CCS in New Zealand

Can carbon capture and storage deliver value to New Zealand as we head towards a low carbon future?

Summary Report

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TRANSFIELD WORLEY

NZCCS PARTNERSHIP
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Preface

In 2009, Transfield Worley Ltd led a consortia of leading practitioners on CCS globally to examine the potential of carbon, capture, and storage (CCS) for New Zealand. This research was supported by the Ministry of Science and Innovation (MSI) under contract TRAN0901, reference CONT-21185-CCS-TRANSFIELDAK.

Specifically, we wanted to find out whether CCS has potential to deliver value for New Zealand as we move towards a low carbon future. As part of that broad question to:

- identify potential opportunities for, and possible benefits of, CCS in New Zealand
- find out what barriers there might be to deploying CCS in New Zealand
- find out what gaps in knowledge and capability there are in relation to CCS in New Zealand
- find out what technical, legal, commercial, environmental and social issues would have to be resolved before CCS could be deployed in New Zealand.

This report presents, in summary form, the results of that research with some additional commentary on carbon business cases by Evans & Peck. A technical report containing detailed case studies is also available on the website of the Ministry of Economic Development (www.med.govt.nz).

About the New Zealand Carbon Capture and Storage Partnership

The NZCCS Partnership was formed in 2006 to create core knowledge, capability and understanding of the options, risks, opportunities and feasibility of CCS for New Zealand, in order for New Zealand to be ready to adopt CCS technologies when they become available and as required. The Partnership includes government and industry contributors.

About the research consortium

The research on which this report is based has been carried out by a number of leading industry practitioners led by Transfield Worley Ltd, and included Schlumberger (Australia), WorleyParsons (USA), Baker & McKenzie (Australia), Montgomery Watson Harza (NZ), and CSIRO (Australia).

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1. Executive Summary

CCS (carbon capture and storage) has global significance as it is one of a range of options available for reducing carbon dioxide emissions. This report considers whether CCS has the potential to deliver value to New Zealand as we move towards a low carbon future.

CCS involves the capture of carbon dioxide emissions from large emitters such as power stations and processing plants. That carbon dioxide is then transported (usually through a pipeline) to a reservoir, very deep underground, where it is injected into porous rock. Although integrated CCS is in its infancy internationally, the individual components (capturing carbon dioxide, transporting it in pipelines, and injecting gas into reservoirs) have all been used internationally and in the New Zealand oil and gas industry for decades.

The NZCCS Partnership (a group of interested industry and government representatives) commissioned a study in 2009 to investigate the implications of CCS should it be deployed in New Zealand. This study, completed by a Transfield Worley Consortium, considered the technical, commercial, legal/legislative, environmental, and social aspects of CCS. This report summarises those findings, while also considering where CCS fits into the international and New Zealand responses to climate change. It includes two case studies considering the viability of CCS for existing and new plants, along with analysis of legislative, environmental, social and economic barriers to the adoption of CCS.

Undertaking a CCS project is not a cheap or simple option for responding to climate change. The capital expenditure alone is in the order of hundreds of millions of dollars. Currently, New Zealand legislation would not easily support CCS developments and would add cost and risk to any CCS project. A lack of detailed information about suitable reservoir sites adds to that risk, as does uncertainty about future carbon prices and a lack of public knowledge about CCS.

These issues, however, can be worked through in time. Overall, this study has found that there are some scenarios in which CCS has potential to reduce carbon dioxide emissions safely, cost-effectively, safely and in a manner that has minimal impact on the environment. Alongside other carbon-reduction technologies, therefore, CCS could be viable in New Zealand and could deliver value to the country as we move towards a low carbon future.

2. What is carbon capture and storage?

CCS is the process of capturing carbon dioxide gas (CO_2) from large sources (such as power stations and industrial processing plants) and transporting it to a suitable underground site for permanent storage.

Carbon capture

The first stage is carbon capture. This can take place at various stages during industrial processes, and using various methods. For example, in a coal-fired power station, carbon dioxide can be captured (separated or extracted) from the flue gases after the coal has been burned. But, in some industrial processes, carbon dioxide can also be captured before combustion or during the process.

Carbon transport

After carbon dioxide is captured, it must be transported to a suitable reservoir. Generally, it will be transported in a pipeline (though it is technically possible to transport it by ship or road). Carbon is transported in a 'supercritical' state, which means its temperature and pressure are raised so it behaves like a liquid and flows through the pipeline.

Carbon storage

Finally, this 'supercritical' carbon dioxide is injected into porous rock very deep (at least 800 metres) underground. For example a depleted gas on oil reservoir on a saline aquifer could potentially support carbon storage. The underground rock acts as a sponge, filling up with the carbon dioxide and trapping it. A layer or layers of less porous rock, known as 'cap rock', prevents the carbon from returning to the surface.

The best sites for carbon storage:

- are reasonably close to the carbon source
- have rock that is permeable and porous
- have high integrity cap rock to provide a suitable seal.

Considerable exploration and testing is required to confirm that a site is suitable for use as a carbon reservoir. For industries considering CCS, this is likely to be the area of greatest uncertainty and cost.

2.1 International experience of CCS

As industries become more carbon constrained, they are likely to adopt a range of approaches to (a) reduce the volume of carbon dioxide they emit and (b) to mitigate the impact of their emissions. CCS provides one option for mitigation, and therefore for reduction in emissions of carbon dioxide to the atmosphere. It is suitable for industries that are large emitters, and is particularly relevant for economies that have a substantial and increasing reliance on fossil fuels.

Internationally, there has been strong interest in CCS as a carbon mitigation option. By 2010, five large scale CCS projects were in operation, and a 2010 study commissioned by the Global CCS Institute identified another 80 large scale projects at various stages of development. Notable efforts from both government and industry can be found in the United States, the European Union (particularly the United Kingdom), Canada and Australia.

The International Energy Association believes that CCS has an important role to play in meeting international emission reduction targets. It estimates that CCS could account for 19% of the energy-related emission reductions that are required to stabilise CO_{2e} concentrations in the atmosphere to less than 450 parts per million. This is similar to the potential emissions reductions from adoption of renewable energy sources.

2.2 New Zealand experience of CCS

New Zealand does not have any CCS projects operating or under development. However, all of the individual components of CCS have been used in New Zealand for many years. Carbon dioxide separation from process/feed gases has been used for several decades (for example in the Kapuni Gas Treatment Plant, operational since 1970). Gas pipelines are relatively commonplace. Gas injection into rock has been used in gas exploration and for methane storage.

The New Zealand Government and industries are taking part in several international initiatives aimed at developing pathways towards commercial adoption of CCS. New Zealand participates in the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), the Carbon Sequestration Leadership Forum and the International Energy Agency's Greenhouse Gas R&D Programme, and the Global Carbon Capture Research Institute. Membership of these international initiatives ensures that New Zealand has access to the most current research and data on CCS.

For example, through its ongoing participation in the CO2CRC, New Zealand has a direct access to the current CO2CRC Otway CCS Demonstration Project. This is an innovative, world-leading project to demonstrate the practicality and environmental requirements for the deep geological storage of carbon dioxide; stored in a depleted gas reservoir in southwestern Victoria. Further injections into different formations are being planned.

It is intended that monitoring and appraisal of this project will help inform public policy and industry decision-makers on the requirements for CCS development, while also providing a greater assurance to the community on the environmental performance of such schemes. Any lessons arising will help shape ongoing research and investigation of CCS in New Zealand, as well as contributing towards industry and government thinking on the potential deployment of the technology in our country.

3. The potential of carbon capture and storage for New Zealand industries

New Zealand has a number of power stations and processing plants that could potentially support CCS in the future. Most of these are in the North Island, though some are in the South.

As a rule of thumb, CCS is considered potentially viable when carbon dioxide emissions are above 0.8 - 1 million metric tonnes (MMT) per year for coal-fired power stations and 0.4 - 0.5 MMT per year for other applications. However, process industries with lower emissions that separate carbon dioxide as part of existing operations should also be considered, as these potentially could be easier and more cost-effective to retrofit. These “low hanging fruit” include the Marsden Point Oil Refinery Hydrogen Manufacturing Unit, the Kapuni Gas Treatment Plant and the Kapuni Ammonia-Urea Plant.

Table 1: Industrial CO2 Emitters Potentially Suitable for CCS

Location & Industry	Existing CO_2 Separation?	Few Sources/ Venting?	CO_2 above 1MMT/y?
Marsden Point Oil Refinery	Y	N	Y
Glenbrook Steel Mill	N	N	Y
Golden Bay Cement Mill	N	N	Y
Huntly Power Station	N	Y	Y
Motunui Methanol Plants	N	Y	Y
Stratford Power Station (incl Peaker Plant)	N	Y	Y
Kapuni Urea Plant	Y	Y	N
Kapuni Gas Treatment Plant	Y	Y	N

Note: In addition to these sites, the Tiwai Point Aluminium Smelter emits more than 1MMT a year of carbon dioxide. It is the only major source of carbon dioxide emissions in the South Island. However, it is not considered suitable for CCS because the concentration of carbon dioxide in its overall emissions is low, and carbon capture technology would therefore not be viable.

Several projects in various stages of planning and execution may add to this list. These include: Solid Energy and Ravensdown’s investigations into lignite conversion to fertiliser in Southland; L & M Energy’s, Comet Ridge’s and Solid Energy’s coal seam gas investigations; Holcim Cement’s proposals for a cement plant on the east coast of the South Island; and potential oil and gas developments in the Taranaki Basin, offshore East Coast, or Southern Basin. In the future, CCS may be suitable for other applications in New Zealand such as biorefineries or biomass power generation.

3.1 Enhanced oil or gas recovery/enhanced coal bed methane

Enhanced oil recovery (EOR) and enhanced gas recovery (EGR) using carbon dioxide have been identified as potential options for New Zealand. These technologies use captured carbon dioxide to increase pressure in an oil or gas reservoir to assist with production.

Enhanced coal bed methane (ECBM) using carbon dioxide has also been identified as a potential option for New Zealand. This technology uses carbon dioxide to displace methane from an underground coal bed, releasing the methane for production.

While these processes are technically possible and are already used internationally, they are not the same as carbon capture and storage. Rather, they are used to enhance production, with some carbon dioxide storage as a secondary benefit only. They can, however, represent an intermediate step on the pathway towards commercial use of CCS and will be obviously more cost effective than standalone CCS deployment.

Table 2 summarises some of the differences between carbon dioxide storage and carbon dioxide EOR or EGR. These differences would need to be considered if these options were progressed.

Table 2: Carbon Dioxide EOR/EGR Versus CCS

	Enhanced Oil/Gas Recovery	**Storage**
1	CO_2 rate depends on Production Strategy (which may change over lifetime of activity e.g decrease)	CO_2 Injection Rate determined by source
2	CO_2 Recycled (recovered from reservoir gas)	CO_2 Stored
3	Legislated under petroleum industry	New CO_2 Regime required
4	No monitoring	Long-term monitoring
5	Revenue from Hydrocarbon	Revenue from price of Carbon
6	Low public awareness (outside of industry)	High public awareness

4. Case studies

These two case studies consider the potential for CCS to cost-effectively reduce carbon emissions into the atmosphere from major New Zealand emitters.

The first concerns CCS technology retrofitted to an existing natural gas combined cycle power plant in Taranaki. The second concerns CCS technology adopted as part of a new lignite processing plant in Southland. Both are hypothetical.

For details of the case studies, including technical assumptions, see the technical report *CCS in New Zealand – Case* Studies *for Commercial Scale Plant*, available on the website of the Ministry of Economic Development (www.med.govt.nz). Some additional information is provided here relating to carbon costs.

Case Study One: Retrofit existing plant

In Case Study One, we considered the potential for CCS to be retrofitted to an existing natural gas combined cycle (NGCC) power station. Most of the gas-fired power stations in the North Island use NGCC technology.

The station was assumed to be similar in size to the Stratford Power Station in Taranaki, owned by Contact Energy. This theoretical project would require:

- installation of an advanced system to capture carbon dioxide from the gas turbine exhaust[1]
- installation of multiple stage compression technology to raise the pressure of the carbon dioxide so it can be transported in a pipeline
- development of a new pipeline to transport the carbon dioxide to the storage site
- five injection wells at the storage site, assumed to be a depleted gas field about 30 km from the power station.

Altogether, the carbon capture technology would capture about 1 million tonnes of carbon dioxide each year. In addition, this case study includes storage of about 300,000 tonnes of carbon dioxide each year from the nearby gas treatment plant or ammonia urea plant, both of which already have carbon dioxide separation as part of their processes.

The most viable option for carbon capture for an NGCC power station is post-combustion capture technology. However, retrofitting an existing NGCC station has two major disadvantages. First, major new capital equipment is required. Second, low pressure steam is diverted from electricity generation to carbon capture. This makes the electricity plant less efficient (meaning that more gas is required to produce each unit of electricity, and overall electricity production from the plant would decline, as Table 3 shows).

[1] Specifically, the system proposed was an advanced monoethanol amine (MEA) solvent based chemical absorption system.

Table 3: Case Study One Power Station Performance Costs[2]

	Load Existing	Load After	Load Change	NZ$/day	% Change
Fuel Gas Increase	2390 GJ/h	3019 GJ/h	629GJ/h	-$90,760	26%
Net Power Lost	369.48MW	356.99MW	12.5MW	-$65,950	3%
ETS (CO_{2e})	142T/h	39T/h	-103T/h	$61,800	72%
			Total (Difference)	***-$94,700***	

Tables 4 and 5 set out estimated capital expenditure and annual costs for operations and maintenance, though these are very broad estimates only.[3]

Table 4: Case Study One Capital Expenditure

Description	Installed Costs ($NZ millions)
Carbon Capture Process Equipment (±40%)	318.09
Carbon Transport	49.83
Carbon Storage (5 vertical injection wells)	136.59
Commissioning	18.00
Contingency (20%)	40.88
Total CAPEX	***563.39***

Table 5: Case Study One Annual Operating Costs

Description	Costs ($NZ millions)
Capture / Transport	15.44
Storage	4.59
TOTAL	***20.03***

In all, it is estimated that capital costs would exceed $560 million, and ongoing operating and maintenance costs would exceed $20 million annually. At these costs, the project is unlikely to be economically viable unless the price of carbon increases significantly from its current level of $25 a tonne (Table 6).

[2] The changes in operating costs are based on assumed unit rates and include: fuel gas = $6NZ/GJ; net power (sales) = 22c/kWh, ETS = NZ25/TCO2e; and are modelled on a later model power station with net efficiency (LHV) reducing from 55.7% to 42.6%. In reality, older power stations (e.g. existing New Zealand models) would be less efficient again.

[3] The capital cost estimate assumes that there are no 'lost development costs' associated with exploration and appraisal of sites that turn out to be unsuitable. For carbon capture and transport, operating costs are estimated as 1% of capital expenditure and maintenance costs are estimated at 3% of capital expenditure. Operating costs and maintenance for carbon storage have been estimated more rigorously and include ongoing costs for consumables (fuel, electricity, water) insurances, and storage site equipment maintenance.

Table 6: Case Study One Carbon Price Points

Discount Rate	Year 1 Carbon Price to Break Even
5% (Social discount rate)	\$NZ 83 / T CO_{2e}
10% (Treasury discount rate)	\$NZ 103 / T CO_{2e}
15% (Industry / commercial discount rate)	\$NZ 128 / T CO_{2e}

Even though this case study suggests that retrofitting CCS to an existing NGCC power station is unlikely to be economic at current carbon prices, retrofitting may be economic in other circumstances. For example, retrofitting may still be economic for existing process plants with carbon dioxide separation processing.

Case Study Two: New process plant

Case Study Two considers the addition of a carbon dioxide compression system to a hypothetical new lignite processing plant, producing urea, in the South Island of New Zealand. This is a purely hypothetical case, unrelated to any specific proposals for lignite plants.

In this case, carbon dioxide separation is assumed to be an integral part of the process. However, additional capital outlay would be required for compression, transport and injection. It is assumed that 4 million tonnes of carbon dioxide are stored each year, in an underground reservoir 100km from the processing plant. A new underground pipeline would have to be built, and the underground reservoir developed.

The carbon capture operation would require additional electricity use, but this would be more than offset by Emissions Trading Scheme credits resulting from the plant's reduced emissions (Table 7).

Table 7: Case Study Two Performance Costs[4]

	Load Existing	Load Change	\$NZ/day	% Change
Electricity Increase	0MW	22.5MW	-\$43,100	n.a.
ETS (CO_2)	456T/h	-456T/h	\$273,970	100%
	Total (Difference)		***\$230,770***	

Tables 8 and 9 set out estimated capital expenditure and annual costs for operations and maintenance (as with Case Study One, these are very broad estimates).

[4] The changes in operating costs and based on assumed unit rates and include - net power (high user) = 8c/kWh, ETS = \$NZ25/CO2tonne,

Table 8: Case Study Two Annual Operating Costs

Description	Costs ($NZ millions)
Capture / Transport	13.20
Storage	15.77
TOTAL	***28.97***

Table 9: Case Study Two Capital Expenditure

Description	Installed Costs ($NZ millions)
Carbon Capture Process Equipment (±40%)	136.16
Carbon Transport	184
Carbon Storage (24 vertical injection wells)	478.05
Commissioning	10
Contingency (20%)	134.41
Total CAPEX	***942.62***

In all, it is estimated that capital costs would exceed $940 million, while ongoing operational and maintenance costs would exceed $20 million a year (though, as with Case Study One, these are very broad estimates only).

At these costs, the project may be viable at the current New Zealand price of carbon ($25 a tonne) or just above (Table 10). However, it must be understood that there is considerable uncertainty over the cost of finding and appraising a suitable storage sites. As with Case Study One, these figures assume that there are no 'lost development costs' associated with exploration and appraisal of sites that turn out to be unsuitable. Before a site can be confirmed as suitable, seismic studies must be completed, and considerable work must be carried out to determine its capacity and its suitability for gas injection. In addition, property rights and regulatory approvals must be obtained. Altogether, it may take many years of exploration and appraisal to determine whether or not CCS will be feasible and cost-effective for any particular project.

Table 10: Case Study Two Carbon Price Points

Discount Rate	Year 1 Carbon Price to Break Even
5% (Social discount rate)	$NZ 20 / T CO_{2e}
10% (Treasury discount rate)	$NZ 32 / T CO_{2e}
15% (Industry / commercial discount rate)	$NZ 45 / T CO_{2e}

Case studies – conclusion

The case studies indicate that CCS may be able to contribute value to New Zealand as the country moves towards a low carbon future. CCS is more likely to be economic when included as part of a greenfield development, rather than when it is retrofitted to an existing plant. It is also more likely to be economic for larger emitters than for smaller ones.

However, the economics of any CCS project will depend, among other things, on the cost of identifying, appraising and developing a carbon storage site, and on present information these costs are very uncertain.

5. A Framework for CCS in New Zealand

Although CCS has potential to provide a cost effective method of reducing carbon dioxide emissions in some circumstances, there are also risks and uncertainties that will influence the viability of any CCS project. These include gaps and barriers in legislation, limited public and stakeholder knowledge of CCS, limited information about potential carbon storage sites, and considerable uncertainty about future carbon prices.

5.1 The business case for CCS

Now that carbon emissions have a price, emitters will have to decide whether it is financially preferable to reduce their emissions (through CCS or other technology) or continue to emit and buy permits under the Emissions Trading Scheme.

Many factors will influence their decisions, including the quantity and intensity of their carbon dioxide emissions, and the availability of technological or processing advances to reduce those emissions. They will also need to take a long range view, as carbon prices will change throughout the life of their processing plant.

Any decision to adopt CCS in order to reduce carbon liability should be based on a sound business case and should reflect consideration of:

- the nature of the facility and the suitable capture technologies commercially available
- the carbon dioxide transport infrastructure available, if any
- the location and risks of underground storage sites (including distance from the plant, and the difficulty and time involved in developing it)
- the legislative and regulatory framework
- potential risks, and how they might affect costs
- the available financing arrangements (for instance, CCS is more easily justified as part of a new process facility than an existing one).

A sound business case study will model the costs of carbon capture, transport, storage, commissioning, operation, and finance. The case studies on pages 7-10 show the magnitude of the costs that could be expected in such a business case.

Assessing risk

To justify the capital expense of a CCS project (either standalone or as part of a larger new project), a business must take account of uncertainty and risk associated with the carbon emissions. A price needs to be put on these uncertainties and risks, so that the business can determine the project's present day value and therefore make a sound decision on whether or not to go ahead. The business case modelling may be repeated and updated throughout the lifetime of the project, as each project phase (concept identification, development, exploration, definition and execution) is completed.

Uncertainty over the price of carbon

In the short term (until December 2012), there is some certainty about the price of carbon emissions, as emitters can buy carbon emission permits at a fixed price of $25 a tonne. As the case studies showed, this price may be sufficient to justify investment in a new process plant or power station, but is less likely to be viable for an existing plant.

In the medium and long term, the price of carbon is less certain. Over the lifetime of a plant, carbon costs could evolve in unpredictable ways depending on international agreements, the performance of market forces, and other factors. Any CCS business case will have to take account of this uncertainty. Determining medium and long term prices of carbon will require a rational risk based approach defining upper and lower bounds around a likely outcome with a probability profile linking them.

Other risks and uncertainties

In developing a business case for CCS, several other uncertainties must also be considered. These include difficulties associated with finding a suitable site for carbon storage, gaps and barriers in legal and regulatory processes, environmental risks, and risks of public opposition on social, cultural or environmental grounds.

Finding and assessing a carbon storage site can take many years and anything from $25 million to $150 million. A considerable amount of work is needed to determine – among other things – the site's capacity, its suitability for gas injection, and its vulnerability to seismic activity and leaks. With any CCS project, there is a risk that timeframes and costs may balloon, as effort is put into assessing sites that turn out to be unsuitable. In New Zealand, the government has undertaken some geological mapping work, which is the first step towards assessing potential sites. But there is still relatively little information publicly available to support decisions about potential CCS reservoirs.

Legal, environmental and social issues are considered below.

5.2 The legal environment

New Zealand does not have a comprehensive legislative framework applying to CCS. Although there are no laws expressly prohibiting CCS, the current legal framework is incomplete and uncertain in relation to its key stages (capture, transportation, and storage). This is likely to create significant uncertainty for CCS project developers, financiers and insurers in relation to legal risks and liabilities. Before CCS could become feasible in New Zealand, gaps and potential barriers in the legislative framework will need to be addressed.

The Resource Management Act

The Resource Management Act 1991 (RMA) appears to be the New Zealand law most relevant to CCS. The RMA is a comprehensive environmental code that applies broadly to all the environmental effects of any activity, and imposes a duty on ‘every person’ to avoid, remedy or mitigate adverse effects on the environment from their activities. It is anticipated the Act will apply to all stages of a CCS project (i.e. carbon capture, transportation, and storage).

As explained below, most of the potential environmental impacts of CCS can be worked through as part of normal resource consent processes. However, the RMA imposes some specific barriers to long-term storage of carbon dioxide in underground reservoirs, including:

- The Act is likely to class carbon dioxide as a contaminant. It therefore imposes specific restrictions on discharges into the environment, and if any carbon dioxide leaks from the reservoir the project owner may be legally liable for discharging a contaminant into the environment.
- The Act does not allow resource consents to be granted for periods longer than 35 years.

In addition, with any RMA process, there may be risks around timeliness of the consent process and these may affect the viability of a CCS project. Furthermore, there may be inconsistent approaches among local authorities from region to region – particularly as some local authorities have more experience of CCS-related technologies than others. In response to this, businesses may consider lodging consent applications directly with the Environmental Protection Authority on the basis that a CCS project is a project of national significance.

Other laws and regulations

Many other laws may apply at different stages of a CCS project. For example, the Crown Minerals Act 1991, the Continental Shelf Act 1964, and the Marine and Coastal Area (Takutai Moana) Act 2011 may all apply to the process of exploration for a carbon storage site and to the process of injecting carbon dioxide for storage.

The Climate Change Response Act 2008 will apply to site exploration and carbon capture. This Act will also have implications for monitoring and reporting.

The Building Act 2004 will apply to the structures used in carbon capture and injection into reservoirs.

The Gas Act 1992, the Hazardous Substances and New Organisms Act 1996 and various regulations will apply to carbon transportation.

Yet within these various Acts and regulations, there are gaps and obstacles to CCS. For example:

- The Crown Minerals Act and the Continental Shelf Act provide for oil and gas extraction, but not specifically injection of gases or liquids into underground reservoirs. Furthermore, exploration permit areas allocated under the CMA are of insufficient size to support a CCS development.
- The Climate Change Act CCS is defined as a carbon removal activity for the purposes of the Emissions Trading Scheme but regulations have not been developed, therefore there is currently no mechanism under the Act.
- The Gas Act governs gas pipeline and operation, but does not currently define carbon dioxide as a gas. This gap would need to be closed before CCS projects could be furthered.

In addition, CCS requires large reservoirs for underground storage of carbon. In many cases, areas that contain potential CCS reservoirs have already been committed (under the Crown Minerals Act permits) for oil and gas exploration. Alternatively, for depleted oil and gas fields, CCS may affect adjacent oil and gas exploration.

5.3 Potential environmental impacts

In general, there are few environmental impacts of CCS that cannot be worked through as part of normal planning and consenting processes.

Of the potential environmental impacts associated with CCS, the area of greatest uncertainty concerns the impact of carbon dioxide escaping from the underground reservoir. This could – in theory – occur either as a slow leak or as a larger release caused by a more rapid failure in the system.

The potential consequences of any leak would depend on how it occurred and how much carbon dioxide was released. If the carbon dioxide leaked into air, it would readily disperse and so cause few if any direct environmental effects. If, however, it leaked in sufficient quantities into a shallow aquifer or a lake or stream that was used for drinking water, it could cause contamination. Leaks may also affect local ecosystems, though there is considerable uncertainty about this. Small seepages may produce no detectable impact, but relatively large releases may cause measurable harm.

While these consequences are theoretically possible, with proper site selection and risk mitigation, the probability of either a slow seepage or a larger unintended release is very low.

As part of any consent application, the owners of a CCS project would have to provide detailed information about risks and risk mitigation. This would include detailed information about the storage site, including its potential vulnerability to leaks and the potential consequences of leaks if they did occur. They would also have to have an ongoing programme in place to (among other things) monitor for leaks and ensure that the cap rock remained stable. They would also have to have appropriate methods in place to stop or control any leaks that did arise and would be liable for leaks under the ETS.

Expansion of the legislative and regulatory regime to specifically cover CCS would assist with proper risk assessment and mitigation.

5.4 Potential social issues

As an emerging technology, CCS remains relatively unknown in New Zealand, and this lack of knowledge may heighten public and stakeholder concerns about the potential risks.

Interviews with stakeholders such as officials, industry representatives, and environment groups[5] suggest that CCS is seen as having potential to mitigate greenhouse gas emissions from electricity generation and resource use. It was seen, therefore, as having potential to contribute to economic growth by allowing exploitation of resources (such as lignite) that might not otherwise be available due to the impact of their carbon emissions.

Some stakeholders saw CCS as having potential to play an important role (along with other technologies) in reducing New Zealand's greenhouse gas emissions, while others believed it failed to address 'the real problem' with respect to climate change (i.e. reducing reliance on fossil fuels). Some stakeholders saw CCS as potentially risky, especially given New Zealand's unique geology and seismic activity.

Many stakeholders saw an important role for the government in providing a policy environment that enabled CCS but did not favour it over other technologies for reducing carbon dioxide emissions into the atmosphere.

Participants felt that CCS projects may encounter local opposition, particularly as the benefits from reducing carbon dioxide emissions are global but the risks are local. Local opposition was likely to vary from place to place, depending on past experiences with major industries. CCS was also seen as potentially conflicting with Maori values relating to land and landforms. Stakeholders emphasised the need for information to improve awareness and understanding of CCS, along with early and comprehensive engagement with all stakeholders over any CCS project.

5 The interviews were conducted and analysed by CSIRO, a member of the research consortium.

6. The path forward

CCS is one of a suite of low carbon and carbon mitigation technologies that could play roles in supporting economic growth while also allowing us to meet our obligations under the Kyoto Protocol.

At present, New Zealand has eight existing industrial plants that have potential to use CCS technology. Several proposed projects could also benefit. In general, the potential for CCS is greater for larger emitters than smaller, and larger for greenfields developments than existing plants.

However, for the potential of CCS to be realised, further work is needed to overcome barriers to its adoption. The Government has a role in addressing legislative barriers (such as those in the RMA and in oil and gas pipeline regulations) and providing certainty over policy. While existing laws and policies may be amended to provide for CCS, it may alternatively be appropriate to develop CCS-specific approaches.

Government and industry may also be able to collaborate in order to gather information about possible CCS reservoir sites. Industry and researchers have roles in developing and using CCS where it is safe, economically viable, socially acceptable, and any environmental risks are minimal or can be mitigated.

Overall, our study has found that CCS has potential to provide value for New Zealand as we move towards a low-carbon future.

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