **[Case Study 7]** and Woodside's Angel CCS hub provides considerable opportunities for capturing domestic emissions created by industry.

At the same time, the strategic positioning of these hubs to the Asia Pacific lends well to support our regional neighbours with their decarbonisation journeys. The development of industrial zones that surround these hubs, including building pipeline infrastructure and transport routes, could create thousands of jobs in construction, operation, and maintenance, particularly for WA. It can also underpin industry development, particularly for industries with high emissions, such as cement manufacturing.

Western Australia's unique geology, geographical location, concentration of industry in key industrial hubs, and our skilled workforces all work in WA's favour to facilitate carbon dioxide imports from Asia, as well as decarbonising local industries.

To generate the scale required to make these hubs commercially viable, Western Australia's proximity to key large and high-emitting economies, including China, India, South Korea, and Japan, means there is immense potential. A study, commissioned by the WA Government and conducted by the CSIRO and Global CCS Institute, estimated that there would be a minimum 10 million tonnes of carbon dioxide per annum (Mtpa) from the Asia-Pacific region to WA, providing a substantial economic opportunity.[16]

[16] Commonwealth Science and Industrial Research Organisation. CCUS Hubs Study for the WA LNG Jobs Taskforce, November 2023.

CASE STUDY 7

Middle Arm CCS Projects: Bonaparte and Bayu-Undan

Status:	Planning
Proponent:	INPEX, Santos, Woodside, TotalEnergies
Location:	Darwin, Northern Territory, Australia

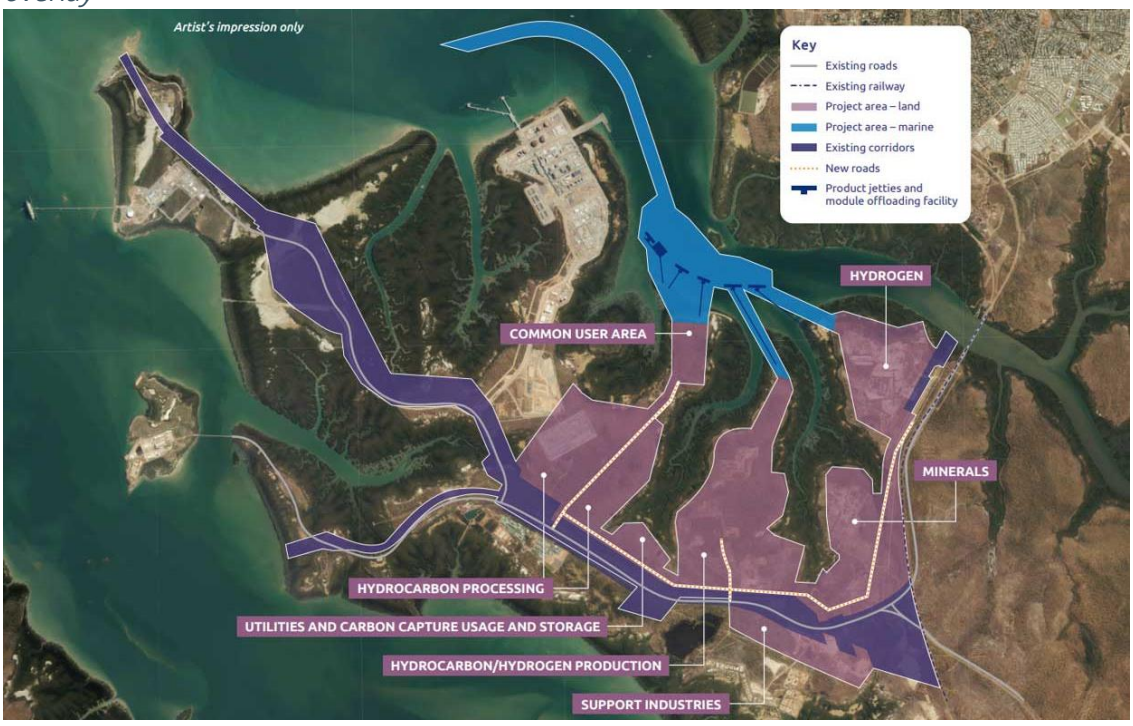
Middle Arm Industrial Precinct (Middle Arm) is a reserved industrial area south of Darwin. The Northern Territory Government has plans to develop the land further, through their Middle Arm Sustainable Development Precinct (MASDP) plan.

MASDP will see the development of an industrial precinct, with a pipeline network and compression equipment linking carbon dioxide from various industrial facilities. These emissions will be combined with emissions from existing LNG facilities, and also provide a future import opportunity. The Territory Government estimates that 90 per cent of emissions produced at Middle Arm will be suitable for CCS, and there is potential for carbon dioxide imports.

Santos is in the process of repurposing their Bayu-Undan gas platform, currently off the coast of East Timor, into a CCS project. Santos anticipates that the site will store up to 10 million tonnes of carbon dioxide each year.

INPEX is currently developing a common user network, and are investigating the potential for a carbon dioxide import terminal. INPEX is working with Woodside and TotalEnergies to deliver this project, and it is believed that Bonaparte has world class storage potential.

IMAGE CREDIT: Northern Territory Government, artist impression of Middle Arm precinct overlay



Utilisation – a circular approach to carbon

There are endless possibilities with how carbon dioxide could be used, some under development, while other ideas are yet to be conceived. Some of these opportunities, for example, are explored in CSIRO's Utilisation Roadmap, which identifies potential uses and research opportunities, and could be the subject of targeted investment.

Earlier in this paper, we outlined the current uses for carbon dioxide, which included food preservation, fire extinguisher suppressant, refrigerant and urea production. There are also emerging uses, which require further research and development for commercial application.

Using carbon dioxide to make synthetic fuel, such as methanol, is one key example. By combining hydrogen with carbon dioxide, under pressure, companies can produce fuel. Porsche is leading the way in developing synthetic fuel production, working with private companies around the world to identify cost-effective methods to achieve production at scale. Considered a cleaner fuel than petrol and diesel, methanol is also considered useful as a fuel for space and aviation.

Concrete and cement production also holds significant potential for carbon capture. There are international examples of concrete companies, such as CarbonCure, Fortera, CarbiCrete and CarbonBuilt, creating stronger and more resilient cement simply by adding carbon dioxide. There are also efforts underway to create low-carbon cement alternatives by injecting bacteria to breaks down carbon dioxide.

Elsewhere, industry and research institutions are also working at ways of splitting carbon dioxide into carbon and oxygen molecules. The carbon produced can then be used to make carbon black, graphite, and graphene. Graphene, for example, is a key component for graphene batteries, and carbon black can also be used as an additive to reinforce rubber products as well as to create black pigment.

These products are subject to further research and development, however, this innovation exemplifies what is possible with further research, development and targeted investment.

Reaping $79.5 billion in baseline economic benefits

The economic benefits of carbon capture are broadly split into the benefits from *capture and compression* (technologies to capture and remove carbon dioxide) as well as *storage*, *transportation,* and *utilisation* opportunities. Due to the nature of utilisation as a future market, it is difficult to quantify its full economic potential. However, there is some modelling and data available for capture and storage, inclusive of associated activities.

The WA Government recently commissioned modelling through the CSIRO and Global CCS Institute, with a focus on creating a Pilbara CCUS Hub. The hub model is predicted to be active from 2030, with carbon dioxide imports from the Asia-Pacific region and carbon emissions captured locally from the Pilbara and Perth-Kwinana regions.

The Pilbara Hub model identified that, at $70 per tonne of carbon dioxide or double the current average price, there would be a $55 billion boost to gross state revenue between 2030 to 2050.[17] This is believed to include economic activity generated by construction, transportation, and ongoing employment and tax revenue.

However, this focuses on one potential area – the North Carnarvon Basin. There are several geological storage basins in WA, both onshore and offshore. The total potential storage – if all storage was used – is estimated by the WA Government to be 195,000 million tonnes.[18]

Modelling by the WA Government and the CO2CRC, a Commonwealth cooperative research centre, can be found in **Table 3,** which identifies the scale of a potential carbon capture sector in Western Australia for both onshore and offshore, as at 2023.[19]

Table 3: Identifying the potential storage opportunity for WA

Geological Basins in Western Australia	WA Government estimated storage	CO2CRC – Annual storage potential for projects expected by 2030
Bonaparte	16,000 million tonnes	12.5-14 million tonnes total[20]
Browse	11,000 million tonnes	Nil
Canning (Onshore)	33,000 million tonnes	Nil
Canning (Offshore)	38,000 million tonnes	Nil
North Carnarvon	48,000 million tonnes	5 million tonnes
South Carnarvon	23,000 million tonnes	4 million tonnes
Perth	30,000 million tonnes	1 million tonnes
Total	*195,000 million tonnes*	*22.5 million tonnes*

[17] Ibid.
[18] We have not been able to verify the accuracy of this figure and whether it reflects contemporary.
[19] Inclusive of Commonwealth waters. This modelling is publicly available, and while accurate at release in 2023, circumstances may have changed. Data featured may not reflect projects currently awaiting final investment decision across each geological storage site. More realistic estimations are likely to be made available as WA projects advance though development phases.
[20] Both projects under development at Bonaparte Basin have onshore support from the Northern Territory, despite being included in WA Government estimations. The Bayu Undan CCS facility is projected to start 2027 with 10 mtpa capacity. A separate facility, G-7-AP Assessment, is due to start in 2030 with at least 2.5 mtpa capacity, potentially up to 4mpta.

Some of these other geological basins are expected to be host to operational carbon capture projects by 2030, assuming these projects meet relevant approvals prior to the expected 7-10 year timeframe. The CO2CRC anticipates that by 2030, Western Australia, and nearby Commonwealth Waters, will be home to five large-scale carbon capture projects, underpinning significant employment and economic benefits for both WA and the Northern Territory. When fully operational, these projects will capture 22.5-24 mtpa, representing about 70% of Australia's carbon capture sector in 2030. [21]

These projects will also provide additional economic activity, on top of the $55 billion for the proposed Pilbara Hub. If the same value of $70 per tonne of carbon dioxide is applied to these projects, over a 20-year operational period, this would mean a further $24.5 billion to the WA economy in carbon capture alone, without factoring in any associated economic contribution from construction, transport, and ongoing workforces.

This means that, in total, this would present a minimum $79.5 billion revenue opportunity between 2030-50, if the WA Government's Pilbara Hub vision is realised and these projects operate as projected. For the projects yet to come online, including additional planned projects for the Perth and Canning basins, WA would have immense economic opportunity.

Not all projects will focus on carbon imports – it's important to note that many onshore projects may be more attractive to local hard-to-abate industries across the State. These projects will play a vital role in decarbonising the local economy, particularly green steel, and provide potential local revenue streams to isolated communities, particularly when carbon removal technologies (such as DAC) are applied to projects.

With the right investment conditions, WA could significantly build on these foundations, both in terms of storage, transportation networks, and utilisation opportunities.

[21] CO2CRC, CCS Projects in Australia – Geological Storage, April 2024

So, what's holding us back?

Since 2020, the annual growth of carbon capture projects under construction globally has been around 57 per cent.[22] The momentum surrounding carbon capture is gaining, which Australia can, and should, capitalise on. However, in doing so, it is necessary to address a series of critical barriers that hinder the widespread adoption and national development of carbon capture projects.

While in recent times there have been some important developments, industry continues to grapple with a complex landscape characterised by shifting governmental support, funding uncertainties, and divergent policy signals. Combined, these signals send the wrong message to local and international communities.

Policy incoherence is creating investment uncertainty

Our engagement with current and potential industrial users of carbon capture has revealed one of the key barriers inhibiting wide-scale adoption is a lack of consistent support and strong political leadership from the Federal Government.

Significant public investment in carbon capture initiatives relates back to the launch of CO2CRC in 2003, with successive Federal Governments announcing funding initiatives and policy positions. However, the topic became heavily politicised prior to the 2013 Federal Election when the Abbott Liberal Government heavily opposed any initiatives to address climate change, including carbon capture introduced under the Rudd Labor Government from 2007.

The former Morrison Liberal Government were supportive of carbon capture, albeit mainly focused on larger projects from established proponents. Some of the key initiatives included:

- in 2020, created the first *Low Emissions Technology Statement*, which gave carbon capture a prominent role in Australia's greenhouse gas emissions reduction strategy.
- in 2021, supported the release of *CSIRO's Utilisation Roadmap*, and, also in 2021, passed legislation to allow the Clean Energy Finance Corporation (CEFC) to invest in carbon capture;
- in 2021, created a $50 million Carbon Capture Development Fund, and delivered funding to 6 key projects;
- in 2021, created a $250 million CCUS Hubs and Technologies Development Scheme to boost Australia's CCUS capabilities, including by encouraging research collaborations and lowering the cost of technology adoption.
- in 2022, introduced regulations to enable the Australian Renewable Energy Agency (ARENA) to support projects relating to carbon capture.

[22] Global Carbon Capture and Storage Institute. Global Status of CCS Report November update, 2023.

However, these initiatives lost support under the new Albanese Labor Government. In addition, the Albanese Government:

- announced the National Reconstruction Fund and the Powering the Regions Fund in 2022. While both funds could potentially fund capture projects, the rules around accessing funds are restrictive and not focused on where costs are – such as common user infrastructure or carbon recycling facilities.
- announced a $2 billion Hydrogen Headstart Fund, but this is only for green hydrogen projects or derivative products such as green ammonia or methanol. A further $2 billion was announced for a second funding round in the 2024-25 Federal Budget, however, developing hydrogen with carbon capture is not supported.
- through changes to regulations, prohibited ARENA and the CEFC from funding carbon capture projects.

While there has been some recent support for carbon capture, there is not nearly enough to spearhead new industrial and economic opportunities, and for major industry to meet their new Safeguard Mechanism requirements. For example, in the 2023-24 Federal Budget, the Federal Government announced $12 million to identify sites for offshore geological storage exploration in several specific areas, and maintained some funding for carbon capture projects, such as the MCi's Myrtle plant in Newcastle.

In addition, it also legislated critical changes to the *Environment Protection (Sea Dumping) Act*[23] to allow for carbon dioxide importation, and for the first time, promoted the potential of geological storage to support decarbonisation of the Indo-Pacific in the Future Gas Strategy. This was a crucial step in unlocking investment from key trading partners and creating scale needed for industry growth.

Supporters of carbon capture are, however, concerned that some decisions taken by the Federal Government may undermine Australia's net zero progress and that big swings in policy, due to changing political views, increase risk and uncertainty for industry.[24] It is evident that the current Federal Government is a strong supporter of renewables and green hydrogen over carbon capture to achieve decarbonisation targets, with considerable funding available for these pursuits, as this stakeholder explains:

> "If you are developing green hydrogen, it's a case of "let me help you". If you have a carbon capture project, it's a case of "I'm not against you, but I'm not going to help you".[25]

[23] The *Environmental Protection (Sea Dumping) Amendment (Using New Technologies to Fight Climate Change) Bill 2023* enables a permit to be granted for the export of carbon dioxide streams from carbon dioxide processes for the purposes of sequestration in sub-sea geological formations.
[24] Ludlow, M. Macdonald-Smith, A. 2022. Scrapping carbon capture funding a 'giant step backwards'. Australian Financial Review.
[25] Quote from stakeholder meeting.

In comparison to the Federal Government, the WA Government, with its desire to diversify the WA economy, is a strong supporter of carbon capture. This is evident through its release of the CCUS Hubs Study highlighting the potential value-add of CCUS hubs positioned near hydrogen and ammonia production sites, and the commitment to develop a CCUS Action Plan. This has the aim of accelerating the deployment of proven CCUS technologies in WA, support research into new CCUS technology, and attract investment.

The WA Government has also created a standard framework via the *Petroleum Amendment Bill 2023*, which allows for the capture, transport and storage of greenhouse gases across the economy.

While the CCUS Hub Study, and the legislation, show what is possible and where value can be created with industrial hubs for Perth-Kwinana and the Pilbara, it only goes so far in demonstrating the scope of opportunity. Absent from this modelling is onshore carbon capture, particularly for the Canning, Carnarvon and Perth basins, and how other industries could be supported to capture, store and utilise their carbon dioxide emissions.

Regulatory barriers and slow approvals processes

The slow pace of approvals in Australia, and its impact on future investment, has attracted considerable interest in recent months. The regulatory framework that captures offshore activities, including carbon capture (storage) projects is currently fraught with complexity.

The need for urgent reform of the offshore approval's regime emerged following the Federal Court ruling against NOPSEMA's approval of Santos' Drilling Plan in 2023 on the basis that an individual from the Munupi clan on the Tiwi Islands (which are located approximately 140 kilometres from the drilling activity) was not directly consulted.

Project proponents now face considerable uncertainty and delay as to when and/or if their Environment Plans will be approved. While robust environmental and consultation standards are expected, project proponents need clarity and certainty over regulatory expectations. While gas projects are caught up in this, carbon capture projects that will support future gas development in this 'net zero world', will also be impacted.

The recent decision by the Queensland Government to ban carbon capture projects in the Great Artesian Basin, which included a commitment to lobby the Federal Government for a broader ban that prohibits other States from developing projects in the Basin, further undercuts Australia's position with international investors. This feeds a concern that investment will be subject to heightened sovereign risk.[26]

[26] Australian Financial Review, Hall J. *Push for wider carbon capture ban in Great Artesian Basin*, May 2024

Similarly, a Greens-led and cross-party Senate Committee recently reached a majority recommendation that onshore carbon capture should become subject to the 'water trigger' within the *Environmental Protection and Biodiversity Conservation Act*.[27] This could have the effect of delaying and disincentivising carbon capture investment.

In addition, while State legislation to enable onshore carbon capture was introduced in late 2023, a large part of policy will remain subject to regulations. While regulations are expected, until their development, proponents lack the certainty they need to make investment decisions.

Furthermore, despite the need to accelerate decarbonisation, the CCUS Hub Study estimates a lead time of up to 10 years is necessary to navigate approvals in Australia, to build the required infrastructure to support carbon capture. In addition, most carbon capture projects require a 15-to-20-year period of certainty to underpin the business case. To this end, the Safeguard Mechanism will continue to be an important instrument, and the 2026-27 review must provide certainty for investment in new carbon capture projects.

If legislative and regulatory frameworks are not future-focused and responsive to the needs of our industries and our regional trading in partners, Australia could miss out on the jobs and economic benefits that would flow from the prospect of carbon capture.

Lack of strong carbon investment signals

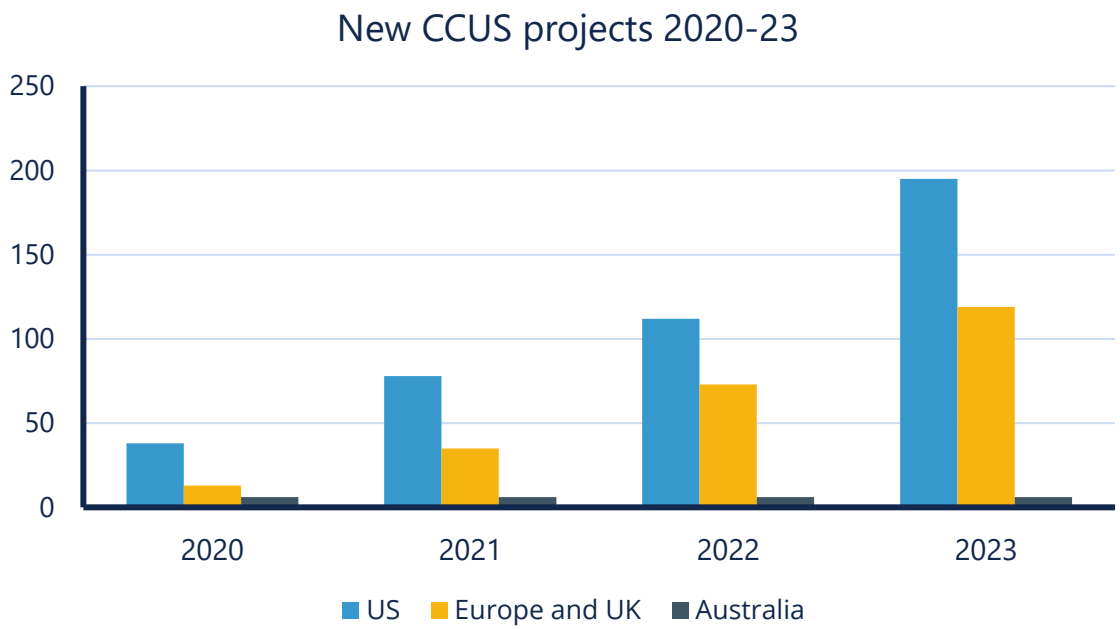
Financial levers

The Global CCS Institute's *Global Status of CCS Report 2023* demonstrates there has been a substantial increase in the demand for, and supply of, global capital for carbon capture projects with supportive political landscapes.[28] For example, in the US, when the Biden Administration introduced the *Bipartisan Infrastructure Law 2021* and the *Inflation Reduction Act,* there was a 152 per cent increase in carbon capture projects between 2019 and 2023. Similarly, in the EU, when the *Net Zero Industry Act* and EU CCS Directive was issued, there was a 63 per cent increase in carbon capture projects between 2021 and 2023.[29] These are compared in **Figure 1**.

For the private sector to invest in carbon capture, industry needs both the commercial incentives and a favourable political and regulatory context. Australia's policies and mixed messaging have been identified as a significant barrier, signalling to investors and industry that there is limited and wavering political support for carbon capture and emerging technologies. In addition to this however, there is also a lack of financial incentives in play.

[27] Senate Standing Committee on Environment and Communications. Glencore's Proposed Carbon Capture and Storage Project. July 2024.
[28] Ibid.
[29] Calculated by comparing Global CCS Institute reports from 2021 through to 2023

Figure 1: New CCUS Projects 2020-2023



Attractive policy settings can underpin private sector investment, particularly private venture capitalists. Elon Musk's XPRIZE foundation provides funding based on companies reaching certain milestones, and BlackRock's investment in STRATOS is another example.

Other jurisdictions see benefit in leveraging public investment to attract private investment. For example, the Canadian Government has funded research company Arca to help attract funding from the XPRIZE foundation for a research project at Mount Keith, near Wiluna, Western Australia.

There are evident cost barriers that need to be addressed to drive large-scale adoption. For example, while DAC holds immense potential - and the technology has been identified by the WA Government to underpin the State Emissions Reduction Strategy – it is incredibly cost-prohibitive for large scale, industrial adoption, due to the high energy requirements.

While the Federal Government now offers production credit incentives for green hydrogen, there is no explicit equivalent for carbon capture. Further incentives encouraging private sector investment are needed to drive the adoption of carbon capture, particularly in hard-to-abate industries.

Closing gaps in research

Research is vital to improving energy efficiency, limiting the release and removing carbon dioxide from the atmosphere, and in identifying new uses. While there is some support for carbon capture, further research into utilisation, identifying low-cost ways to purify carbon dioxide streams, and ways to reduce energy requirements for carbon capture technologies are needed.

Monash University's *Monash Carbon Capture and Conversion* (MC^3) is one of the main carbon capture research groups in Australia and Malaysia, researching carbon capture technologies such as microalgae, forestry, and direct air capture solutions. However, their research is not to the scale occurring in other jurisdictions.

For example, there are some interesting projects underway in North America for DAC and DAC-similar technologies. For example, *280 Earth*, an offshoot from Alphabet (the parent of Google), is investigating ways to co-locate DAC and sources of waste heat, such as heat produced by data centres. *280 Earth* has developed a system where 80% of the thermal energy needs can be provided by waste heat.

Similarly, in the utilisation space, CarbonCure is a cement company, which has created a more resilient cement, simply by injecting carbon dioxide into concrete. There are now many similar companies, with origins as research startups, attracting funding in the US and Canada, before becoming fully fledged businesses. There has been little to no equivalent here in Australia, to our detriment.

While the CSIRO released a Carbon Dioxide Utilisation Roadmap in 2021, which identified opportunities for utilisation, there is no funding attached to the Roadmap to identify what might be feasible and which industries could benefit from adding carbon into their products. Only further research and development will underpin these opportunities.

The Mount Keith DAC Mineralisation study **[Case Study 8]** is an example of what is possible with additional research and funding support. Projects, such as these are important, and should be actively encouraged by government to help close gaps in carbon capture research in Australia.

CASE STUDY 8

Mount Keith DAC Mineralisation study

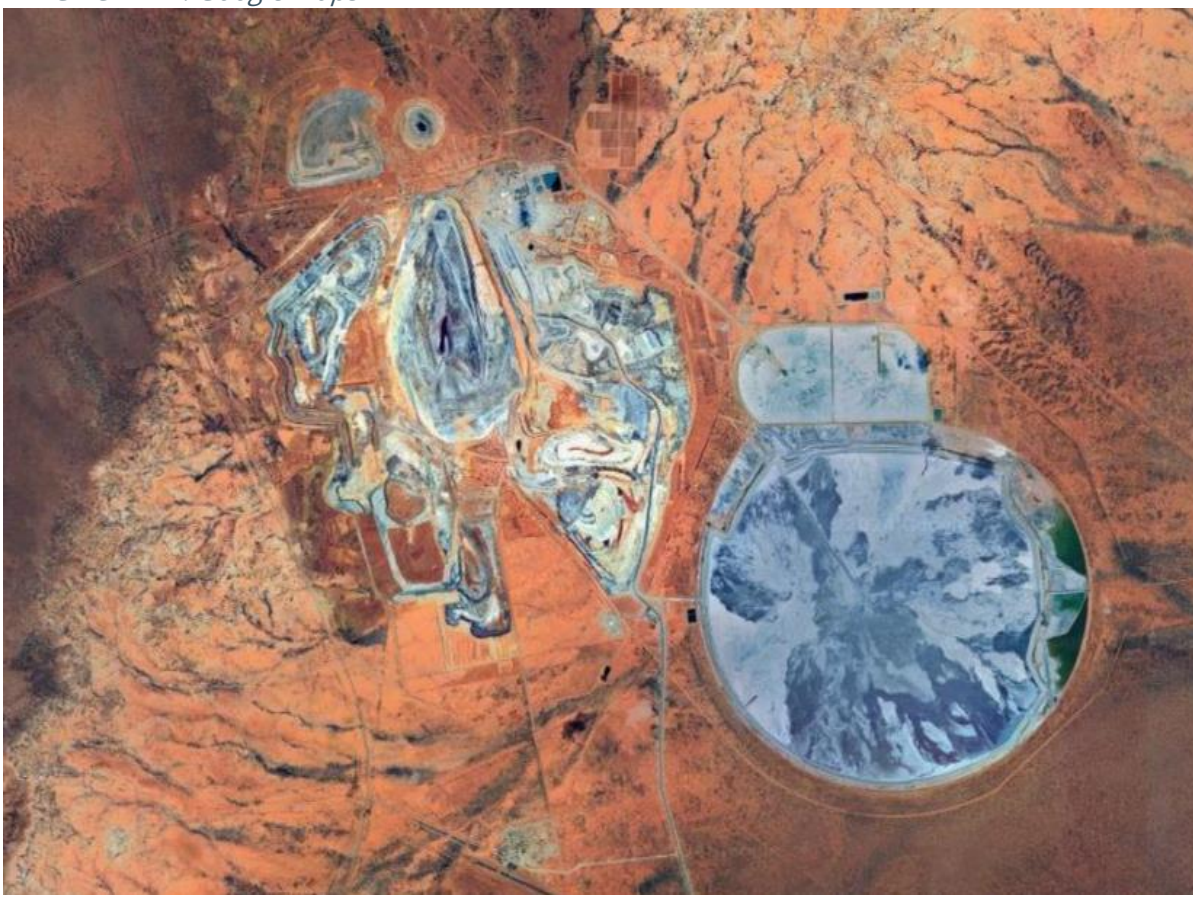
Status:	Operational
Operator:	BHP, Arca
Location:	Wiluna, Western Australia, Australia

In 2020, researchers at BHP Nickel West's Mount Keith operations identified the nickel tailings dam was naturally drawing down approximately 40,000 tonnes of carbon dioxide directly from the atmosphere each year. This quantity is comparable to offsetting the annual carbon emissions of 15,000 average-sized combustion engine cars.

This attracted the attention of Arca, a Canadian company focused on DAC and mineralisation. Arca's own research estimated the site was only operating at 1% efficiency, with the potential to mineralise 4 million tonnes of carbon dioxide.

Committed to investigating further, Arca managed to secure pilot project funding from the XPRIZE Foundation and the Canadian Government. The 18-month pilot project, which began in November 2023, seeks to map where mineralisation is occurring, and how to realise the site's full potential. The project sees autonomous rovers churn topsoil, to increase tailings exposure to the atmosphere.

IMAGE CREDIT: Google Maps



Scalability

It is also increasingly acknowledged that for carbon capture to be successful, it must be done so at sufficient scale to justify the investment required. In the case of storage, 'hub' models are increasingly being pursued in other countries, and other jurisdictions around Australia. Hub models drive the necessary scale required to make a storage project viable and can be a value-add for industrial precincts for climate-conscious industries.

However, to achieve the necessary scale, there must be investment in common user infrastructure, such as pipelines, electrical transmission lines, and other related infrastructure. Providing carbon capture common user infrastructure when developing industrial estates is likely to become attractive for industry, as will measures from both private and public sector to facilitate industry entering carbon capture agreements across different types of industry and across geographical areas.

While the WA Government's recently announced $500 million *Strategic Industries Fund* is welcome, only $145 million has so far been allocated for acquiring and developing industrial land, with the vast majority, $125 million, being allocated to the Latitude 32 precinct near Kwinana. There is $314 million currently unallocated across the forward estimates, but this provides an opportunity to support new carbon capture initiatives in future Budgets in coming years.

Current carbon credits and accounting structure disincentivises investment

In Australia, a suite of measures are currently at play, which create a framework to encourage businesses to decarbonise. For example, the *Safeguard Mechanism* applies to facilities that emit more than 100,000 tonnes of carbon dioxide each year, and *Australian Carbon Credits Units (ACCUs*), through the *Emissions Reduction Fund*, exist to incentivise emissions reduction. Participants earn one carbon credit per tonne of carbon dioxide stored or avoided by emission reducing projects. ACCUs are then bought and sold in the *Secondary Carbon Credit Market*, and the *Australian Carbon Exchange.*

Despite carbon capture being recognised internationally as a legitimate option to meet decarbonisation targets, a key issue identified here in Australia is not all forms of carbon capture generate ACCUs.[30] For example, despite pyrolysis and biochar being recognised as legitimate forms of carbon capture by the ICPP, the Federal Government does not consider them sufficient to be an ACCU.

This acts as a clear disincentive for businesses looking to invest in carbon capture in Australia and impacts the attractiveness of Australia as an investment destination for these emerging technologies.

[30] Department of Climate Change, Energy, the Environment and Water, Independent Review of Australian Carbon Credit Units: Call for submissions. *NSW Government submission*, October 2022

There is also uncertainty as to whether carbon border adjustment mechanisms, both internationally and in Australia, may also impact ACCU generation and the economic potential of future carbon capture projects.

Lack of information is fuelling social licence concerns

There are multiple factors influencing the social licence for carbon capture projects. In Australia, as in many other places, the social licence for carbon capture projects can be challenging to secure due to a significant knowledge gap between the carbon capture proponents and the public, as well as the perpetuation of myths and misconceptions that exist around carbon capture.

Some of the common myths or arguments against carbon capture that undermine its social licence, include:

- **These technologies are unproven and large-scale projects are unviable:** This argument ignores the fact that carbon capture has been successfully demonstrated and deployed in various sectors and regions around the world for decades, with 30 projects currently operating globally, and another 167 in various stages of development.

- **It cannot ever be carbon-neutral or negative because it requires lots of energy:** This argument overlooks the fact that carbon capture can significantly reduce the net emissions from industrial processes that would otherwise be released into the atmosphere. The energy penalty of carbon capture depends on various factors, such as the type of capture technology, the source of emissions, energy source to power operations, and whether it is attached to storage or utilisation. Under most settings, carbon capture has been shown to reduce the net emissions from fossil fuel-based power generation or industrial processes by up to 90 per cent.[31] Moreover, it can achieve negative emissions when applied to bioenergy or direct air capture.[32]

- **It can pose a massive environmental threat if it fails:** This argument exaggerates the potential risks of carbon dioxide leakage from storage sites, which are very low if proper site selection, monitoring, and remediation measures are implemented. The carbon dioxide that is injected into deep geological formations is subject to various physical and chemical trapping mechanisms that prevent it from migrating to the surface. According to the IPCC, the probability of retention of carbon dioxide in geological storage is likely to exceed 99% over 1,000 years.[33] This compares to current processes which see all carbon emissions created entering the atmosphere.

[31] Frontiers Research. *Direct Air Capture and Bioenergy with Carbon Capture and Storage Technologies for Negative CO_2 emissions*, 2023
[32] Center for Climate and Energy Solutions. *Carbon Capture*
[33] UNEP. *Can carbon dioxide storage help cut greenhouse emissions?,* 2018

- **It is not necessary and in fact locks in our use of fossil fuels:** carbon capture is not a substitute for renewable energy or energy efficiency, but a complementary method that can help achieve deep decarbonisation across multiple sectors. It can also complement and enable other low-carbon technologies, such as hydrogen, synthetic fuels, and biogas. Furthermore, it can facilitate new jobs and economic opportunities for workforces, and communities, that depend on fossil fuel industries.

- **It provides a 'get out of jail free' card for sectors which don't want to decarbonise:** This argument implies that carbon capture is used as an excuse or a distraction by some industries to avoid taking action on reducing their emissions. However, this is not supported by evidence. Carbon capture is not a cheap or easy option for industries; it requires significant capital investment, operational costs, regulatory compliance, and social acceptance. Industries that adopt carbon capture do so because they recognise its value and necessity for their long-term sustainability and competitiveness.

The 2020 Satartia pipeline rupture in the US is also often used as an example of the failure of carbon capture, and the potential environmental and health hazards that are associated with its use.[34] However, this incident also offers some crucial lessons around infrastructure failure and the importance of ensuring the safety and integrity of carbon dioxide pipelines, which are essential for transporting large volumes of carbon dioxide from capture sites to storage sites or utilisation markets.

Addressing the knowledge gap and debunking common myths surrounding carbon capture is crucial in shaping public perception and gaining social licence for these projects in Australia. Public education and transparent communication about the importance of carbon capture, the benefits, as well as its limitations can play a significant role in achieving public support and ensuring carbon capture's essential role in accelerating decarbonisation efforts.

[34] The explosion was caused by a mudslide that ruptured a 24-inch pipeline carrying liquefied carbon dioxide near a small village in Mississippi, affecting more than 200 residents and sending at least 45 people to hospital. The Satartia incident highlights the potential hazards and impacts of pipeline failures, particularly environmental damage and public health risks.

What needs to change?

The entire WA and national economy, and broader community, would stand to benefit if governments worked with the business community, rather than against it, to achieve our decarbonisation goals. Carbon capture is integral to Australia's and the global economy's decarbonisation pathways, yet we stand to miss out on the global movement that is driving carbon capture to new heights.

Carbon capture needs to be recognised as an integral component of Australia's decarbonisation pathway. It also holds considerable economic opportunity associated with storage and utilisation. We consider there to be three headline benefits that are currently being overlooked:

- **Decarbonising industries:** A crucial facet of generating economic growth and maintaining global competitiveness. By capturing carbon emissions from industrial processes, such as cement and steel production, hard-to-abate sectors can reduce their carbon footprint and transition toward more sustainable practices. This not only aligns with global emissions reduction targets but also enhances the attractiveness of Australian exports by demonstrating a commitment to responsible production.

- **Producing critical low-carbon products:** Carbon capture offers the opportunity to decarbonise the production of critical products and materials essential for the global energy transition and export markets. As the world shifts toward cleaner energy sources, the demand for products like chemicals, hydrogen, ammonia, and carbon-based materials with reduced carbon footprints will increase. Carbon capture can play a pivotal role in producing these goods more sustainably, positioning Australia as a leader in low-carbon exports.

- **Creating jobs and new areas of economic opportunity:** The establishment and operation of carbon capture projects, for both storage and utilisation, necessitate a skilled workforce. This creates employment opportunities related to engineering, construction, research, and maintenance. Products using carbon dioxide in a circular way, along with the jobs created across storage and utilisation, not only drive economic growth and economic diversification, but also contribute towards a low-carbon future, ensuring that the benefits of decarbonisation are distributed broadly across society.

To capitalise on these opportunities, both State and Federal Governments should do the following:

- **Champion, and normalise, carbon capture to broad benefit:** if carbon capture was given the same political attention as green hydrogen, then the sector could develop. This requires moving away from 'picking winners' approach toward a 'technology-agnostic' approach. Blue hydrogen, which uses carbon capture, will

also help support normalising access to hydrogen for use across industry and for long-haul transport.

- **Ensure a robust and efficient approvals system:** to ensure projects can be delivered in a timely manner to meet decarbonisation targets. As outlined in CCIWA's Green Web report, released in November 2023, bureaucratic processes and red tape continue to hold up economic activity and potential, ironically also, holding up our decarbonisation progress. A robust and efficient approval system should include clear requirements relating to consultation, particularly offshore consultation.

- **Support industry investment through strategic partnership and incentives:** to embolden industry to invest in carbon capture, government needs to set the right fiscal and policy framework to enable this to occur. This includes undertaking the required planning and investment (including via strategic partnerships) into common user infrastructure, both onshore and offshore, benefitting multiple industries and regional neighbours, as well as targeted incentives that would help facilitate decarbonisation across multiple industries.

There is a clear alignment across industry of the need to foster carbon capture to assist Australia's industries and our regional trading partners to decarbonise, while at the same time diversifying our economy with an eye on long-term opportunities.

By addressing regulatory hurdles, creating funding priorities, and explicitly endorsing the use of carbon capture, Australia can position itself as a regional leader in carbon capture innovation and large-scale project development.

The following outlines specific actions that both the Federal and WA Governments should take to drive carbon capture investment and progress.

Recommendations

Federal Government

Recommendation 1: Promote and champion carbon capture

The Federal Government's messaging on carbon capture has been mixed, which, in turn, creates an environment where misinformation and misperception within the community exist. To address industry and community concerns, the Federal Government should:

- demonstrate strong political leadership by holding a consistent position across Cabinet that supports and encourages investment in carbon capture in the same way renewable hydrogen is supported. In doing so, the Federal Government must approach the decarbonisation agenda in a technology agnostic manner.
- strongly promote and celebrate industry efforts to decarbonise using carbon capture with the aim to educate the broader community about the role it plays in decarbonising Australia's and the global economy.
- develop a National Carbon Dioxide Storage Strategy, and a National Carbon Dioxide Utilisation Strategy, with funds to support implementing both plans over the long term.

Recommendation 2: A robust approvals framework

Proponents across the economy face significant challenges and extended timeframes to get projects approved. To address industry concerns, the Federal Government must:

- immediately work to identify opportunities to cut red tape and streamline overlapping approvals.
- oppose carbon capture being considered under the EPBC Act 'water trigger'.
- commit Ministerial support for approvals reform that supports broad adoption of carbon capture.
- legislate changes to Regulation 11A of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009, providing greater clarity in relation to consultation requirements for offshore projects.

Recommendation 3: Support industry investment

The Federal Government should develop clear funding streams to drive industry investment in developing low-cost technology, utilisation pathways and storage.

The Federal Government must play a role in incentivising progress and action, by:

- **Broadening funding opportunities:**
  - removing the regulation that prevents the Australian Renewable Energy Agency and the Clean Energy Finance Corporation from supporting carbon dioxide removal technologies and related infrastructure.
  - adopt technology agnostic funding models, such as expanding the $2 billion Hydrogen Headstart Fund in terms of value and scope to include emissions reduction and low emissions technologies.
  - support State and Territory Governments to fund strategic common user infrastructure, both onshore and offshore, particularly greenhouse gas hubs, where carbon dioxide can be compressed and treated for transport. Infrastructure should be future-proofed to assist future industry development, and leverage existing assets.

- **Updating regulatory and policy settings:**
  - use the national Sector Emission Reduction Strategies process to work with industry to define how carbon capture is to be applied and used, and collaborate with industry to develop voluntary 'Sector Use Strategies'.
  - expand the carbon credit system so that all carbon capture technologies, such as biochar and direct air capture, are eligible for Australian Carbon Credit Units (ACCUs).
  - develop a long-term timeline, with requisite funding, to implement the CSIRO's Carbon Dioxide Utilisation Roadmap to drive research and industry investment.
  - accelerate initiatives outlined in the *Future Gas Strategy* to position Australia as a carbon management solutions provider for the Indo-Pacific region, and attract global capital to invest in innovation and product development.

WA Government

Recommendation 4: Champion the benefits of carbon capture

The WA Government should build community awareness about, and continue to recognise the role of, carbon capture by:

- adopting a 'move first' approach by releasing a State CCUS Action Plan in the next 12 months.
- working closely with the Federal Government to gain their support for the recommendations above.
- identifying a lead agency to champion carbon capture and its benefits as an economic diversification opportunity and to help local businesses decarbonise.
- working with WA companies to promote and celebrate carbon capture.

Recommendation 5: Improve approvals and regulatory frameworks

The WA Government's ambition to improve approvals systems is welcomed, however, to promote carbon capture, the WA Government should:

- allow regulatory sandboxes to fast-track carbon capture trials and pilots.
- broaden the scope of the new Green Energy Major Project Unit to include carbon capture projects.
- ensure the State CCUS Action Plan includes a state-wide overview of both onshore and offshore opportunities, including greenhouse gas aggregation and treatment facilities. The plan should also include a timeframe for development of a carbon capture sector for local industry and imports, and identify funding commitments.
- work closely with industry to identify the key regulatory gaps and barriers that exist while fast tracking regulations for the *Petroleum Legislation Amendment Act 2024.*

Recommendation 6: Support industry investment

To support industry investment into carbon capture, the WA Government should:

- through the New Industries Fund, provide incentives to assist research and product development associated with onshore industrial decarbonisation (beyond gas).
- improve intellectual property (IP) policies to empower businesses to seek WA Government investment.
- work with industry to identify gaps in existing grant programs, such as the Carbon Innovation Grants program, to ensure the program delivers on intent.
- continue to work with industry to identify new carbon capture opportunities within the Sectoral Emissions Reduction Strategies.