Low Emission Technology Australia

Submission to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) on the *Interim National Action List for offshore carbon dioxide sequestration* (I-NAL)

1. Introduction

Low Emission Technology Australia (LETA) is a A$700 million fund established in 2006 by the Australian black coal industry to invest in a range of technologies that significantly reduce greenhouse gas emissions and support the transition to a low emission global economy, in line with the Paris Agreement.

LETA partners with government, research institutions, universities and industry locally and internationally to develop projects that reduce and remove greenhouse gas emissions from large scale industrial processes such as power generation, steel and cement manufacturing, mining, and future energy sources such as low-carbon hydrogen.

LETA's submission addresses specific aspects of the *Interim National Action List for offshore carbon dioxide sequestration* (I-NAL), focussing on those areas/questions that are particularly important for LETA's members and the unique perspective they bring to these issues.

LETA and its members are examining opportunities to work with a range of trading partners that could see hubs developed in major trading partners like Japan and Korea, where emissions are captured from a range of industrial facilities (steel, chemicals and similar industrial process, many of which are supplied by Australian coal and natural gas), liquefied at a central hub and then transported via ship in specialised CO_2 transport vessels for storage at a suitable location.

LETA's perspective therefore is a relatively unique one – representing members who are unlikely, at least in the short-term, to be storage site developers, but will rather be part of commercial arrangements with key trading partners and potential storage services providers to be sources of greenhouse gas (GHG) streams for storage.

This potentially includes, as is outlined on page 7 of the Department's paper, GHG streams from power generation (such as coal-fired power) and industrial processes (such as cement manufacture, steelmaking, chemicals manufacture and minerals processing), where Australian coal has played a key role over many decades in the development of those industries (including, for example, in key trading partners like Japan and Korea).

2. The importance of a NAL that supports the development of a broad range of offshore CCS activities in Australia

The NAL has an important role to play in the development of a broad range of offshore CCS activities in Australia.

While LETA agrees an appropriate NAL needs to act as a screening tool to assess suitability for the disposal of CO_2 into sub-seabed geological formations, outline acceptable incidental associated substances and upper limit thresholds and support the assessment of potential effects on the marine environment and human health, it also needs to provide for the development of an offshore storage industry in Australia. An appropriate NAL, developed in close consultation with industry, can achieve each of these objectives.

In doing so, it will be important that the NAL reflect international experience and industry operational experience. It will also be vitally important that the NAL not act as inappropriate barrier or unnecessarily increase costs[1] for proponents looking to develop sites for sub-seabed storage or to provide GHG streams for sub-seabed storage.

[1] For example, while unnecessary for CO_2 to be safely and permanent stored in a sub-seabed storage location, any GHG stream arising from coal-related post-combustion capture (an example of which is included in Figure 1 on page 8 of the Department's paper) would require further and costly processing to meet the I-NAL as written.

The I-NAL, as presented in the Department's paper, risks adding inappropriate costs to the development of CCS storage sites for sub-seabed storage. Various parts of the I-NAL will require amendment before a NAL is finalised (noting that, as is the case with CO_2 specifications around the world, any Australian NAL will need to be open to regular review and update as the industry develops) to better reflect international experience and to ensure a safe and competitive CO_2 sub-seabed storage industry can develop in Australia.

This also means the I-NAL, as it stands, risks delaying offshore CCS projects moving forward in a timely manner which will delay CCS as an option for a range of industries. These industries face significant emissions reduction obligations under the reformed Safeguard Mechanism and their own corporate emissions reduction targets. These and other industries are now also working with trading partners to develop carbon stewardship solutions. In addition, and as is considered further below, the I-NAL does not appear to have considered the full scope of CO_2 sources (for example, coal gasification, SMR, coal-fired power generation, cement, steel, other manufacturing).

3. Comments on the I-NAL

LETA offers the following comments (highlighted in blue) on the I-NAL as presented in Table 2 of the Department's paper. LETA's comments are focussed on those parts of the I-NAL that will require amendment to ensure an appropriate NAL can be developed and released in 2025.

With that in mind, LETA:

- Agrees with the proposition underpinning the development of the NAL is that the risk is overwhelming that of relating to CO_2, and we also agree with the methodology described in the NAL based on the approach of de Visser et al. (2008), as referenced on page 10 of the Department's paper, for the calculation of upper-limit values for incidental associated substances in Table 2.
- Notes there appear to be some inconsistencies with the use of the calculation methodology used to develop the upper limits proposed in Table 2. LETA's comments have addressed specific species in the Table below.
- Recommends the use of aggregate analytes, such as "amines" rather than a specific MEA and refrigerants. This is similar to the approach provided by de Visser et al. (2008). This would allow the NAL to avoid the issue of "missing a compound".
    - It would then be the focus for each proponent to account for compounds relevant to their project under an aggregate limit.
    - For example, there is unlikely to be many industrial scale processes using MEA, with the significant benefits of more advanced amine systems.
- Notes the importance of water limits in the GHG stream and its impact to corrosion and loss of containment. We have proposed a lower water limit to reflect this.
    - In addition, LETA has focused the risk on other acid related to human health, as in the absence of water these species do not pose a corrosion risk. This is consistent with the international pipeline standards and existing guidelines[2].
- Also notes the limits proposed below are reasonably achievable by the best current available technology and strikes an appropriate balance between the objectives of the NAL outlined above[3].
- Notes that that matters relating to the specific suitability of a GHG stream in a specific reservoir is overseen by a detailed and rigorous NOPSEMA assessment process. This assessment recognises that some reservoirs will be able to receive much higher quality of contaminants (hydrocarbons into a depleted oil/ gas reservoir), and some may need lower parameters.
    - LETA understands the remit of the NAL is to provide a structure for assessing safe and reliable GHG conveyance into an approved reservoir.

---

[2] National Energy Technology Laboratory (2019), Shirley, P and Myles, P, *Quality Guidelines for Energy System Studies: CO_2 Impurity Design Parameters. United States: N*. p. 2019. (available at www.osti.gov/biblio/1566771); and Technical Report ISO/TR 27921 (2020) (E) *Carbon dioxide capture, transportation, and geological storage — Cross Cutting Issues — CO_2 stream composition* (available at www.iso.org/obp/ui/#iso:std:iso:tr:27921:ed-1:v1:en).

[3] Namely, to act as a screening tool to assess suitability for the disposal of CO_2 into sub-seabed geological formations, outline acceptable incidental associated substances and upper limit thresholds and support the assessment of potential effects on the marine environment and human health, and to provide for the development of an offshore storage industry in Australia.

- LETA also notes two recent storage specific guidelines related to specific reservoirs Northern Lights Project and the Aramis Project[4].

[4] The CO_2 specifications for the Northern Lights Project (the most recent (February 2024)) can be found at norlights.com/wp-content/uploads/2024/02/Northern-Lights-GS-co2-Spec2024.pdf. These updated (and expanded) the 2021 specifications, which are available at norlights.com/wp-content/uploads/2021/12/Quality-specification-for-liquified-c02.pdf) and the CO_2 specifications for the Aramis Project (February 2023) can be found at www.aramis-ccs.com/news/co2-specifications-for-aramis-transport-infrastructure). LETA would note these have been developed to suit European conditions and not necessarily conditions in Australia or in Asia, where Australia's relevant trading partners are located.

Table 1 Interim offshore CCS NAL with upper limits in liquid CO_2

Contaminant	Upper Limit	Rationale for Limit	LETA suggested Upper Limit	LETA comments: rationale for proposed change
H_2S (hydrogen sulphide)	200 ppm	• Health and safety aspects • Engineering with respect to mitigation of stress cracking of steels due to hydride formation	200 ppm	• Health and safety aspects. • Engineering with respect to mitigation of stress cracking of steels due to hydride formation.
HCl (hydrogen chloride)	40 ppm	• Health and safety aspects • Engineering with respect to mitigating metal corrosion • Environmental with concerns about dissolution of carbonate minerals, especially in sub-surface rock formations or well-bore cements due to acidic nature of HCl in water (forms hydrochloric acid)	100 ppm	• Health and safety aspects (Section 2.3) ratio calculation on TWA = 5 ppm (STEL not available). • Corrosion and formation of hydrochloric acid managed by water limit.
HF (hydrogen fluoride)	10 ppm	• Health and safety aspects • Engineering with respect to mitigating metal corrosion • Environmental with concerns about dissolution of carbonate or silicate-rich minerals, especially in sub-surface rock formations or well-bore cements due to acidic nature of HF in water (forms hydrofluoric acid)	60 ppm	• Health and safety aspects (Section 2.3) ratio calculation on TWA 3ppm (STEL not available) • Corrosion and formation of hydrofluoric acid managed by water limit.
CH_3OH (methanol)	4,000 ppm	• Health and safety aspects	5,000 ppm	• Health and safety aspects (Section 2.3) ratio calculation on STEL 250 ppm.
NO_x (nitrogen oxides)	4 ppm	• Health and safety aspects • Engineering with respect to mitigating metal corrosion • Environmental with concerns about dissolution of carbonate minerals, especially in sub-surface rock formations or well-bore	50 ppm	• Health and safety aspects (Section 2.3) ratio calculation on N02 STEL 5 ppm gives 100 ppm limit. • Negligible risk of acid condensing triggering

Contaminant	Upper Limit	Rationale for Limit	LETA suggested Upper Limit	LETA comments: rationale for proposed change
		cements due to acidic nature of NO_x in water (forms nitrous and nitric acids) • Microbiological with respect to any nitrites and nitrates (formed by the acid reaction) acting as electron acceptors in the anaerobic sub-surface formations with multi-step reductions to nitrous oxide (N_2O, small amounts) and nitrogen (N_2, main product) • Chemical with respect to possible reaction with other contaminant species to form new compounds		corrosion when water content (or content of other impurities is low). • Species to form new compounds. • Negligible risk of microbiological action in target storage formations due to formation temperature above $80^{O}C$. • Recent research shows possible interaction with other impurities Chemical with respect to possible reaction with other contaminants. • Recommend safety factor of two to H&S limit – 50 ppm.

Contaminant	Upper Limit	Rationale for Limit	LETA suggested Upper Limit	LETA comments: rationale for proposed change
SO_x (sulphur oxides)	5 ppm	• Health and safety aspects • Engineering with respect to mitigating metal corrosion • Environmental with concerns about dissolution of carbonate minerals to form sulphates, especially in sub-surface rock formations or well-bore cements due to acidic nature of SO_x in water (forms sulphurous and sulphuric acids) • Microbiological with respect to sulphates (formed by the acid reaction) acting as a sulphur source in the anaerobic sub-surface formation with indigenous sulphate reducing bacteria (SRB) to form hydrogen sulphide souring • Chemical with respect to possible reaction with other contaminant species to form new compounds	50 ppm	• Health and safety aspects (Section 2.3) ratio calculation on S02 STEL 5 ppm gives 100 ppm limit. • Negligible risk of acid condensing triggering corrosion when water content (or content of other impurities is low). • species to form new compounds. • Negligible risk of microbiological action in target storage formations due to formation temperature above $80^{O}C$. • Recent research shows possible interaction with other impurities Chemical with respect to possible reaction with other contaminants. • Recommend safety factor of two to H&S limit – 50 ppm.
CH_2=O (formaldehyde)	6 ppm	• Health and safety considerations	40 ppm	• Health and safety aspects (Section 2.3) ratio calculation on formaldehyde STEL 2 ppm gives 40 ppm limit.
~~CH_2=O &~~ CH_3OH (~~formaldehyde &~~ methanol)	6 ppm	• Health and safety considerations • Note: Where there is formaldehyde and methanol, formaldehyde is chosen for its lower exposure threshold	5,000 ppm	• Suggest separating formaldehyde and methanol as limits are different. • Health and safety aspects (Section 2.3) ratio calculation on methanol STEL 250 ppm gives 5000 ppm limit.

Contaminant	Upper Limit	Rationale for Limit	LETA suggested Upper Limit	LETA comments: rationale for proposed change
~~MEA (monoethanolamine)~~	120 ppm	• Health and safety considerations		• We recommend the use of aggregate analytes (“amines” rather than a specific MEA etc).
Specific gas components: *The sum of the following must = <4% due to engineering considerations*				
Group of Cd (cadmium), Hg (mercury), Tl (thallium) and the 3 elements grouped limit value: *transition metals classed as heavy metal contaminants that have broadly similar modes of toxicity and persistence in the environment. Grouped value required due to derived heavy metal analytical methods that do not speciate individual metal species. The combined sum of the 3 heavy metal concentrations may become of human or environmental concern. Individual values required as the chemical and physical properties vary such that they also need individual entries for their exposure limits*				
Cd (cadmium)	0.022 ppm	• Health and safety considerations • Environmental with respect to persistent and bio-accumulative heavy metal compounds	Draft guideline of 0.022 ppm	• There is very limited data on Cd levels in GHG streams from any source[5].
Tl (thallium)	0.24 ppm	• Health and safety considerations • Environmental with respect to persistent and bio-accumulative heavy metal compounds	Draft guideline of 0.24 ppm	• There is very limited data on Tl levels in GHG streams from any source[6].
Cd, Tl, Hg (cadmium, thallium, mercury)	0.022 ppm	• Health and safety considerations • Environmental with respect to persistent and bio-accumulative heavy metal compounds. • Note: In this suite of heavy metals, Cd exposure limits chosen for its slightly lower exposure limits	LETA recommends removing this aggregate measure	• The impacts are covered by each element above, and there is an order of magnitude difference in the limits.

[5] For example, from National Energy Technology Laboratory (2019), Shirley, P and Myles, P, *Quality Guidelines for Energy System Studies: CO_2 Impurity Design Parameters. United States: N*. p. 2019. (available at www.osti.gov/biblio/1566771) or Technical Report ISO/TR 27921 (2020) (E) *Carbon dioxide capture, transportation, and geological storage — Cross Cutting Issues — CO_2 stream composition* (available at www.iso.org/obp/ui/#iso:std:iso:tr:27921:ed-1:v1:en).
[6] As above.

Contaminant	Upper Limit	Rationale for Limit	LETA suggested Upper Limit	LETA comments: rationale for proposed change
Group of ethane (C_2H_6), propane (C_3H_8) and CFC-13 (chlorotrifluoromethane): *The sum of the following cells must = <0.2% due to engineering considerations*				
Special exceptions: *substances with no human exposure limits, but need limiting due to engineering or subsurface considerations*				
H_2O (water)	500 ppm	• Engineering considerations with respect to corrosion mitigation by formation of acids from certain contaminant gases (NO_x, SO_x, HCl, HF) when dissolved in water • Engineering considerations with respect to blocking of pipelines and valves due to solid hydrate formation and erosional damage to compressors	250 ppm	• Engineering considerations with respect to corrosion mitigation by formation of acids from certain contaminant gases (NO_x, SO_x, HCl, HF) when dissolved in water. • Engineering considerations with respect to blocking of pipelines and valves due to solid hydrate formation and erosional damage to compressors.