# Submission to MBIE on "Proposals for a Regulatory Regime for Carbon Capture Utilisation and Storage"

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My professional career was as a chemical engineer. I specialised in technical and economic assessment of CCS from its inception. In this submission, I first present my personal observations of the evolution of CCS over the last 40 years. I then, respond to the submission questions in that context.

**The history of CCS**

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In the early 1980's, Carbon Capture and Storage (CCS) had its beginnings in the UK coal industry. The Chief Scientist had read about Global Warming. He recognised the threat it posed to the coal industry. He challenged his boffins with the simple question *"We know how to remove $SO_2$ from flue gas from a coal-fired power station to avoid acid rain. Can we remove $CO_2$ from that flue gas to avoid Global Warming"*. Their initial thought was to send a polite reply saying, *"No. Don't be so silly."* with an explanation of the scientific constraints. But the boffins put their heads together and brain-stormed ideas. *[I was one of those boffins.]*

The boffins came up with the four ways to separate $CO_2$ from gas; chemical, physical, membrane and cryogenic. They checked out these ideas in their laboratories and assessed the economics of them. It became clear that economic front runner was chemical separation from coal power plant flue gas, using energy drawn from the power plant. They also proposed that the best place to store $CO_2$ would be in depleted gas fields, where natural gas had been held for millions of years without leaking out. The boffins told the Chief Scientist that CCS was credible but expensive.

In the late 1980's CCS ideas were refined further. An International Energy Agency Research and Development Programme was set up at Coal Research in the UK to co-ordinate studies of CCS technologies, which were happening at many institutes. They were all seeking a breakthrough technology, which would bring down the cost of CCS. There were improvements, but there were no dramatic breakthroughs. The benchmark process was CCS on a coal fired power station, which was estimated to cost of the order of US$100/tonne of $CO_2$ emission avoided.

In the 1990's the focus of CCS investigations expanded to consider seriously the storage part of CCS. The obvious place to put $CO_2$ was in old gas fields that had filled up with water as the gas was drawn out. The injection of supercritical $CO_2$ could displace that water again and remain captured by the proven gas cap. At Sleipner the cost of injecting $CO_2$ from Norwegian natural gas stripping was funded by avoiding a high carbon tax. The world's first CCS scheme was operational. However, the higher cost of CCS from coal or gas fired power generation was much greater than the incentive provided by carbon charge avoidance at that time. CCS was deemed to be impractical, when really it was just uneconomic.

*[In 1994 I was invited to prepare and present evidence on CCS for the proposed Taranaki Combined Cycle power station, as an overseas expert witness to the Government Call-in of the resource consent application. I explained how CCS could be done, with $CO_2$ storage in depleted natural gas fields. I estimated that CCS would more than double the cost of electricity from that gas-fired power station. CCS was again deemed to be impractical, when really it was just uneconomic. When the lead lawyer asked me to informally summarise for him the problem with CCS from a natural gas power plant, I*

*said "It is like an Irishman giving road directions and saying "If I was going where you are going I would not be starting from here"" He didn't let me present that joke in my formal evidence.]*

In the 1990's Enhanced Oil Recovery (EOR), using injected $CO_2$ to release additional trapped oil from some aging oil fields, had become an established technique in the oil industry. EOR provided a market for captured $CO_2$ as a commodity. Most EOR operations used the low-cost $CO_2$ that had to be stripped anyway from high-$CO_2$ natural gas. However, a few EOR operations used the more expensive $CO_2$ captured from coal-fired power generation (e.g. Boundary Dam in Saskatchewan). While such operations served to demonstrate the technical feasibility of CCS, the critical CCS objective of reducing the net emissions of $CO_2$ to atmosphere was not met, because each tonne of carbon injected in the form of $CO_2$ on average enabled one tonne of carbon in additional crude oil to be extracted from a depleted oil well. Therefore, from a holistic perspective, there was no net reduction in $CO_2$ emissions. In practice linking $CO_2$ capture from coal fired power generation to EOR has not proved to be the economic success that was hoped for and only a few applications have been built.

In the 2000's the CCS community became increasingly concerned about the security, credibility and lack of reproducibility of permanent geological storage of $CO_2$. The storage of $CO_2$ in the oceans was investigated in detail. Trials of discharging liquid $CO_2$ into the ocean at a depth of 800 metres (where liquid $CO_2$ is less dense than seawater) were proposed, but an uproar from the environmentalists, concerned about the inevitable ocean acidification, caused those trials to be abandoned. The prospect of any form of ocean storage of $CO_2$ was abandoned by the CCS community, due to the lack of social licence. Incidentally, putting $CO_2$ in the ocean would also take the matter of $CO_2$ storage out of the control of the oil and gas industry.

*[In the 1980s, I was project leader for a technical and economic engineering study of laying a 1 metre diameter liquid $CO_2$ pipeline from The Netherlands to a deep ocean location in the Atlantic Ocean at a depth of 3000 metres, where the density of liquid $CO_2$ exceeds seawater. That engineering study concluded that it was technically feasible but expensive. In the late 1990's I carried out an investigative study for the IEA GHG programme, which explored the accessibility of deep ocean $CO_2$ disposal sites from coastal locations.]*

In the 2010s the CCS community became increasingly concerned about the lack of social licence for CCS schemes and the very small number of runs-on-the-board. Focus shifted to considering $CO_2$ as a valuable commodity not a waste product, which was perceived to be more socially acceptable. The acronym CCS evolved into CCUS, which gave $CO_2$ utilisation schemes an air of respectability, regardless of their scientific merits. Many schemes for converting $CO_2$ into liquid fuel appeared, but they all had energy requirements greater than the energy obtained from the fuel combustion that had made the $CO_2$ in the first place. The CCUS label was also attached to the production of commodity $CO_2$ for the food industries, despite the fact the $CO_2$ is only held up for a few days before it is released into the atmosphere. In the context of the objectives of CCS, $CO_2$ utilisation is a distracting irrelevance.

*[In 2013 I carried out a study for the World Bank investigating a CCS scheme for a proposed coal fired power plant in Indonesia. The available $CO_2$ storage location was in natural gas fields. The $CO_2$ from that single power plant would fill all the available gas field capacity in the whole region. Ten such coal fired power plants were on the drawing board in that part of Indonesia. The location was not far from the huge Natuna gas field with 72% $CO_2$ content. If that resource is exploited in Indonesia the stripped $CO_2$ would swamp the geological $CO_2$ storage capacity in the region.]*

*[In 2016 and in 2018, I wrote papers and presented posters for the biannual International Greenhouse Gas Technologies conference. I revisited the concept of deep ocean $CO_2$ storage and linked it to direct air capture from the air above, providing reproducibility, visibility, and unlimited*

*capacity. In deep ocean trenches $CO_2$ will form stable solid $CO_2$ hydrate, preventing it from acidifying the ocean water above. However, the international CCS community is firmly wedded to geological storage of $CO_2$ and my conference offerings were sidelined.]*

Currently the CCS community, funded largely by the oil and gas industry, continue to produce bullish statements and organise major conferences every two years promoting the capabilities and merits of CCUS schemes. However, after 40 years of scientific endeavour the promise of CCS with geological storage as a solution to the global climate change problem remains elusive.

# Responses to submission questions

1. *Do you agree that the government should establish an enabling regime for CCUS?*

No. The existing ETS legislation should provide the necessary economic incentive for reducing $CO_2$ emissions from industrial $CO_2$ sources (e.g. Ngawha and footnote 7)

2. *Do you agree with our objectives for the enabling regime for CCUS?*

I agree with the first two objectives

Efficient emissions abatement – Provided the assessment of emissions reduction reflects actual real permanent reductions in $CO_2$ emission on a holistic basis.

Environmental integrity – Provided the permanence of geological storage can be accurately monitored and any leakage paid for in the long term.

I do not agree that a CCUS enabling regime has a role to play in the objective of achieving energy security.

3. *Should the ETS be modified to account for the emissions reductions achieved using CCS? If so, how do you think it should be modified?*

The facility for Geothermal operations to apply for a unique emission factor that reflects actual net emissions after accounting for CCS could be expanded to apply to gas processing plants that discharge $CO_2$ to atmosphere. The unique emission factor should reflect the actual $CO_2$ emissions to atmosphere **plus** any commodity $CO_2$ that is sold, which will very soon also be released to atmosphere after it has performed its practical task.

4. *Do you agree that all CCS activities should be eligible to receive recognition for the emissions captured and stored? If not, why not?*

This depends on the definition of "CCS activities". Emissions captured and permanently stored should be determined from detailed mass balances of the operation as the difference between operation with and without the CCS activity.

5. *Do you think there should be a separate non-ETS mechanism for providing economic incentives for CCS? If so, what would this mechanism be?*

In the short term, providing the ETS mechanism is allowed to operate properly, a benchmark in terms of "\$/tonne of $CO_2$ emissions avoided" will be provided for proponents of CCS schemes to base their decisions on.

In the long term, if the government is legally obligated to reduce $CO_2$ emissions more than can be achieved with the ETS mechanism, uneconomic domestic CCS activities might need to be Government funded to help address the shortfall. That scenario is outside the scope of this proposed regulatory regime.

6. *In your opinion, which overseas standards for monitoring, verification and reporting of CCUS-related information should New Zealand adopt?*

This should read CCS. Utilisation of $CO_2$ is irrelevant for carbon accounting.

7. *Is there any other information that CCS project operators should be required to verify and report?.*

Operators must provide a certified and auditable comparative mass balance with and without the CCS scheme.

8. *What methods should be used to quantify $CO_2$ removal and storage in CCUS projects?*

This should read CCS. Utilisation of $CO_2$ is irrelevant for carbon accounting.

Audited mass balances with their variability over time should be the basis of quantifying CCS performance. The main uncertainty is the long term retention in geological storage.

9. *Are additional mechanisms required to ensure compliance with monitoring requirements?*

Independent auditing is essential.

10. *What level of transparency and information sharing is required?*

Transparency should be on the basis of " All information is public except as specifically defined for good reasons." This is contrary to the common practice of "All information is confidential except as specifically required to be divulged"

11. *Do you consider there should be a minimum threshold for monitoring requirements so that small-scale pilot CCS operators would not have to comply with them? If so, what should be the threshold?*

Small scale CCS pilot operations, which have the purpose of testing the technical and economic feasibility of a CCS application, would need to be rigorously monitored to achieve the research objectives. If emission reductions are large enough to be worth accounting for financially, then they should be fully auditable.

12. *Should a monitoring regime extend to CCU activity?*

No. Utilisation of $CO_2$ is irrelevant for carbon accounting.

13. *Do you agree the proposed approach on liability for $CO_2$ storage sites aligns with other comparable countries (like Australia)? If not, why not and how should it be changed?*

International standards should be adopted, based on independent auditing.

14. *Is the proposed allocation of liability consistent with risks and potential benefits? Are there other participants that should share liability for CCS operations?*

Any sharing of liability should be arranged by insurance underwriting companies. The requirement for long term liability insurance should be a requirement for $CO_2$ storage operations.

15. *Should liability be the same for all storage sites if projects are approved? Or should liability differ, depending on the geological features and characteristics of an individual storage formation?*

The liability for $CO_2$ leakage should be for the operator to pay the going rate for discharges to atmosphere like any regular $CO_2$ emitter, regardless of the type of $CO_2$ store. However, a fundamental problem with geological storage of $CO_2$ is the difficulty in seeing what is happening underground, which is only achievable by indirect monitoring and modelling. In contrast $CO_2$ storage on the ocean floor in the form of $CO_2$-hydrate would be visible.

16. *Do you consider there should be a minimum threshold for CCUS operators being held responsible for liability for $CO_2$ storage sites so that small-scale pilot CCS operators would be exempt? If so, what should be the threshold?*

If emission reductions are large enough to be worth accounting for financially, then they should be fully auditable.

17. *Should the government indemnify the operator of a storage site once it has closed? If so,what should be the minimum time before the government chooses to indemnify the operator against liabilities for the $CO_2$ storage sites?*

No. The operator of a storage site should purchase an *"indemnity in perpetuity"* on the insurance market.

18. *Are additional insurance mechanisms or financial instruments required to cover potential liabilities from $CO_2$ leakage in CCS projects?*

Yes. If emission reductions are large enough to be worth accounting for financially, then they should be fully auditable and financially liable.

19. *What measures should be implemented to monitor CCS projects for potential leakage and ensure early detection?*

Ones that work effectively.

20. *Do you agree that trailing liability provisions are needed? How do you think they should be managed?*

The operator of a storage site should be required to purchase an *"indemnity in perpetuity"* on the insurance market.

21. *Are inconsistencies in existing legislation for consenting and permitting impacting investment?*

Any inconsistencies in existing legislation should be resolved before enacting any new legislation.

22. *Should the permit regime for CCUS operations be set out in bespoke legislation or be part of an existing regulatory regime (such as the RMA, EEZ Act, the CMA or the Climate Change Response Act 2002)?*

To the extent that any new legislation is needed, it should be an extension of existing legislation.

23. *Should CCS project proponents be required to submit evidence that proposed reinjection sites are geologically suitable for permanent storage, in order for projects to be approved? If so, what evidence should be provided to establish their suitability?*

Yes. Evidence of geological suitability must be in a form that can be fully audited by independent experts.

24. *Should there be a separate permitting regime for CCU activity if there is no intention to store the $CO_2$?*

No. Utilisation of $CO_2$ is irrelevant for carbon accounting.

25. *Are there regulatory or policy barriers to investment and adoption of CCU technologies?*

Utilisation of $CO_2$ is irrelevant for carbon accounting.

26. *What potential markets for $CO_2$ derived products do you see as most critical in New Zealand?*

Utilisation of $CO_2$ is irrelevant for carbon accounting.

27. *Are there any specific barriers to transportation of $CO_2$?*

Large scale transportation of $CO_2$ only makes sense in a pipeline, which would present routing issues.

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