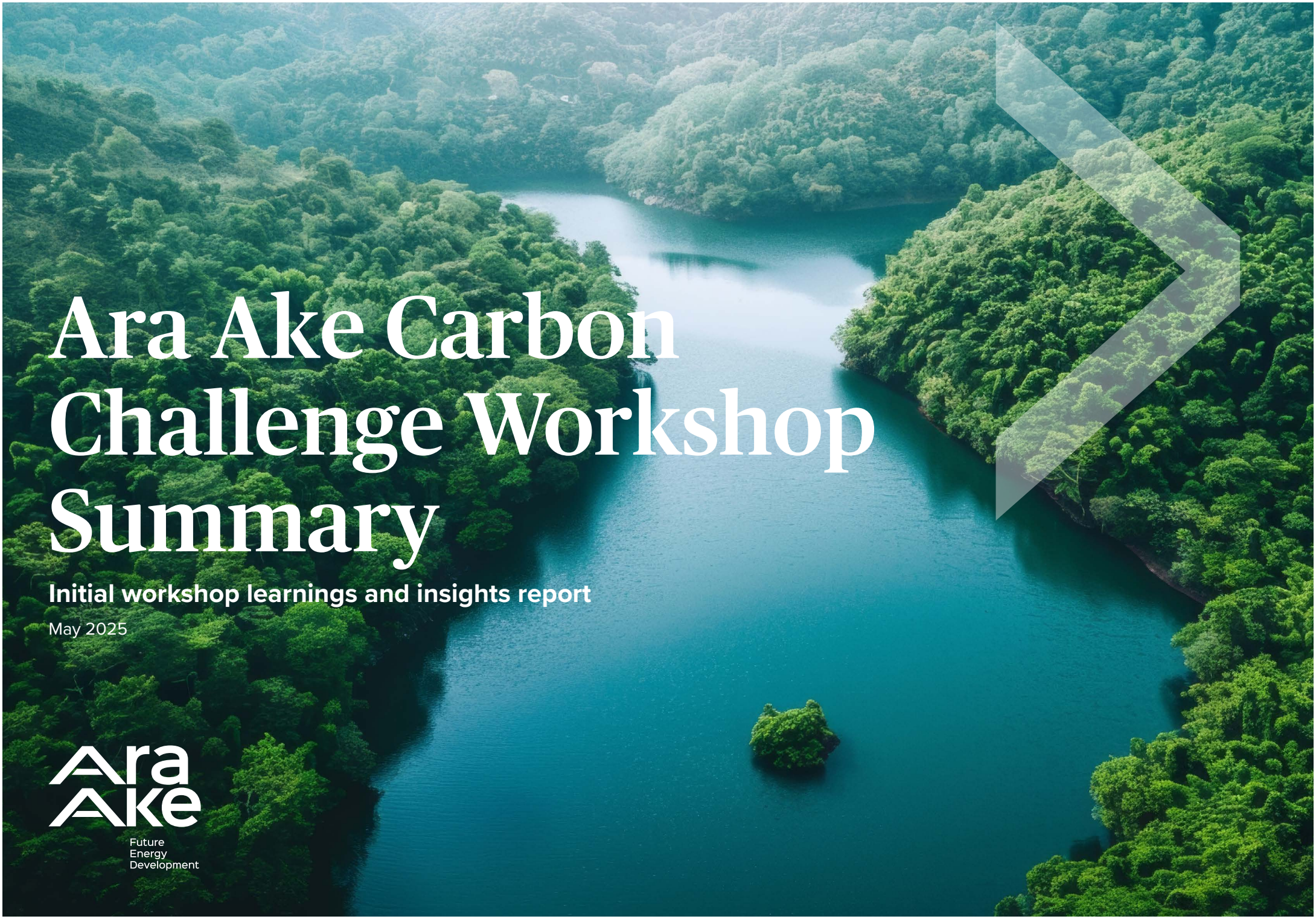

Ara Ake Carbon Challenge Workshop Summary

Initial workshop learnings and insights report

May 2025

Ara Ake

Future
Energy
Development

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Preface

The Carbon Challenge summit was a one-day seminar and workshop hosted by Ara Ake in Wellington on 1 October 2024.

During the seminar, participants heard from domestic and international experts about the state of carbon capture, utilisation and storage (CCUS) technology, the specific challenges and opportunities facing various industrial sectors, late stage emerging technologies which may address some of those challenges and opportunities, and how they may interact with the legal and regulatory regime.

Chief Executive of the New Zealand Climate Change Commission, Jo Hendy's keynote speech highlighted the work that local geothermal generators have done to reinject carbon dioxide from their processes at a lower cost than paying the ETS price. Her challenge was where else in the New Zealand economy we can do similar things.

"There is no one silver bullet here, we need a whole lot of silver buckshot"

Jo Hendy | Chief Executive, Climate Change Commission

The afternoon session looked to take on her challenge with industry participants workshopping the problems that are standing in the way of widespread take up of CCUS in their industries, and what they'd want innovators and their technologies to be able to do in order to solve those problems.

Acknowledgements

Ara Ake thanks the experts from New Zealand and overseas who presented and facilitated at the Carbon Challenge summit:

Andreas Heuser | Managing Director, Castalia

Andrew Knight | Chief Executive, Gas Industry NZ

Billie Moore | Chief Executive, NZ Airports Association

Brigid McArthur | Partner, Greenwood Roche

Callum Thorpe | Principal Policy Advisor, MBIE

Chris Burgess | Investment Adviser, NZTE

Christopher Oze, Mark Chadderton | Aspiring Materials

Craig Barry | Policy and Climate Lead, ERA

David Dempsey | Canterbury University

Jo Hendy | Chief Executive, Climate Change Commission

John Burnell | Senior Reservoir Modeller, GNS Science

Katie McLean | President, NZ Geothermal Association

Luke Shors and Maryjo Muller | Capture6

Nick Cozens | Technical Director – Infrastructure & Renewable Energy, BECA

Professor Barry Barton | Waikato University

Raewyn Bleakley | Chief Executive, New Zealand Food & Grocery Council

Russell Dyer | Energy and AFR Manager, Golden Bay Cement

Shane Telfer | Captivate

Vlatko Materic | Hot Lime Labs

Ara Ake also thanks John Hancock from Signature Consulting for facilitating the afternoon session, along with the workshop participants.

Summary

The Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report states that projected CO_2 emissions from existing fossil fuel infrastructure exceed the remaining carbon budget for limiting warming to 1.5°C.[1] It also concludes that deploying carbon dioxide removal (CDR) technologies to offset hard-to-abate residual emissions is essential to achieving net zero CO_2 or GHG emissions.

The International Energy Agency (IEA) echoes this view. In its Net Zero Emissions by 2050 Scenario—aligned with the Paris Agreement goal of limiting warming to 1.5°C—it forecasts that around 1 billion tonnes of CO_2 per year will need to be captured and stored by 2030.[2]

In Aotearoa New Zealand, the Climate Change Commission (CCC) has consistently included the continued use of natural gas for electricity generation and as an industrial feedstock beyond 2050 in its advice to government. However, unlike the IPCC, the CCC has not incorporated broader forms of carbon capture or CDR into its emissions modelling. This is primarily due to the projected rates of afforestation, which indicate less tree planting will be required to meet net zero goals, and because CDR technologies remain costly and at an early stage of development.[3]

Since 2019, the costs of CDR technologies—including carbon capture and storage (CCS), bioenergy with CCS, and direct air capture—have remained high. While emerging solutions are being tracked, there has been no domestic uptake to date, and the CCC expects only incremental changes going forward.

The exception is geothermal electricity generation. Operators at Ngāwhā, Te Huka and Ngātamariki have successfully reinjected CO_2 and GHG emissions from geothermal fluids back into their reservoirs. These innovations have reduced emissions and proved more cost-effective than purchasing ETS credits.

To explore further opportunities for CCUS in New Zealand, Ara Ake launched the Carbon Challenge—aimed at identifying and supporting the deployment of innovative CCUS technologies in industries where capturing carbon could be more cost-effective than purchasing emissions credits, or where CO_2 can be used as an input in other processes. Potential applications include producing sustainable aviation fuel (SAF) or supporting carbon-intensive export industries that may face carbon border adjustments.

The Challenge began with a curated workshop that brought together industry, regulators, academics and innovators to define the key barriers to CCUS deployment. The primary challenge, consistent across sectors, is cost. A significant reduction—by an order of magnitude—is needed for CCUS to be viable. There are also regulatory barriers to carbon storage, while carbon utilisation is generally permitted under current frameworks.

In the next phase, Ara Ake is seeking to support demonstration pilots in partnership with New Zealand industry and CCUS technology providers. Before going international, we're calling on:

- New Zealand industry players with a CO_2 source
- New Zealand industry players with a CO_2 need

We're particularly interested in opportunities where CO_2 can be used as a feedstock in other processes—improving both the economics and regulatory compliance of capture.

1 Climate Change 2022: Mitigation of Climate Change, 2022, Intergovernmental Panel on Climate Change p. 36

2 iea.org/commentaries/it-is-time-for-ccus-to-deliver

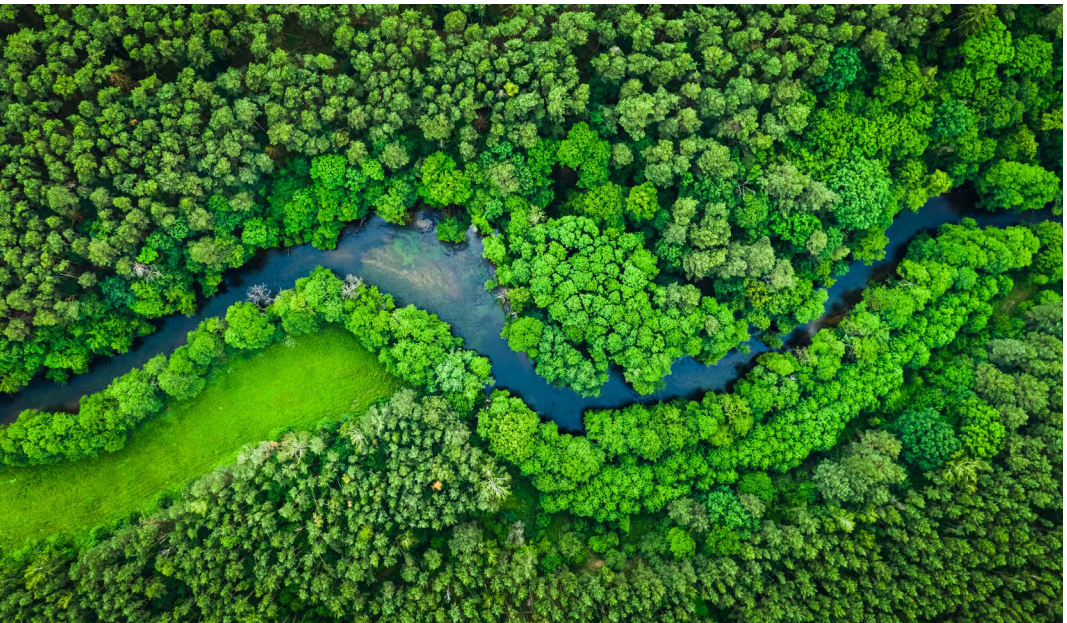
3 Draft advice on the fourth emissions budget period (2036–2040), He Pou Rangi | Climate Change Commission, April 2024 pp. 25, 74 and 87

Background to the Carbon Challenge

In 2022, Ara Ake published the report Carbon Dioxide Removal and Utilisation in Aotearoa New Zealand. Four of the report's objectives were to:

- Highlight emerging technologies that could enable opportunities for "negative emissions" using CCUS which could accelerate the journey to net zero, and potentially beyond
- Acknowledge carbon dioxide is also a valuable feedstock for low emission fuels, such as sustainable aviation fuel, and that capturing and utilising waste carbon dioxide can create an economic value chain
- Emphasise information gaps, such as a thorough geological knowledge of carbon storage opportunities in New Zealand, and an absence of a current assessment (or case studies) on the economic viability of CCUS opportunities.
- Investigate the effectiveness of the Emissions Trading Scheme to support the extraction of carbon dioxide from the atmosphere.

Building on these objectives to populate research questions that could be issued to innovators worldwide, Ara Ake hosted a Carbon Challenge summit at Te Papa in Wellington on Tuesday, 1 October 2024.



Ara Ake EDB Challenge

The Carbon Challenge builds on the success of the EDB Challenge. A similar process is envisioned that will result in innovators and industry working together to solve the challenge of carbon using capture, utilisation and storage.

In 2022, Ara Ake started a two year **Electricity Distribution Business (EDB) Challenge** aimed to bring together electricity distribution businesses and innovators to collaboratively tackle common challenges facing the sector as we transition to a more sustainable, resilient and equitable energy future.

This Challenge saw Ara Ake working closely with a subset of New Zealand's 29 EDBs to identify and articulate their specific problems, followed by a global search for innovative solutions to pilot on New Zealand's electricity distribution networks.

In early 2022, Ara Ake held several workshops with EDBs. The goal was to collaboratively identify and articulate their key decarbonisation challenges. Using design thinking tools, we identified two main challenges. These were expressed as problem statements and shared in a call for solutions. The call targeted both local and international innovators through Ara Ake's network. We partnered with Elemental Excelerator (now known as Elemental Impact), a nonprofit investor in the USA focused on scaling climate technologies with significant community impact. The call specifically invited innovators with pilot-ready technologies that could address one or more of the problem statements.

After a month-long innovator search, we received 29 applications (from the USA, Canada, Europe, the UK, India, Japan, Chile, South Africa, Australia and New Zealand). Six of the applicants were selected to pitch their innovation in New Zealand to the participant EDB CEOs.

Following the pitches and deliberations, a prize pool was divided between three innovators, two from Australia and one from NZ, who partnered with seven of the eight participating EDBs to create individual pilot projects.

The EDB Challenge is a testament to the power of collaboration among all the organisations involved and their commitment to delivering better outcomes for New Zealanders.

Ara Ake Carbon Challenge

The Carbon Challenge summit advanced the discussion on carbon capture, utilisation and storage in its various forms, and brought together innovators and industry working together to find solutions to the challenge of carbon highlighting insights from leaders in technology, industry challenges, regulatory updates and international developments.

To inform the identification of problem statements the event:

- Brought together science leaders, technology innovators, industry professionals and government officials to discuss carbon removal technologies
- Highlighted technologies that could enable negative emissions through carbon capture and storage in combination with bioenergy, accelerating the journey to net zero, and potentially beyond
- Built awareness of global advancements in nature-based carbon storage and the development and deployment of carbon capture, utilisation and storage technologies
- Provided updates on the New Zealand Government's regulatory work regarding carbon removal, utilisation and storage activities
- Considered provisions for inclusion in the Emissions Trading Scheme to support carbon capture, utilisation and storage.

This report summarises the context and themes identified during the seminar to increase CCUS uptake in New Zealand. It outlines the key problems that hinder progress and the solutions needed, which will form the requirements Ara Ake will issue to innovators worldwide in a future phase of the Carbon Challenge.

Context and themes

The presentation themes from the Carbon Challenge summit provide a valuable primer on global and New Zealand perspectives of CCUS, challenges to NZ industries adopting CCUS, relevant innovation and emerging technologies and local regulatory enablement.

Global and New Zealand perspectives

In contrast to countries with direct subsidies for the technology, New Zealand's market-led approach to climate change at present relies on industry exploring CCUS as a way of reducing its liabilities whether as exporters under carbon border adjustment mechanisms or domestically in the Emissions Trading Scheme.

When the price is right, the NZ ETS is stimulating new opportunities for CCUS

Chief Executive of the New Zealand Climate Change Commission, Jo Hendy's keynote explained why the Commission has not focused on CCUS in its modelling of NZ's pathway to a net-zero economy by 2050. Their analysis suggests that CCUS is and will likely remain more expensive than other removal options such as planting trees.

Her challenge to the summit was to take inspiration from the a case study where the ETS has forced **Top Energy to eliminate the emissions from its Ngāwhā geothermal power station** in order to remain economic. In its initial advice to government, the Commission had assumed that high emissions intensity geothermal power stations would become uneconomic and close due to a rising emissions price.

Rather than closing, Top Energy took this as motivation to find a cheaper way of capturing and storing emissions at Ngawha. They budgeted $6 million for the project but it cost a couple of hundred thousand.[4]

"(Ngāwhā) totally flipped the narrative that I had been hearing since starting my work on energy that high emissions geothermal plants would have to close."

Jo Hendy | Chief Executive, Climate Change Commission

It's a great example of where CCUS is the more affordable option, but it took the prospect of a rising ETS price for industry to identify challenges to the use of CCUS technologies and come up with innovative solutions. Jo Hendy's challenge to the summit was to identify other opportunities to reduce the cost of the technologies so that we can take advantage of them faster than the Commission is forecasting.

"Geothermal – fantastic to see that investment that's been made at a remarkably low cost to decarbonise one of our previously identified hard-to-abate geothermal fields. What a fantastic outcome and that should be celebrated, absolutely, from the rooftops."

Andrew Knight | Chief Executive, NZ Gas Industry Company

4 thinkgeoenergy.com/ngawha-becomes-new-zealands-first-zero-carbon-geothermal-power-station/

Jo Hendy warned us "we may be living in an overshoot world" where countries that are not on track to meet their Paris commitments are increasingly setting net-negative targets in the later years of the transition. For this to be affordable, the costs of CCUS need to come down and risks, like permanence, need to be managed.

Narrative change: carbon removal will be essential

Consistent with Jo Hendy's insights, BECA's Technical Director for Infrastructure & Renewable Energy, Nick Cozens, started with a reality check: we are not on track to achieve net zero by 2050 and the International Energy Agency is clear "achieving net-zero goals will be virtually impossible without CCUS". His point was not that net zero is unachievable, just that we're behind schedule and so removals are just as relevant as future emissions elimination in a world with finite carbon budgets.

Treating CO_2 not so much as a "demonised gas" but a valuable commodity is part of the narrative change which will get us back on track to net-zero. CO_2 as an industrial input, sourced from point emissions will require reimagining of business models – more circular than linear.

"Let's change the narrative: Carbon Capture Utilisation and Disposal – we're really trying to get rid of CO_2"

Nick Cozens | Technical Director – Infrastructure & Renewable Energy, BECA

Internationally, there is an increasing number of examples of CCUS implementation at scale – from the recently commissioned 1.7 MT PA **Moomba carbon capture and storage facility** in South Australia to the 10.6 MT PA enhanced oil recovery **reinjection in the Brasilian Santos basin**.

Emissions pricing is working across borders and accelerating this trend. European importers have been reporting carbon imports from NZ since 2023 and will levy a "carbon border adjustment mechanism" for a range of carbon intensive products. The UK are looking at replicating a carbon border mechanism like the EU. CCUS is part of the development of new decarbonised business models. Emissions prices are providing an incentive for innovators to find and adopt these technologies and make them reality.

NZ has plentiful and diverse academic research on CCUS looking for implementation partners

New Zealand universities and Crown Research Institutes have been researching CCUS technologies and their applicability to New Zealand for decades. There are more projects underway today than ever. David Dempsey from the Civil and Natural Resources Engineering department at Canterbury University reviewed them and their applicability to our decarbonisation challenge. Areas of work he referenced included:

- Reviewing CCS opportunities in Waikato and Taranaki, including sedimentary basins (saline aquifers), coal fields, and depleted reservoirs of which Onshore Taranaki (Mt Messenger, Mangahewa) appears the most prospective with marginal prospects in Waikato (South Manukau) and offshore Taranaki
- Improve geothermal CCS performance by controlling mineralisation of CO_2 and Hydrogen Sulfide (H2S) when it is reinjected into NZ geothermal fields with novel chemical additives which could be used in other emission-intensive industries
- Studying the permanence and performance of mineralisation when CO_2 interacts with rocks
- Geological modelling of the Hamilton Basin (near point source emitters) looking for NZ aquifers suitable for dissolved-phase CO_2 storage
- Projects to capture CO_2 in rock, concrete and "clever chemicals"
- Derisking large-scale carbon dioxide removal by exploring science, engineering, environmental, policy and sociocultural dimensions of technologies that remove CO_2 directly from the atmosphere
- Accelerating the natural process of rock weathering by grinding up basalt and dunite rocks, spreading on pasture which react when it rains
- Integrating emissions from bioenergy with geothermal CCS to a net-negative emission energy system
- Identifying pathways, roadblocks and opportunities to CCUS deployment by matching sources of CO_2 with existing pipelines that connect to potential carbon sinks or users (such as horticulture or food processing)

Several of these technologies are entering commercialisation and were presented later in the seminar by early-stage innovators.

"I thought it would be quite easy to get through New Zealand research on CCUS in 10 minutes ... and then I dove into it. There's a lot of good work out there!"

Associate Prof. David Dempsey | Canterbury University

Opportunities for CCUS in different sectors

The second set of presentations contrasted experiences from large producers and industry bodies, the challenges and opportunities that they see for CCUS in their own operations

Hard to abate sectors need really cheap capture and storage

Cement is a notoriously "hard to abate sector" since CO_2 is produced in the core process, which is a chemical reaction where calcium carbonate is heated to produce calcium oxide and CO_2.

Golden Bay Cement (GBC) is NZ's only cement producer. Russell Dyer, their Energy Manager, traced the steps they've already taken to reduce emissions by replacing coal with tyres and treated timber (demolition waste which would otherwise go to landfill). The site is the second biggest contributor to a circular economy in NZ, reducing around 100,000 tonnes of landfill with a target of increasing that to 210,000 tonnes. Longer term, the site, which is near the former refinery in Whangarei, is a source of CO_2 that could be used for SAF production.

After concrete is mixed, it absorbs carbon and continues to for the rest of its life. Adding CCUS would make the entire manufacturing process net-negative, but the main barrier is cost.

Decarbonisation through CCUS could triple the cost of cement: capture, storage and transport of CO_2 are all expensive. Russell suggested that it would help his business case if the ETS gave him credit for the CO_2 that GBC captured, particularly when GBC competes with imported cement. Without a carbon border adjustment mechanism in New Zealand, if overseas producers don't face the full cost of their carbon emissions, GBC needs to match them be competitive.

"(With cheap enough CCS, Golden Bay Cement) could become a CO_2 removal option and become a zero-carbon building solution."

Russell Dyer | Energy and AFR Manager, Golden Bay Cement

Although fossil fuels are being phased out, they will inevitably be part of NZ's economy for decades to come – and we need to remove their emissions

Energy Resources Aotearoa is one of the peak bodies for the oil and gas industry. Craig Barry, their Policy and Climate Lead repeated the call for pragmatism – given our overwhelming reliance on fossil fuels, he opened quoting Oxford climatologist **Myles Allen**,"There is no way we are going to be able to ban the entire world from using fossil fuels in time to meet our climate goals".

Craig Barry suggested that the solution to achieving net-zero is to reframe "strongly held but rarely examined beliefs" that stand in the way of finding solutions to meeting our carbon budgets.

"CCUS is perceived as prolonging the oil and gas industry: "the catastrophising of carbon dioxide ... it's useful for all sorts of things".

Craig Barry | Policy and Climate Lead, ERA

CCUS is a complementary instrument to the production and use of SAF for decarbonising aviation

As CEO of the NZ Airports Association, Billie Moore works with all parts of the aviation sector, another notoriously hard-to-abate sector.

Billie pointed to the Canadian innovator, Carbon Engineering. Carbon Engineering's air to fuels project has targeted a process where CO_2 is used as a raw material to manufacture synthetic fuel. Carbon capture has the potential to play a key role in the production of SAF.

"We should conceptualise airports and ports as industrial and commercial hubs that are already integrated into transport supply chains and already have land use powers that can be leveraged for the types of investment and consolidation of technology that is conceived with things like CCUS hubs."

Billie Moore | Chief Executive, NZ Airports Association

NZ's 2023 CO_2 shortage shows the value of CO_2 as a feedstock

Like the decarbonisation of Ngāwhā, NZ's recent CO_2 shortage[5] is a case study for the importance of CO_2 as a feedstock and has highlighted that there is not a good understanding of how we use food-grade CO_2.

Raewyn Bleakley, CE of the NZ Food and Grocery Council, which represents food and drink producers, took the seminar through the crisis. NZ used to have two manufacturers of food-grade CO_2. When the NZ Refinery at Marsden Point closed its operations, the only domestic producer was the Todd Energy plant at Kapuni which was temporarily shut down in early 2023 over safety concerns.

With no domestic production, the food industry was faced with an 800% cost increase **for imported CO_2**.

Some members tried to use substitutes such as nitrogen (where applicable), but for some applications there is no substitute and the cost increases drove several craft brewers out of the market.[6]

"Carbon dioxide is used for carbonation – it makes beer and sparkling wine bubbly. It preserves food: it's used a lot in freezing and cooling food. Chicken nuggets, for example … need carbon dioxide to become solid as part of their processing. It's also used in things like decaffeination. It's also used in the humane, ethical steps in the end of life for animals. So it's widely used, it's hard to replace, and it's also used in health and in water treatment that will be prioritised over the food industry."

Raewyn Bleakley | Chief Executive, New Zealand Food & Grocery Council

Raewyn's presentation highlighted a subset of a larger set of opportunities to use carbon dioxide[7] which include:

- Food and Beverage – decaffeinating coffee, adding bubbles to beer, soft drinks, and wine, keeping perishable food cold when transported, quick freezing, displacing air during manufacturing processes and as a propellant
- Agriculture – displacing air and killing insects, manufacturing fertilizer and enriching air in greenhouses
- Manufacturing – as a welding gas and to prevent oxidisation, methanol and urea production, to harden castings and for enhanced oil recovery.
- Construction
- Health care – to stimulate breathing and diagnose disease
- Synthetic fuel production
- Plastic manufacturing
- Growing algae as a feedstock for making carbon fibre

5 nzherald.co.nz/viva/food-drink/everything-you-need-to-know-about-new-zealands-co2-shortage/NVD7HD4UHVFSLEKJEA7UVSQLEI/

6 businessdesk.co.nz/article/finance/another-nz-brewery-goes-bust

7 cganet.com/carbon-dioxide-a-necessary-and-useful-gas/ and atlascopco.com/en-nz/compressors/wiki/compressed-air-articles/carbon-dioxide-uses and vox.com/energy-and-environment/2019/11/13/20839531/climate-change-industry-co2-carbon-capture-utilization-storage-ccu

- Water and wastewater treatment to control acidity
- Cleaning - dry ice for cleaning surfaces, stopping leaks and cleaning up industrial spills and
- As a solvent in electronics manufacturing and for blast cleaning.

Geothermal electricity generation shows the way to CCUS in NZ

While Ngāwhā is the golden child of CCUS deployment in NZ, reducing its emissions from 312gCO_2e/KWh to zero, the entire sector is following, with both Contact Energy and Mercury Energy deploying similar reinjection techniques at Te Huka and Ngatamariki.

President of the NZ Geothermal Association, Katie McLean reviewed the technical and regulatory issues around geothermal reinjection and the pathway the sector is on to becoming entirely emissions-free.

Not all fields have the ability to dissolve fugitive CO_2 at reinjection depths which has required operators to find other solutions to using and storing those emissions.

"Ohaaki is a different type of power station that has a solubility issue so we're actually looking at capturing that for food grade CO_2."

Katie McLean | President, NZ Geothermal Association

Innovation and Emerging Technology

New Zealand already has early-stage innovators looking to commercialise CCUS technologies. Some are University spinouts, others are from overseas. The summit heard from four companies outlining their solutions and the opportunities they see for their wider deployment:

Direct air capture and brine – emissions removal that produces freshwater

Rather than being a net consumer of fresh water, **Capture6's** technology uses brine in direct air capture carbon sequestration to produce freshwater and industrial chemicals that can be used as feedstock for various industrial processes:

- Hydrogen – a green fuel
- Chlorine – PVC manufacture and water treatment
- Hydrogen chloride – steel manufacture
- Food-grade CO_2 – SAF manufacture and food/beverage production
- Purified water – water treatment and desalination and
- Carbonates – cement and glass production

Luke Shors and MJ Muller explained that the company has a pilot project in NZ and sees potential for the country to become a hub for sustainable technologies.

Metal-organic framework materials to sieve carbon dioxide from point sources

Shane Telfer is a Professor of Chemistry at Massey University and **Captivate Technology** is his spinout business. Captivate synthesises adsorbent MUF-16 metal-organic pellets which react with CO_2 from point source flue gases.

The technology has a low capture cost because of being able to treat impure water and flue gases without needing large amounts of heat.

Scale trials have replicated laboratory performance results with the technology ready for larger scale deployment.

Accelerated carbon storage in olivine rock

Aspiring Materials uses naturally-occurring olivine rock (magnesium hydroxide) which reacts with water and carbon dioxide from a point source to create magnesium carbonate: a stable, solid storage form.

The technology offers carbon capture and storage for less than US$100/t. CEO Mark Chadderton describes this as "the world's lowest cost".

As a mineral, magnesium carbonate locks CO_2 away permanently and can be used as a feedstock to other industrial processes, where the value of other byproducts reduces the overall cost of CO_2 capture.

Novel high-temperature use of limestone to produce clean CO_2 as plant nutrient in high-tech hydroponic greenhouses

Hot Lime Labs gasify crop and wood waste which produces heat, biochar and CO_2. The CO_2 is passed over hot limestone pellets which "soak it up" for later use. Founder Vladko Materic is targeting high-tech hydroponic greenhouses as his primary market – offering them a controllable source of CO_2, heat for greenhouse heating or biomass drying.

The company offers a niche circular economy solution which uses locally sourced forestry and crop waste to reduce the costs of managing greenhouse cultivation and monetisable biochar.

Regulatory Enablement

The innovators were consistent in their support for New Zealand's regulatory environment:

- Callum Thorpe from MBIE outlined the "least regrets" permissive regulatory regime for CCUS that the Ministry has consulted on.
- Professor Barry Barton from Waikato University described how the existing regulatory regimes for carbon use can accommodate CCUS and the specific legal issues that long-term storage raise.

"(Capture and use) don't present as many legal issues, complexities, difficulties."

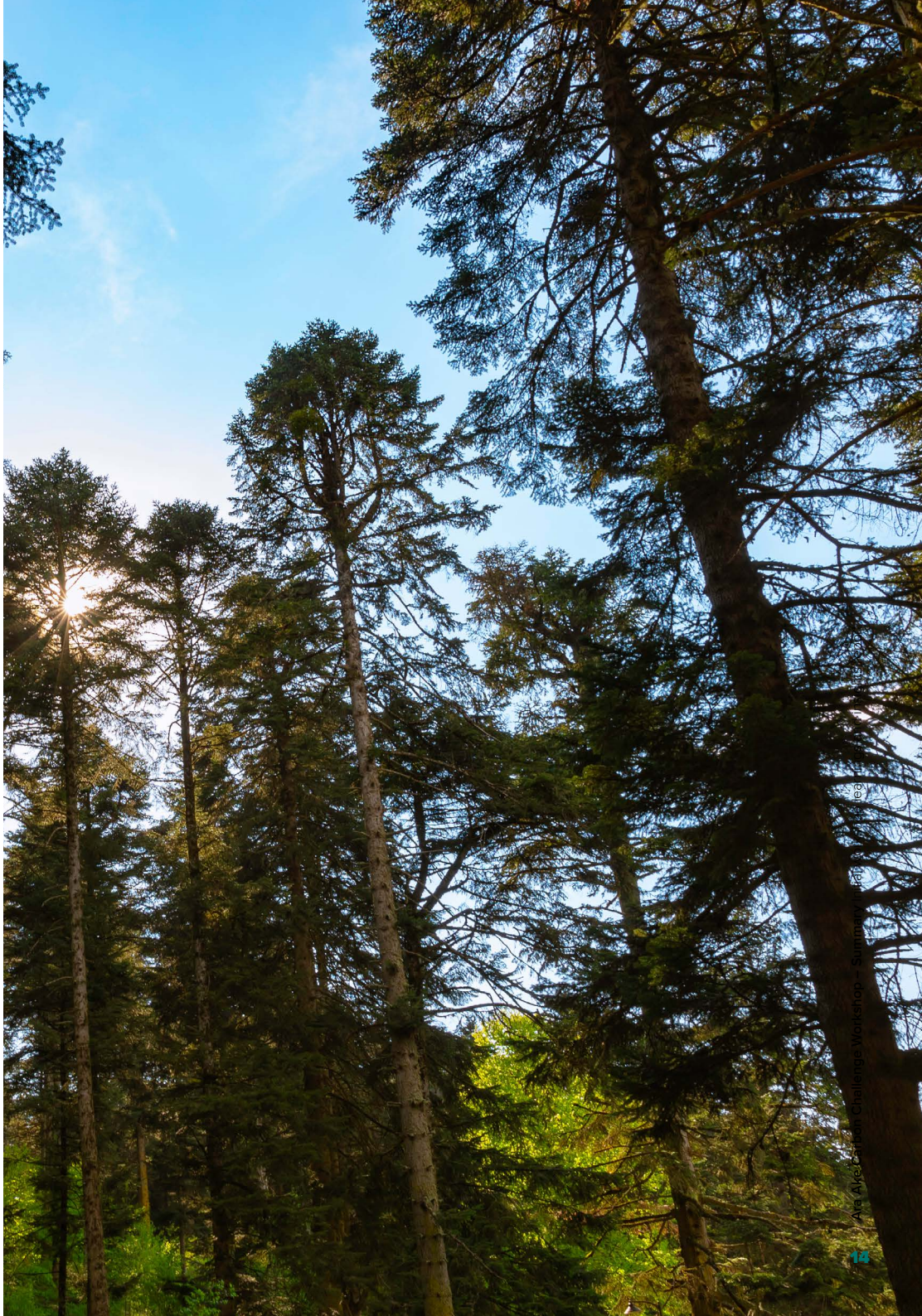
Professor Barry Barton | Waikato University

- John Burnell from GNS Science built on Katie McLean's presentation to explain some of the risks and uncertainties in reservoir properties and their implications for long-term storage
- Andy Knight, CEO of sector co-regulator, the Gas Industry Company, drew on the **World Energy Council "trilemma"** to suggest that social licence for CCUS is less dealing with NIMBYism[8] than showing the role of the technologies in maintaining supply security and energy affordability as we decarbonise

"In New Zealand we've associated gas (and CCUS) with "dirty" ... we're not ready as a country to go through the rapid decarbonisation that goes with turning off gas and coal ... I think we've fallen into a trap of believing we can decarbonise quickly without having the dramatic devastation of our jobs and our economy."

Andrew Knight | Chief Executive, NZ Gas Industry Company

8 "The behaviour of someone who does not want something to be built or done near where they live, although it does need to be built or done somewhere" **dictionary.cambridge.org/**



Problem statements

Ara Ake hosted a workshop in the afternoon following the seminar, with representatives of key industries that emit and use carbon. The workshop built on the morning's presentations to clarify what technical problems are preventing the wider deployment of CCUS in New Zealand.

Large scale CCUS is expensive

Russell Dyer's presentation concluded with the market reality that all stages of CCUS are expensive and none of those costs can currently be recovered in prices when Golden Bay Cement is competing against offshore companies whose production is not subject to a carbon price.

The solution is simple: CCUS technologies need to be much cheaper than the current ETS price. To be commercially attractive, CCUS innovations need to be less than 10% as expensive as current technologies.

Small scale carbon capture is expensive

Ara Ake's report, **Carbon Dioxide Removal and Utilisation in Aotearoa New Zealand**, identifies that New Zealand has a relatively small number of large point source carbon emitters. Much of our fugitive CO_2 is from small scale operations all over the country.

CCUS has economies of scale and it is too expensive for commercial deployment at small point sources. For widespread deployment at distributed sources in New Zealand, innovations need to lower the cost of capture.

Filtering food-grade CO_2 is expensive

The national CO_2 shortage has improved our understanding of the importance of food-grade CO_2 in the food, beverage, health and water treatment sectors. Imported food-grade CO_2 is eight times as expensive as that produced domestically but those who have entered the market to create supply options since the shortage have found it difficult to comply with food regulations, particularly from smaller sources of CO_2, at a cost the market is prepared to bear.

Making synthetic fuel is too expensive

A major potential use for captured CO_2 is as a feedstock for sustainable aviation fuel.

Currently biogenic SAF is three to five times the price of fossil jet fuel, while eSAF (produced from green hydrogen and DAC) is more than ten times the price.

Electricity costs are a key input to both bioSAF and eSAF manufacture but achievable with innovations to reduce the cost of carbon capture and transportation to SAF production sites that use standalone low-cost intermittent renewable generation that isn't burdened with national security, resilience and balancing costs.

Innovator requirements

The challenge is simple: make the costs of CCUS as low as possible, several orders of magnitude cheaper than it is now, without necessarily relying on economies of scale.

The ideal innovator to solve the Carbon Challenge can provide:

- A technology with the potential to achieve very cheap carbon capture (<<$100USD/ tCO_2), likely through a process which is decoupled from national electricity prices (i.e. powered by standalone local production or highly flexible interconnected plant)
- A technology which is modular and scalable
- A technology capable of capturing not only carbon, but is capable of producing multiple revenue streams i.e. value stacking, and
- A technology eligible for internationally verified credits.

Since New Zealand's regulatory framework for carbon storage is not yet finalised, and there is a growing industry demand for CO_2 as feedstock, Ara Ake will initially focus on carbon usage. The aim is to connect industries with emissions challenges and feedstock shortages, with innovators to bridge the gap[9].

The Ara Ake Challenge perspective has highlighted the complementary roles of carbon use and storage that can drive the price down on the capture of CO_2.

We want to partner with:

- New Zealand industry players with a CO_2 source
- New Zealand industry players with a CO_2 need and
- an innovator or innovators who can essentially connect the two

One of the key learnings from the summit was that regulations allow for CCU now, whereas CCS still has a way to go. As a result, CCU was identified as a near-term opportunity, although in itself its impact in reducing CO_2 in the atmosphere is likely to be minor.

9 Long-term storage raises its own issues which are not for Ara Ake to resolve.

Conclusions and next steps

Participants have echoed that the Carbon Challenge summit brought together those with real-world experience of emissions costs and a need for CO_2. Problem Statements and Innovator Requirements were reached in the afternoon workshop.

There is really one problem statement: CCUS is too expensive even at current ETS prices although there are specific use cases (large and small scale, processing food grade CO_2 and manufacturing synthetic fuel) which different technologies and innovations will address.

Ara Ake is looking for innovators with technologies that could reduce costs by an order of magnitude or more and industry partners whose processes emit carbon and who can host trials to realise those cost reductions.

The next step for Ara Ake is to recruit those industry partners.

Ara Ake

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