BELLONA

Bellona Briefing:

Addressing differences in permanence of Carbon Dioxide Removal

April 2022

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SUMMARY

Different types of carbon dioxide removal differ greatly in the extent to which they are permanent. The risk of reversal is always present for land-based sinks and other types of removal based on short duration carbon cycles. In contrast, removals to geological storage are largely permanent. This Policy Brief paper sets out three broad approaches to recognising these differences.

01 //

APPROACH 1 SEPARATE POLICIES

DISTINCT TREATMENT OF LONG AND SHORT CYCLE REMOVALS

Under this approach, policies are separate for the different broad types of removal, with limited fungibility and separate targets for each. Among other things, use of land-based removals would likely be restricted to balancing land-based emissions. They would not be eligible for balancing emissions of fossil carbon.

02 //

APPROACH 2 EXCHANGE RATE

SHORT CYCLE REMOVALS DISCOUNTED

Under this approach, the cumulative probability of reversal is set in advance by regulation and is used to scale the number of removal certificates surrendered to meet obligations, creating an "exchange rate" between different types of certificate. For example, a 25% risk of reversal requires 1.33 certificates ("risk adjusted tonnes") to be surrendered to balance a tonne of emissions. Calculation of the risk of reversal takes into account estimates of the future direct and indirect effects of climate change, and risks arising from policy, and from management, ownership, and governance of projects.

An additional buffer or safety margin may be built to recognise uncertainties in the estimates of probabilities. For example, assessment may be based on confidence intervals of a distribution rather than the mean. Removals with a risk of reversal above a certain threshold could be deemed ineligible.

Under this approach the effect of the scaling parameter on certificate value is clear. However, it gives limited incentives for subsequent management, as the probability of reversal is set in advance. It is also potentially administratively quite burdensome if calculations are specific to detailed project characteristics (e.g. tree species), location and jurisdiction. Furthermore, the concept of probability based on an average outcome may not be robust to risks correlated across very large numbers of projects, for example mass dieback of forests.

03 //

APPROACH 3 PERMANENT EQUIVALENCE

CERTIFICATES ARE SOLD WITH AN OBLIGATION TO REPLACE REVERSALS

Under this approach, certificates for removals carry an obligation to make good any reversals at the time the reversal occurs, by creating or buying certificates to match any reversals. This obligation continues in perpetuity. There is no buy-out available from simply paying a carbon price.

As with Approach 2 it would be possible to specify a safety margin or buffer to recognise the presence of residual risks.

To mitigate the risk of default, holders of certificates must demonstrate they have the means to meet this obligation, for example through an insurance policy or funds held in escrow. Government may have a role here due to uninsurable risks.

The price of a certificate would reflect the cost of the storage project, the cost of insurance or funds held, and continuing Monitoring, Reporting and Verification (MRV) costs. It would thus be set by markets (at least in part). The equivalent of ratings for bonds may emerge over time for different types of certificates.

This approach uses market mechanisms to reveal the value of different types of removals, while ensuring permanence. It creates direct incentives to manage stores of carbon, and potentially covert to permanence, for example via Bioenergy with CCS (BECCS). However, continuing MRV is potentially costly.

There may also be an unwillingness among private sector parties to take on the required risks, reducing the supply of certificates. However, this would in any case reveal information about risks.

These three approaches are not mutually exclusive. For example, Approach 1 could be pursued to define the overall framework, including limited fungibility, with Approach 3 applied within the land-use sector. Similarly, a hybrid of Approaches 2 and 3 could be implemented.

BACKGROUND

The removal of carbon dioxide from the atmosphere (Carbon Dioxide Removal - CDR) is widely acknowledged as having an essential role to play in reducing climate change.[1] It is essential for balancing emissions that are hard to abate, such as some from agriculture and long-haul aviation. Beyond that, it is essential for eventually reducing atmospheric concentrations of CO_2 through net-negative global emissions.

However, securing the full climate benefits of removals requires that they are permanent and irreversible over very long timescales. Delaying emissions does not constitute a removal. This is because climate change depends, broadly, on the cumulative emissions of CO_2 to the atmosphere.[2] Delaying emissions through capture and subsequent release of CO_{2F} does little to change eventual cumulative total. It therefore has little effect on long-term climate outcomes, even if emissions are delayed by several decades. Nevertheless, there may be some benefit to temporarily reducing atmospheric concentrations, especially if this reduces or delays the peak in concentration of carbon dioxide in the atmosphere. This benefit may be relevant to assessing policies in some cases but does not constitute carbon removal.

Methods for CDR have very different risks of reversal. For geological storage, part of very long carbon cycles, the risk of reversal is very low, and permanence can be largely guaranteed. In contrast, terrestrial sinks such as forests, which are part of a much shorter carbon cycles, risk substantial reversals over years or decades.[3]

This creates a challenge in comparing the value for reducing climate change of different approaches to CDR. This briefing paper looks at three different approaches to addressing this challenge:

1. Removals to long and short carbon cycles are regarded as not comparable, and each is treated separately on its own merits.

2. Removals are compared using an “exchange rate” set by regulation, based on parameters estimated ex-ante and separately for each type of removal.

3. Removals are compared using markets, based on a requirement of permanence.

In each case removals from the atmosphere generate certificates. The unit of account in Approach 2 and Approach 3 is a tonne permanently (irreversibly) removed from the atmosphere. This briefing does not review how demand for certificates might be created nor how these certificates should be used. This might be, for example, through inclusion of permanent storage in an existing emissions trading system, establishing a separate trading system for certificates, or imposing requirements to meet separate targets.

In all cases, removals are assumed to be:

- bought or paid for by government or emitters;
- intended and expected to be permanent, with temporary measures (such as some types of soil treatment and most CCU) excluded;
- necessary for compliance of some kind, rather than voluntary; and
- where relevant, subject to necessary standards for biodiversity and indirect land use change.

Certificates are assumed be generated by a net flow of atmospheric CO_2 into storage. Adequate MRV is assumed to be in place, including MRV to measure changes to land-based carbon sinks, with local enforcement of standards and procedures. Measurement will need to take lifecycle emissions into account and only the net amount of CO_2 removed should be certified (i.e. atmospheric CO_2 stored minus lifecycle emissions).

1 See for example IPCC, 2018: Global warming of 1.5°C. An IPCC Special Report https://www.ipcc.ch/sr15/download/
2 https://www.ipcc.ch/report/ar6/wg1/
3 Similar reasoning applies to some man-made sinks, for example buildings.

APPROACH 1: "SEPARATE POLICIES": DISTINCT TREATMENT OF LONG AND SHORT CYCLE REMOVALS

Removals to geological storage and land-based sinks have quite different properties. Some of the main differences are summarised in the table. Under this approach they are not alternatives. It is assumed that both are needed ("and" not "or").

TABLE: CHARACTERISTICS OF DIFFERENT TYPES OF CARBON DIOXIDE REMOVAL FROM THE ATMOSPHERE

Type of storage	Capture from air to geological storage	Capture from air to terrestrial sinks
Length of carbon cycle	Long (Many millennia to millions of years)	Short (decades or centuries)
Risk of reversal	Very low	Moderate to high
Cost	High to very high at present but with substantial scope for reduction.	Low to medium in short to medium term (allowing for some benefits being distant in time because, for example time taken for trees to grow). However, long run MRV costs and need for permanence may greatly increase costs.
Scale	Currently small – about three decades likely needed to reach Gt scale	Readily scalable
Requirement for continued management and MRV	Low	Moderate to high

Their different properties require different policy approaches, including potentially different targets. There is limited fungibility between them. Policies and markets designed for one are mostly not used for the other, although there may be commonalities, for example in accounting frameworks. Within each broad type there may be further division. For example, different types of land use change may require different policy instruments.

Use of certificates generated by removals by land use could be restricted. Land based emissions, for example from agriculture, can be balanced by certificates from removals by land use (short cycle emissions vs. short cycle removals). However, emissions of fossil CO_2 need to be balanced by geological storage (long cycle emissions vs. long cycle removals), with land-based removals not eligible. However, land-based emissions could also be balanced by geological storage: a one-way gate.

FIGURE 1: KEEPING DIFFERENT CARBON CYCLES SEPARATE

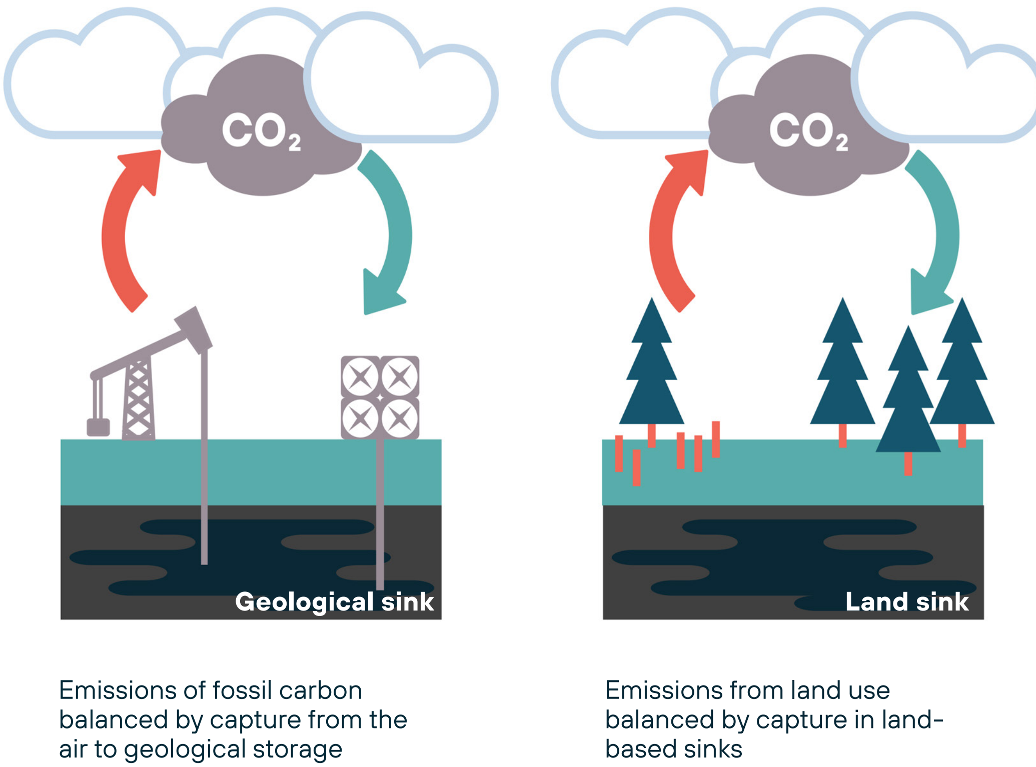

Figure 1: Carbon dioxide removal policy should make a clear distinction between the carbon cycle of the geosphere and biosphere. Geosphere carbon involves the extraction and return of carbon in geologic sinks, where it can reside for thousands or millions of years. Biosphere carbon involves the extraction and return of carbon to biomass, soils, and other sinks where carbon resides for years to decades or centuries.

This approach has the advantages of simplicity and recognising different characteristics and risks. Each type of removal is treated in ways that recognise its particular characteristics.

However, although different types of removal have different properties, policy makers often tend to see them as "basically doing the same job". For example, land-based storage is allowed for compliance under the UK's carbon budget, and (with limits) for the EU's Fit for 55 package. Consequently, policy makers are already comparing different types of removals, and will likely look to continue to do so. We therefore look at how they might usefully be compared to take account of different risks of reversal.

APPROACH 2: "EXCHANGE RATE": SHORT CYCLE REMOVALS DISCOUNTED BY A PROBABILITY WEIGHTING

Under this approach, short carbon cycle removals are given lower values based on higher estimated probabilities of reversal.[4] These probabilities are set by a regulator, which may be an independent body established for this purpose.

The regulator estimates cumulative probabilities of reversal based on the risks to which removals are subject, including:

- projected direct effects of climate change, varying over time, for example risks of drought and wildfire;
- projected indirect effects of climate change, again varying over time, for example pests leading to loss of trees;
- risk of land ownership change, with consequent changes to use; and
- the risk of inadequate governance and management, or policy changes, leading to stores being lost, for example due to deforestation.

Risks will be based on forward looking estimates, for example of climate related risks. There is an inevitable difficulty that types of risks may arise in practice that modelling had not anticipated.

Protocols for the modelling will need to be established so that calculations are transparent and replicable. Calculations need to be location specific, because the probabilities of reversal vary by:

- Geography, with different climate risks; and
- Jurisdiction, with different risks of administrative changes leading to reversal.

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UNDER THIS APPROACH, SHORT CARBON CYCLE REMOVALS ARE GIVEN LOWER VALUES BASED ON HIGHER ESTIMATED PROBABILITIES OF REVERSAL

The probability of reversal sets the value of each certificate generated by a removal. Removals are in effect be converted to "risk adjusted tonnes". R is the cumulative probability of reversal. A certificate is defined as (1-R)% of a permanently removed tonne, requiring 1/(1-R) certificates to discharge the obligation of surrendering a tonne. For example, with a 25% chance of reversal, (1-R) would be 0.75, and 1.33 certificates would be needed be discharge each tonne of an obligation. R might in practice indicate large probabilities of reversal in some cases, e.g. R=0.9, and some threshold might be set, above which projects would not be eligible for certificates at all. The probability of reversal would be almost zero in the case of geological storage, so (1-R) would be very close to 1.

THE PROBABILITY OF REVERSAL SETS THE VALUE OF EACH CERTIFICATE GENERATED BY A REMOVAL. ”

4 Related ideas of multiple surrender have been suggested here: https://carbon-direct.com/2022/02/accounting-for-short-term-durability-in-carbon-offsetting/

FIGURE 2: ADJUSTING VALUE OF REMOVAL TO THE ESTIMATED RISK OF REVERSAL

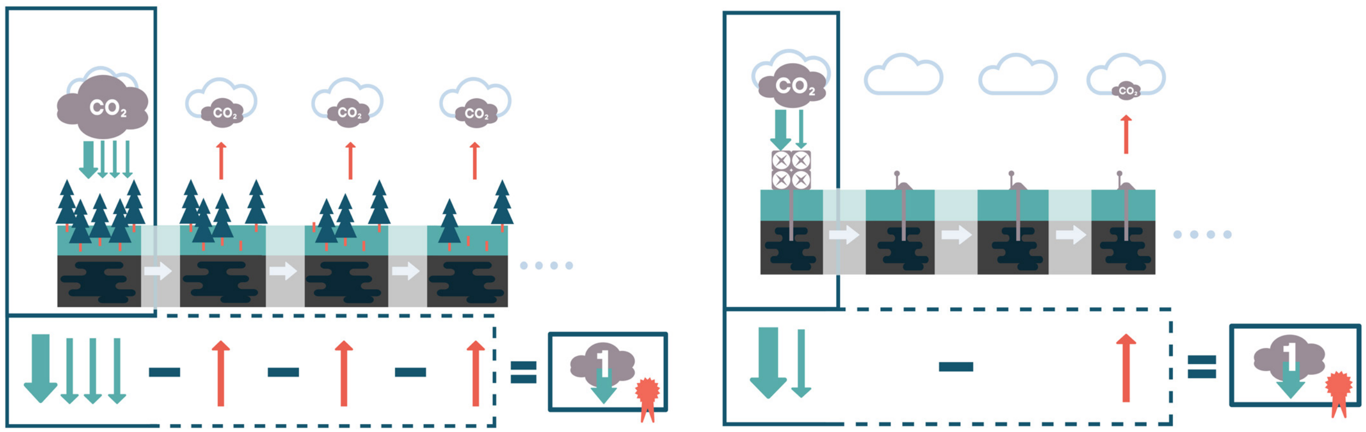

Figure 2: Different carbon dioxide removal options have different risks of reversal. One option to compensate for this risk is for the removal credit to be based on the "average removal" over a defined timespan (e.g. one or more centuries). Therefore, the amount of removal that qualifies for a credit must exceed the "face value" of the credit of an amount large enough to compensate for any potential reversal over that timespan. This amount will vary with the CDR option used. As there is no ongoing liability to the credit-holder, a key consideration of this option is the need for obligations on some party for management to minimize risks of reversal.

The value of R, the cumulative probability of reversal, is fixed in advance of issuing the certificate for storage. No revisions subsequent are made to reflect changing assessments of probabilities.

Probabilities are cumulative, giving the total risk of reversal over time. The calculations would therefore likely have the following features:

- Based on estimating probabilities along different pathways, which are likely to be conditional on the state of the system, and likely the previous pathway.
- The pathways would include probabilities of different degrees of reversal in any year.
- Parameters would vary over time.
- It would be open for debate whether the calculation would include an inter-temporal discount rate.
- A finite time horizon would need to be set, because an infinite time horizon would lead to probabilities of reversal converging to 1 (except in some cases of an inter-temporal discount rate being used).

Some adjustment could also be made to recognise the value of temporary removals lasting many decades, for example in reducing peak atmospheric concentrations.

Parameter values would be inevitably uncertain, and may fail to foresee some risks entirely. An additional margin could be added to recognise this. This could be done, for example, by choosing a 97% confidence interval rather than the mean from a modelled distribution of risk of reversal. Alternatively, a simple factor might be applied. So, for example, with a modelled 30% probability of reversal, a base of R=0.3 might become (say) R=0.6.

ADVANTAGES AND CHALLENGES OF THIS APPROACH

01 //

THE ADVANTAGES OF THIS APPROACH INCLUDE THE FOLLOWING:

- **It recognises the value of permanence, and the different characteristics of different types of removals in this respect.**
- There is clarity and consistency of value of different types of removals.
- **There is no long-term liability (in contrast to Approach 3) which may be attractive to certificate buyers.**
- There is no reliance on intermediaries or third parties, other than the regulator.

02 //

CHALLENGES TO THIS APPROACH INCLUDE THE FOLLOWING:

- **The probability of reversal may be correlated, for example if there is widespread dieback of forests, so that there is limited diversification in practice. Mitigating actions, such as ensuring geographical diversity of projects, may only partly address this risk. There may be a consequent risk that removals will turn out to be less than expected, even if a safety margin is included. (Conversely, estimates may be cautious and greater removals might be achieved.)**
- There is little incentive to manage the risk of reversal, for example by better land management, once certificates have been issued. This could in part be dealt with by contract terms requiring good stewardship, but these may be less effective than direct financial incentives.
- **The parameters used will be highly uncertain, implying a potentially large margin and scale factor, which may reduce the value of certificates simply due to uncertainties present. This may in turn reduce supply.**
- Calculations may be administratively onerous given the number of products and the likely requirement for specificity of the calculations to project characteristics, location and jurisdiction. There will inevitably be a trade-off between administrative complexity of matching characteristics of each project and the increased accuracy of assessment that may result.

APPROACH 3: "PERMANENT EQUIVALENCE". CERTIFICATES ARE SOLD WITH AN OBLIGATION TO REPLACE REVERSALS

An alternative to setting the exchange rate by regulation is to set it using a market-based approach. Again, a certificate with higher reversal risk would be less valuable. However, the reduction in value would be set differently.

THE BENCHMARK OF PERMANENCE

Under this approach the certificate remains attached to a specific removal project, for example a particular reforested area. Each certificate is accompanied by an obligation to ensure permanence. This obligation is perpetual (at least until converted to permanent geological storage).

The obligation imposes a liability in the event of reversal. If the stored tonnes on which the certificate is based are released (a reversal) there is an obligation to buy (or create) certificates matching the tonnes released. The certificates used to make good any reversal need to be contemporaneous with or in advance of the outflow from storage. For example, replanting trees to absorb the same number of tonnes in future would not qualify. The holder of the obligation would need another existing forestry project or equivalent generating certificates now.

FIGURE 3: CONTINUOUS OBLIGATION TO REPLACE REVERSALS

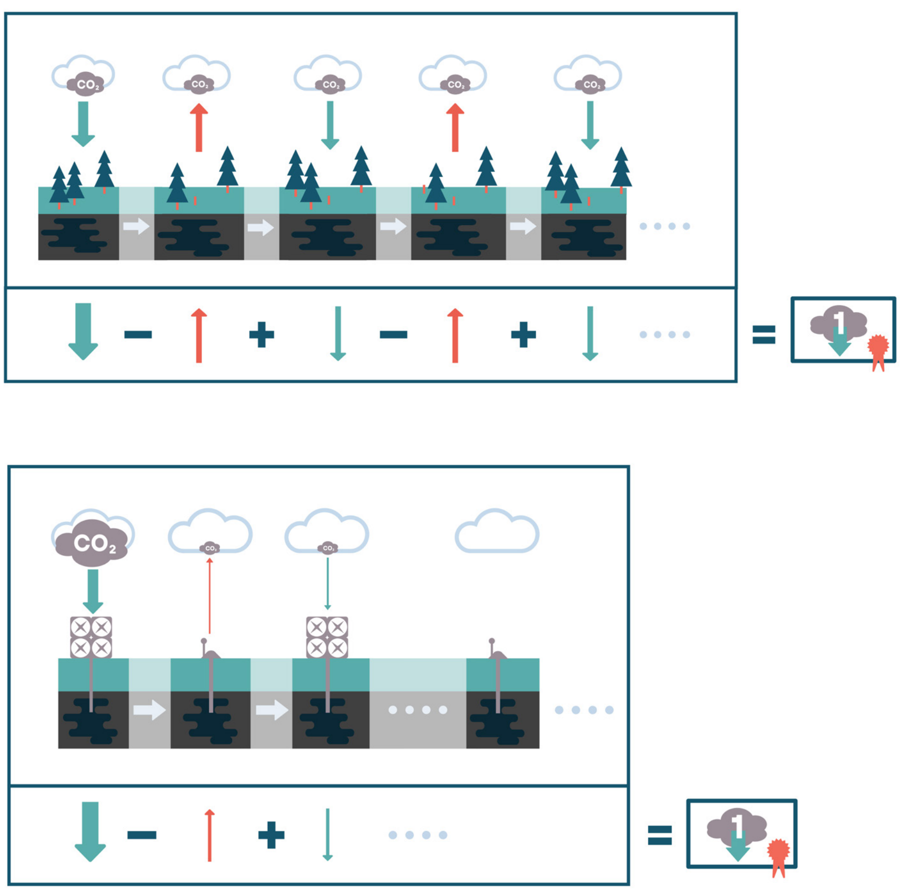

Figure 3: To compensate for the risk of reversal of removals, a credit could come with the permanent obligation to maintain the total amount of removals. Therefore, the creditholder would be perpetually responsible to ensure additional removals in the event of a reversals. Failure to do so would nullify the value of the certificate. If the nullified certificate was used to balance an emission, a penalty would need be incurred for that past emission.

CONTINUED LIABILITY TO ENSURE PERMANENCE

This would, in effect, put the penalty for reversal at a certificate price set by the cost of removals equivalent to those reversed. A buyout of the obligation by paying a separate carbon price would not be allowed.

This would create a continuing incentive to convert certificates to more permanent certificates, in particular geological storage.

Continuing insurance against reversal would likely be required by many projects to mitigate the risk of default. The main exception to this is likely to be governments, who would likely self-insure. The price for removals would likely be set by the cost of the storage project (including any continuing MRV), plus cost of insurance for permanence. Regulation would still define what is eligible as a removal, and set MRV requirements.

An alternative to insurance would be to hold funds in an escrow account sufficient to make good any reversals. The funds that need to be held may be set by regulation, based on the sort of calculations set out under Approach 2. This could vary with the cost of alternatives, so for example might come down over time as the cost of Direct Air Capture with CCS (DACCS) reduces.

If provisions of this type proved to be very expensive in practice this would give a strong market signal to develop DACCS more rapidly.

It would again be possible to include a margin or buffer, so a measured tonne of removals might only generate (say) 0.9 tonnes of removals. This could help:

- accommodate measurement or other uncertainties;
- allow for residual risks, for example of default; and
- recognise uninsurable risks.

This approach would require management of storage over many decades, and perhaps a century or more. However, this does not appear to be an insuperable obstacle. Private law contracts can handle commitments over at least many tens of decades, including for example:

- Private pensions c. 70 years
- Property leases up to 999 years in UK (limited to 99 years in California).

Reversal after many decades might incur reduced liability to reflect the value of keeping carbon out of the atmosphere in the interim.

INSURANCE FOR REMOVALS

It may be possible to include provisions to hand obligations over to government after a defined period (for example, 130 years).

It is likely that the equivalent of bond ratings would emerge for different products. The rating would be a guide, but would not set price, for example (purely for illustration): Geological storage would be AAA, woodland carbon units in UK might be A-, reforestation in poorly governed countries might be CCC+ and so forth.

Insurance companies would be need to be regulated specifically to ensure robustness to this type of risk. Measures such as stress tests and margin requirements would be needed, as with other licensing of financial institutions. It would probably be necessary for insurers to be robust to system level risk (for example mass die-back of trees) which may require them to have financial strength from areas outside the land use sector.

Insurance markets of this type may fail to emerge. There are already indications from insurance companies that natural disasters might become uninsurable due to climate change. This would mean that governments may need to act as insurer of last resort, perhaps effectively self-insuring on projects they establish themselves.

The UK, with its relatively strong legal framework for emissions targets, illustrates how this approach may be challenging for governments. The UK is expecting land use removals to be part of meeting net-zero targets. The framework of legally binding five year carbon budgets implies that any reversals from land-based sinks would need to be balanced by additional removals within the five years. This would need to be done without recourse to international removals, which are excluded from the UK's interpretation of net-zero. Sourcing additional removals at short notice may be difficult and may require some sort of reserve of certificates to be established.

In any case governments will need to ensure the existence of legal infrastructure necessary for credible long-term private law contracts.

ADVANTAGES AND CHALLENGES OF THIS APPROACH

01 //

THE ADVANTAGES OF THIS APPROACH INCLUDE THE FOLLOWING:

- **It recognises the value of permanence, and the different characteristics of different types of removals in this respect.**
- It creates extended producer responsibility for certificates.
- **It uses markets to reveal information about risks.**
- It creates incentives to manage risks including through project design, project management, and through diversification of types of project.
- **It incentivises innovation, including for replacing removals with types that have greater permanence, for example using BECCS (though care is required to avoid double counting removals).**
- With constrained supply of permanent CDR at present, buyers could purchase more potentially reversible options in the short term, with incentives for these to be replaced over time by more permanent options.

02 //

CHALLENGES TO THIS APPROACH INCLUDE THE FOLLOWING:

- **Risks may be uninsurable, or very expensive, which may deter projects. Government may therefore need to play a more active role if it is keen for projects to proceed.**
- There may be default on insurance contracts, even with regulation for robustness, especially in the event of correlated outcomes (e.g. mass dieback).
- **There may be a risk of private sector upside but public downside in the event of systemic failure. The 2008 global financial crisis is a relevant precedent here.**

CONCLUDING REMARKS

It is essential for good climate policy that the different risks of reversals for different types of carbon dioxide removal are recognised, and that policy takes account of them. This briefing outlines three possible approaches for a certification system for removals to manage these risks. Much more work is needed to develop them further: none of the approaches are perfect, nor are they mutually exclusive.

For example, **Approach 1** (separation of sinks) is the simplest approach since it **isolates long-cycle removals from short-cycle removals**, which are significantly more susceptible to reversals and require more complex management. However, this approach does not fully address the issue of permanence for these short-cycle removals. It could nevertheless define the overall framework, eliminating or limiting fungibility between sinks.

Approach 2 (exchange rate) presents advantages from the perspective of the institution purchasing or funding the removal, since the **liability for reversals is calculated and handled upfront**, thereby eliminating the long-term liability associated with removals and providing clarity and consistency to the certificates. On the other hand, there is also **little incentive to manage the risk of reversal** and the robustness of this approach relies entirely on an administratively onerous methodology to predict future risks. This approach may underestimate the risk of reversal and thus overestimate the amount of carbon that is permanently removed.

Approach 3 (permanent equivalence) **attaches a perpetual liability to a removal certificate, ensuring that the owner of the certificate is required to make good on any reversals and preserves the value of the removal certificate**. This approach provides an incentive to minimise reversals. It also offers possibilities to invest in more reversible options in the short term and remediating them with more permanent options as they become available. **In some cases, risks may be uninsurable**, although this questions whether these risks should be undertaken at all. Public institutions are likely to be the insurer of last resort, requiring confidence that these can undertake a perpetual liability and trust that individual market actors, and the market as a whole, can avoid a systemic failure which the public would have to shoulder.

A hybrid of all three approaches is likely to be required for the system to be effective. Since the value of removals in limiting climate change is dependent on the permanence of the carbon storage, any certification of removals must recognise the fact that a reversal of carbon storage also results in a reversal of the value of a removal certificate unless robust measures are in place to account for and manage reversals.

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