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# Injecting Carbon Beneath the Seabed

## dumping, pollution, waste ... or something else?

### Introduction

In a tiny fraction of Earth's history, humanity has induced climate change on an unprecedented scale. Despite widespread consensus that a changing climate threatens the very existence of the human species, even now effective measures are not in place to prevent it. Reducing $CO_2$ emissions to safe levels, bringing with it real or perceived reductions in development capacity, is proving extremely difficult to achieve.

It is in this context that people are increasingly turning to technology and science for solutions that soften the impact of the carbon-intensive activities seen to be crucial to continued economic growth. One measure that has gained particular credence in recent years is carbon capture and storage (CCS). This involves the capture of $CO_2$ emissions at point sources (such as power stations or industrial plants) and the injection of compressed $CO_2$ streams into deep and secure subsurface formations. CCS has been occurring beneath the North Sea for over 20 years, and large-scale operations are now appearing across the globe. The focus of this article is on marine CCS – where injection occurs under the seabed.

Technological developments such as CCS do not exist in a normative legal or policy vacuum. Legal frameworks have generally not contemplated CCS specifically, so lawmakers must choose how and where it is to be regulated. Overseas, it has been common for regulatory and policy responses to CCS to be driven by industry or public perception of the technology rather than by well-considered or principled normative positions. For example, negative community perception of land-based CCS in Europe has proved fatal to large-scale projects in recent years, and essentially forced future deployment offshore. In some countries, CCS has captured the public imagination as a measure perpetuating the extraction of coal, with the substantial normative baggage that this framing brings (Global CCS Institute, 2015a, p.3). Some

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jurisdictions have also chosen to regulate CCS as an extension of petroleum legislation rather than an activity in its own right, because of pragmatic considerations (new legislative schemes are hard to create) or fears of petroleum proponents that an independent CCS industry will threaten their interests (Barton, Jordan and Severinsen, 2013, p.342). Among a raft of normative questions such as these, one stands out as being particularly important for the future of marine CCS deployment, and is the subject of this article: should the injection of $CO_2$ beneath the seabed be treated in law as a form of pollution, waste, dumping or other similar concept?

#### Carbon capture and storage: the process

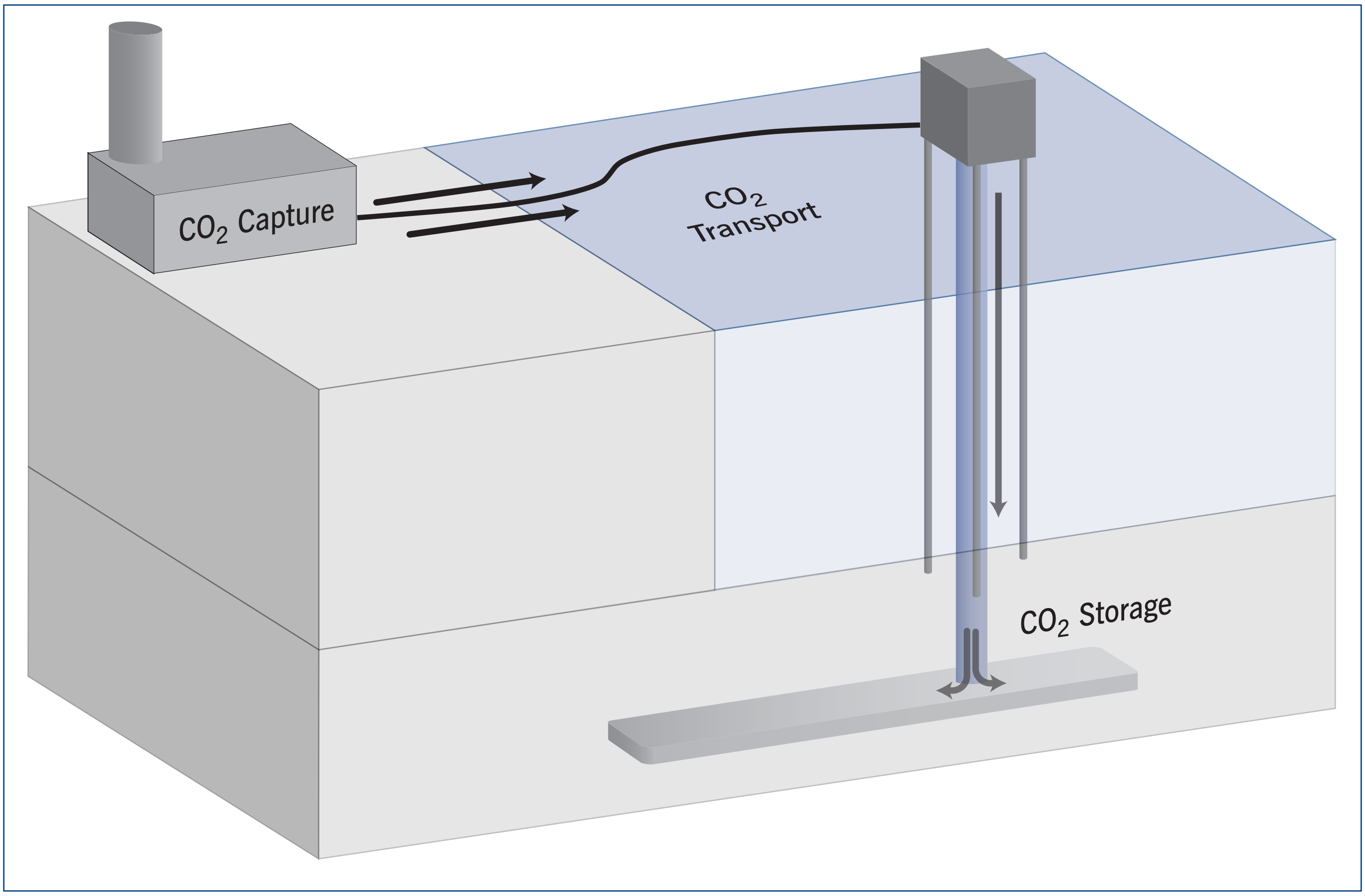
Before turning to this question specifically, it is worth outlining the process of CCS. Technically, CCS is feasible, and has been used for many years overseas with few issues.

First, $CO_2$ is captured from a point emission source such as a fossil fuel-fired power plant or heavy industrial facility. This is known as the capture phase. Many emitters are compatible with capture technology. Special mention can also be made of bioenergy CCS (BECCS), which involves coupling CCS with the combustion of biofuels (sourced from plant materials that have themselves removed $CO_2$ from the atmosphere) to produce energy. The result in such cases is net negative emissions.[1] The capture phase involves considerable expense, because it generally requires large amounts of electricity – an 'energy penalty' of about 10–40% (IPCC, 2005, p.4). However, some have stressed that CCS is actually a cost-effective measure when a wider view is taken, because short-term mitigation is bound to be cheaper than future mitigation or adaptation measures (Global CCS Institute, 2014, p.9).

Second, captured $CO_2$ is purified, so as to remove reactive and corrosive substances such as water. It is cooled and compressed (generally into a supercritical state to improve flow)[2] and transported to a storage site (the transport phase). Third, $CO_2$ streams are injected deep into the sub-seabed for permanent storage (the storage phase). Site selection is crucial: a formation must be able to sequester $CO_2$ effectively and permanently. Injection is most likely to occur in either partially depleted or dry petroleum reservoirs or into (usually much deeper) saline aquifers. Sites must have adequate confinement (to prevent vertical migration of pressurised $CO_2$) and capacity to store $CO_2$ (including sufficient depth). The period of injection is likely to last many years.

Once $CO_2$ is injected it diffuses into the geological pore space to form a plume. As the plume disperses, the pressure in the complex dissipates and, from this point, the stored $CO_2$ can be trapped in a variety of site-dependent ways. Physical or structural trapping is the dominant form during and immediately after injection, where a plume is physically blocked by an impermeable geological structure such as a cap rock. As time passes, this changes from physical to residual (capillary) trapping, which involves the isolation of $CO_2$ in increasingly small pores. Over the course of several thousands of years $CO_2$ is expected to dissolve completely in formation fluids (dissolution or solubility trapping) and finally react with rock to form solid, stable carbonate minerals (IPCC, 2005, p.206).

**Figure 1: The carbon capture and storage process**



Once injection has ceased the well is sealed and the behaviour of the plume is monitored. Given that storage must be secure for tens of thousands of years for the technology to be effective, it is important to prevent post-closure leakage. The Intergovernmental Panel on Climate Change (IPCC) has stated that a leakage rate of over 0.1% is unacceptable (IPCC, 2005, p.197). However, the risk of a more than negligible rate of leakage has been assessed as very low if a storage site is selected and managed well, and that risk declines steadily over time (ibid.).

$CO_2$ can also be injected to enhance the recovery of underground oil and gas. Where $CO_2$ used for this purpose remains securely stored after injection, it is one example of a concept called carbon capture, utilisation and storage (CCUS), represented in Figure 2. However, not all reservoirs suitable for storage are compatible with the use of such techniques. Storage of $CO_2$ can sometimes result in the degradation of subsurface mineral resources (World Resources Institute, 2008, p.82).

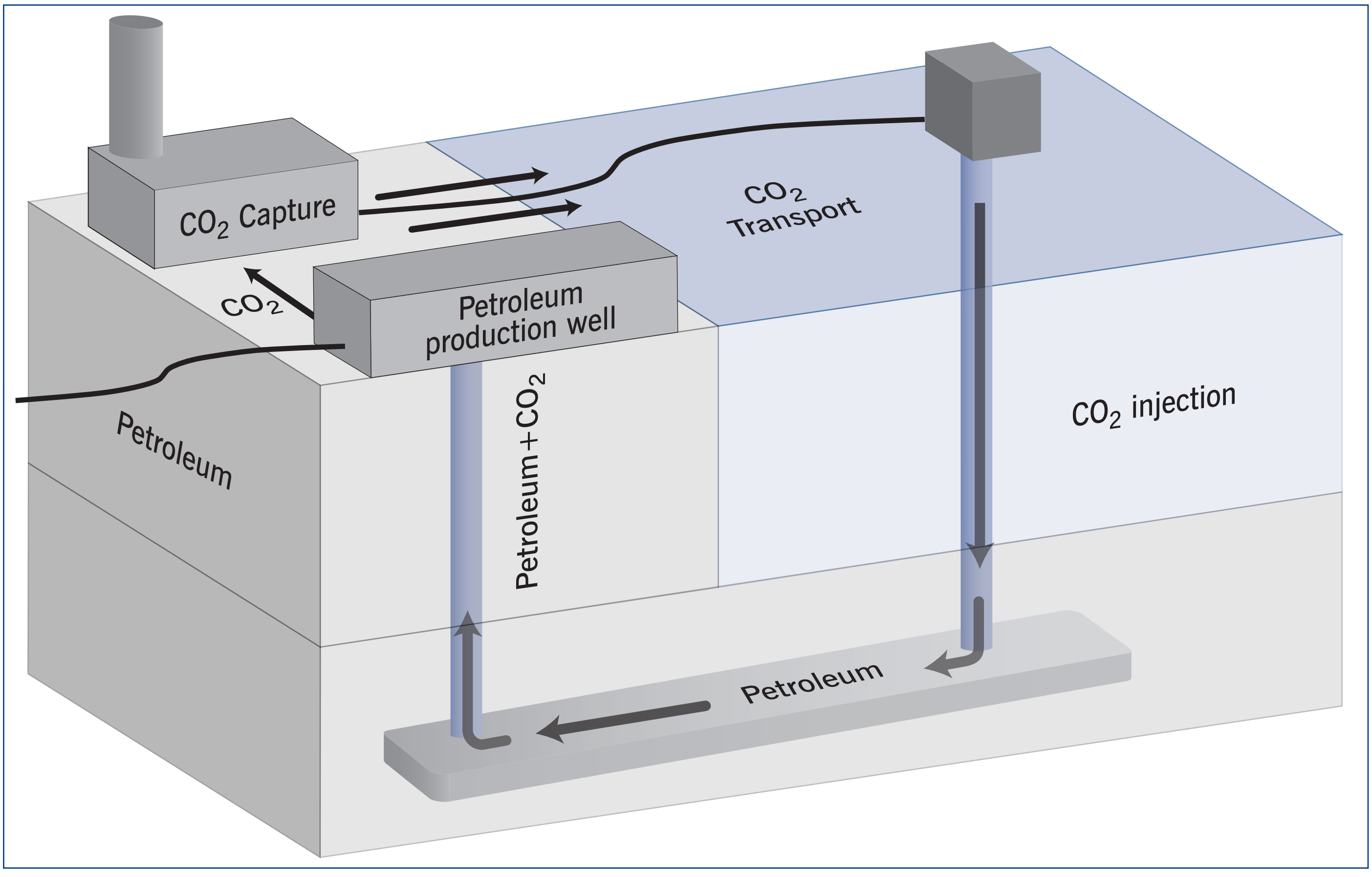
The geological storage of $CO_2$ poses a number of other environmental risks, although overall these have been considered to be low and similar to those of petroleum activities (IPCC, 2005, p.12). Excessive injection rates or seismic activity could fracture an overlying seal, producing potential leakage pathways out of a storage site (Swayne and Phillips, 2012). Excessive pressures can force subsurface brine into overlying potable groundwater reservoirs and mobilise harmful metals and minerals (International Energy Agency, 2010, p.91). Unintended leakage also poses risks to the local surface environment. Perfect containment cannot be guaranteed, but significant leakage is unlikely (IPCC, 2006, 5.12). Experience has corroborated this conclusion: no unintended leakage has been recorded at the oldest marine sites, at Sleipner and Snøhvit off the Norwegian coast (Havercroft, Macrory and Stewart, 2011, p.29). If a leak occurred, high $CO_2$ concentrations could adversely affect marine life by causing acidosis (lowering of PH in body fluids), hypercapnia (increased blood concentration of $CO_2$) and asphyxiation (impaired oxygen transport) (OSPAR, 2007, 4.5). The magnitude of effects depends on the rate of leakage, the chemical buffering capacity of the receiving environment, and patterns of local dispersion. In other words, risks are context-specific. Induced seismicity and ground heave on a minor scale is another potential effect of storage, as it is of other activities involving the pressurisation of the subsurface (International Energy Agency, 2010, p.91).

### The global context of carbon capture and storage

The feasibility of CCS has been demonstrated by its deployment in a number of places around the globe over the last two decades. Incentives for doing so have been varied. In a minority of cases a sufficiently high 'carbon' price has provided an economic incentive to deploy CCS,[3] and in places substantial state subsidisation has led to investment (McCoy, 2014, p.21). A stronger incentive (particularly in North America) has been the potential for $CO_2$ to enhance petroleum recovery, with storage a secondary consideration (Global CCS Institute, 2014, p.11).

However, broad commercial deployment of CCS remains limited.

**Figure 2: Carbon capture, utilisation and storage**



Primarily this is because the cost of the technology remains higher than the price of emitting $CO_2$, and there are few regulatory requirements to invest. One representative of the oil and gas industry in New Zealand has even spoken of CCS in current conditions as 'commercial suicide' (Coyle, 2014, p.56). An uncertain and unsupportive legal and policy environment has been cited as another key hurdle to commercial interest in CCS, and New Zealand has been ranked poorly on this score (Global CCS Institute, 2015b, p.9).

In New Zealand, the price of carbon under the emissions trading scheme currently falls far short of that needed for commercially viable CCS projects (Barton, Jordan and Severinsen, 2013, p.241). Moreover, enhanced petroleum recovery appears not to be a significant driver for future CCS deployment in New Zealand. That said, interest has been shown in CCS by both government and industry. CCS is envisaged to form a limited – but viable – part of mitigation efforts (Ministry of Business, Innovation and Employment, 2016), and investigations have been undertaken that suggest CCS is achievable within New Zealand's geological context and emissions profile. Potentially suitable formations have been scoped (Field et al., 2009) and several point emission sources have been identified (Gerstenberger et al., 2009). At the international level CCS is more emphatically recognised as an integral part of a global response to climate change. Indeed, in the most recent assessment report of the IPCC, CCS deployment is built into all predictive models that have a meaningful impact on the global climate (IPCC, 2014, pp.23, 28, 89, 99).

The prospect of CCS deployment in New Zealand in the future suggests that considering its environmental regulation is an exercise well worth undertaking in advance. The International Energy Agency has specifically recommended that states review and develop legal frameworks for the technology, and that uncertainties in regulation be avoided (International Energy Agency, 2002, p.6). Yet a common experience internationally has been for regulators and policymakers to be led by industry, and for legal regimes subsequently to be developed under pressure. In New Zealand, in contrast, there is a valuable window of opportunity to design a legislative framework for CCS that is well considered and normatively defensible.

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#### The normative treatment of marine CCS

Now that the technology has been placed in its technical and global context, let us turn directly to the core question of this article: should marine CCS be treated in law as a form of dumping, pollution, waste or similar concept? In New Zealand's environmental law we can observe a strong aspiration to reduce the generation and disposal of waste and pollution, particularly in the marine environment.[4] This is more ambitious than simply responding to the adverse effects of waste/pollution once it occurs. The idea of dumping is also viewed through a particularly negative normative lens (Doody, Becker and Coyle, 2012, p.12). Whether $CO_2$ should fall into these morally charged categories, and be regulated under frameworks with such concerns at their core, deserves close attention.

'Waste' is conceived of broadly in New Zealand's legislation, and includes anything disposed of or discarded (essentially, abandoned).[5] Yet 'disposal' requires that a 'waste' be deposited for the long term in a place set apart for that purpose (or incinerated).[6] The definition is therefore partly circular, and there remains an inherent subjectivity in how we define waste (and terms like pollution) in any given case. An acceptance that we should minimise waste and pollution does not in itself determine whether a particular class of activity actually amounts to waste or pollution (Pike, 2002, p.207). It is, in fact, possible to classify CCS in a range of ways, which can be negative, positive or neutral. It can be seen as the dumping, discharge or disposal of a waste, pollutant or contaminant (Campbell, James and Hutchings, 2007–08, p.181), as the use of a geological resource (McCoy, 2014, pp.18, 22), as the prevention of climate harm, or as the storage of a resource or by-product (Gerstenberger et al., 2009, p.37).

Other jurisdictions continue to grapple with similar issues of classification (Robertson, Findsen and Messner, 2006, p.8). The commonly used international moniker 'carbon capture and storage' is itself notable, in that it has not captured the global imagination as carbon 'dumping' or 'disposal'. However, the movement of gaseous or liquid substances into an uncontained receiving environment – as with CCS – has historically been perceived as a matter of pollution control. This tends also to be the initial perception of the layperson (IPCC, 2005, p.257). Indeed, storage bears many similarities to more conventional forms of waste disposal such as landfilling. Some scholars have supported the 'orthodox view' of $CO_2$ as a waste that contributes to climate change (Barton, Jordan and Severinsen, 2013, p.379) and a report on CCS in South East Asia has recommended that $CO_2$ needs to be classified as waste or pollution in order to make use of existing regulations (Asian Development Bank, 2013, p.63).

However, this is by no means the only view. Western Australian law does not consider $CO_2$ to be a 'pollutant' (Robertson, Findsen and Messner, 2006, p.28). Similarly, the European Union has developed a targeted directive for the technology, despite many member states being parties to international maritime treaties that characterise it in a negative way as dumping. A New Zealand study has shown that the public may in fact conceive of storage rather paradoxically as both the disposal of waste and the use of a resource (Coyle, 2014, pp.68, 106-7), and a UK study concluded that public perceptions of the technology can change once it is placed firmly within its climate change context (IPCC, 2005, p.257). The IPCC has also left the question open, pointing out that analogues could be as diverse as nuclear waste disposal and temporary natural gas storage (ibid., p.69).

At the global level, parties to the London Dumping Protocol have accepted that CCS offshore is a form of dumping, to be regulated under a regime aimed squarely at controlling the adverse effects of pollution, rather than one emphasising the need for climate outcomes to be realised (Havercroft, Macrory and Stewart, 2011, p.145). However, this has been more the product of accident and convenience than a conscious choice to characterise it in a negative way. CCS was actually prohibited under the protocol until specific amendments were made to it in 2006. This is because the protocol takes a precautionary approach whereby all dumping is deemed prohibited unless specifically included in a 'white' or 'reverse' list in annex I. $CO_2$ streams were added to that list to allow it to occur. Consequently, the London protocol has become the de facto location for the most detailed international regulation on marine CCS. Best practice guidelines have been developed under its auspices, which contain considerations that are vital in issuing permits (such as site selection, CCS stream characterisation, risk assessment, and ongoing monitoring and maintenance).[7]

To some extent, and somewhat ironically, the adoption of the London regime as the 'home' for CCS-specific guidance is because it has historically presented the most substantial regulatory obstacles to the technology (Langlet, 2009, p.298). To give a hypothetical comparison, it would be conceptually similar to regulating for the success of the mining industry within conservation legislation. The protocol's normative roots are in the reduction of marine pollution, not in the facilitation and regulation of a climate change mitigation technology. The key reason for the choice has been pragmatism: it is much easier and faster to amend and build upon existing international legal frameworks through existing institutional structures than it is to negotiate and ratify entirely new frameworks. No existing regimes other than the London protocol have been suitable for doing so (Langlet, 2015, p.401). We would do well to remember that such difficulties do not exist to the same degree in domestic legal systems, where choices of legislative design are much freer.

The international siting of CCS within the London dumping regime illustrates that the choice of legal framework has more than just academic significance. In that case it has generated significant legal questions, tensions and uncertainties, because CCS does not fit the traditional model of dumping. For example, article 4(1) of the protocol provides that, in granting permits, particular attention must be paid to opportunities to avoid dumping in favour of 'environmentally preferable alternatives'. It reflects the assumption that, ordinarily, the dumping of waste in the oceans is seen as a last resort. That position is not beyond debate for marine CCS. What exactly a 'preferable' alternative would be in the case of storage is not made clear, although presumably the secure storage of $CO_2$ below ground may be justified as environmentally preferable to an atmospheric discharge (Langlet, 2009, p.293). A similar issue arises from the wording of annex 2(6), which provides that:

> A permit to dump wastes or other matter shall be refused if the permitting authority determines that appropriate opportunities exist to re-use, recycle or treat the waste without undue risks to human health or the environment or disproportionate costs.

'Re-use' and 'recycling' would be largely inapplicable considerations in the context of storage, unless large-scale uses for captured $CO_2$ became common. Yet on occasion it might be possible and cost-effective to 're-use' anthropogenic emissions as fluid for enhanced petroleum recovery, and the London protocol's explicit preference for re-use over storage is curious. Without some guarantee that enhanced petroleum recovery would result in permanent storage, it may be more harmful to the global environment than CCS.

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#### Recommendations for New Zealand

Fortunately, the London protocol does not *require* New Zealand law to define storage as a form of dumping. It simply requires parties to implement the standards and considerations contained within it. But the examples above show that there are many different normative brushes with which we can paint CCS in New Zealand. The most important lesson must be that the choice of brush is significant, and therefore worth paying close attention to before legislating. By siting regulation and policy within particular legal frameworks, we are (potentially inadvertently) predetermining the appropriate normative direction for the technology. That should not be done lightly.

Some may contend that CCS by its very nature is a form of pollution, dumping or waste disposal, and should be treated as such. However, the story of such CCS opposition can equally be seen as a marketing or communications failure, not a fundamental flaw or characteristic of the technology itself (Doody, Becker and

Coyle, 2012, pp.54, 60). As some commentators have put it, CCS has effectively been picked as a climate 'loser' compared to energy efficiency and renewable electricity measures, and 'has undermined its own credibility' because of how it is perceived (ENGO Network on CCS, 2013, pp.4, 7).

Yet a positive narrative around storage is not out of reach (Heiskanen, 2006, p.15). After all, this has been the experience with 'clean, green' – but also environmentally harmful – renewable energy projects.[8] Terms such as 'waste' and 'disposal' (as with terms such as 'harm' and 'risk') are ultimately human constructs rather than inherent features of particular substances or actions. They describe our attitudes towards something and its effects rather than a thing or action itself (Havercroft, Macrory and Stewart, 2011, p.186). Many legal regimes simply assume we will recognise waste when we see it.[9] Biological sequestration of $CO_2$ (in trees) is certainly not perceived or treated as the dumping or disposal of carbon, although it arguably *could* be if we defined it by action rather than outcome (Doody, Becker and Coyle, 2012, p.29). Classifying CCS streams negatively based on their origin, commercial valuation, or an abstract assessment of the nature of $CO_2$ is therefore not helpful unless that classification assists in achieving the results that we, as a society, desire. Negative public perceptions are often based on misunderstandings of the climate role of storage and exaggerations of its risks rather than well-considered ethical positions (Gerstenberger et al., 2009, p.32). The law must respond to principle, not perception.

Do we wish to discourage, minimise and reduce the use of CCS through a negative normative classification? Legal principle suggests that we do not. For one, the principles of intergenerational equity (that basic interests of future people need to be safeguarded) and subsidiarity (that decisions ought to be made according to the community of interest most affected) suggest that weight be given to the global, atmospheric and intergenerational impacts of the technology relative to its local, geological and short-term effects. The climate imperative is to increase deployment of CCS, especially BECCS (Global CCS Institute, 2015a, p.3). In contrast, deep geological change from storage is, at worst, normatively neutral (as long as it does not impact on resources we value, such as potable water). These factors come out in favour of a positive normative classification of CCS.

This is consistent with the conclusions of Macrory et al. that $CO_2$ streams used for enhanced petroleum recovery are not waste under EU law because they serve a useful function (Macrory et al., 2013, p.23), and Marston and Moore's prediction that pure storage streams may have value in the future (Marston and Moore, 2008, p.428). It is also essential that the climate benefits of CCS are realised. Regimes concerned with dumping, discharges, pollution and waste are invariably focused on the prevention of adverse effects rather than the achievement of positive effects, so CCS should not be classified in this way or assumed to be harmful as a blanket normative position. The literature is replete with exhortations to provide a supportive legal environment for the technology.

Given this conclusion, the next logical step is to assess how marine CCS would be treated under New Zealand's existing environmental laws, and therefore whether reform is required to achieve our aims and support CCS. This is not the place for a detailed analysis of those laws. However, it is fairly clear that, at present, marine CCS is classified as a form of marine dumping under section 15A of the Resource Management Act 1991. The same position is more clearly spelt out in the context of the exclusive economic zone, where regulations refer to CCS specifically as a form of dumping.[10] As under the London Dumping Protocol before its 2006 amendments, it appears that CCS is prohibited outright under the RMA, by virtue of pollution regulations.[11] Although CCS is not subject to a blanket prohibition in the exclusive economic zone legislation, it is provided for as a discretionary activity and thus exposed to the negative normative direction embedded in the purpose of the act when decisions are being made on applications.[12] These outcomes illustrate the normative dangers of locating CCS in frameworks concerned with inherently harmful activities like dumping, waste and pollution without expressly considering its implications. The more normatively sound approach would be to remove CCS from such regimes, and instead locate its regulation in more neutral laws that target both its specific environmental risks and ensure that its positive (climate) impacts are realised.

1 As long as such biomass is replanted at the same or higher rate than it is used.
2 A state having characteristics of both gas and liquid.
3 Being the Snøhvit and Sleipner projects: see Global CCS Institute (2014).
4 See Resource Management Act, ss.15A-15B; Waste Minimisation Act 2008, s3; Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, s10(1)(b).
5 Waste Minimisation Act 2008, s5; Climate Change Response Act 2002, s4; Carter Holt Harvey v North Shore City Council [2007] NZCA 420, [2008] 1 NZLR 744 at [749].
6 Waste Minimisation Act 2008, s6; Climate Change Response Act 2002, s4.
7 London Dumping Protocol Risk Assessment and Management Framework for $CO_2$ Sequestration in Sub-Seabed Geological Structures (CS SSGS, LC/SG–$CO_2$ 1/7, annex 3).
8 Maniototo Environmental Society Inc v Central Otago District Council EnvC Christchurch C103/2009, 28 October 2009 from [386].
9 Waste Minimisation Act 2008, s.6; Climate Change Response Act 2002, s4.
10 Exclusive Economic Zone and Continental Shelf (Environmental Effects – Discharges and Dumping) Regulations 2015, regulation 33(d).
11 Resource Management (Marine Pollution) Regulations 1998, regulation 4.
12 Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, s10(1)(b).

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