Coalition for Negative Emissions

Collective expertise, a shared vision

Being Positive about Negative Emissions

Incorporating carbon removals into Net Zero strategies

May 2023

Coalition for Negative Emissions

Introduction

It is becoming increasingly clear that **staying within 1.5 or even 2.0 degrees of global warming is ever more challenging**. We are simply not reducing emissions fast enough; there is emerging scientific consensus that we are about to pass the point by around 2030 when 1.5 degree warming is almost inevitable, unless we massively scale up carbon removals thereafter to address greenhouse gas emissions; both at the Government and company level.

Companies have a critical part to play in meeting this challenge.

But a surprisingly low number of companies currently have currently implemented a Net Zero strategy, despite the regulatory, demand, resilience and carbon price risks that not having a positive plan entails. Companies should be committing to and implementing Net Zero strategies now for both ethical and risk reduction reasons.

Just reducing emissions will never be enough to meet those global targets; any further CO_2 emissions from today will cause temperatures to rise. **We can only achieve Net Zero and stand a chance of staying below 1.5 degrees of warming if we have an industry that can remove CO_2 from the atmosphere at scale** - and the IPCC is recommending a greenhouse gas removals industry exceeding 10 Gigatons of CO_2 pa by 2050 - mitigating residual emissions and compensating for our ongoing failure to reduce emissions fast enough.

There is a large growth opportunity for companies providing negative emissions.
But in addition, nearly all companies' paths to Net Zero will require them to purchase negative emissions to compensate for their residual, hard-to-abate emissions.

For companies not deeply embroiled in the 'Net Zero' debate that are new to this field, the apparent complexity of the negative emissions sector is a barrier to incorporating negative emissions into their corporate strategies. What are negative emissions, what is the difference between emission reductions and carbon removals, are they robust, what are the underlying industries, will negative emissions be allowed as offsets to emissions, and when will they be available at scale?

Building on previous reports by the Coalition for Negative Emissions, this report in particular therefore considers;

- the emerging negative emissions industries - their breadth, the accounting, the evolution of the voluntary, government-assisted and regulatory/compliance markets
- how all companies should be implementing a Net Zero strategy to decarbonise by 2030-40 in all but the highest emitting sectors

- the importance of buying robust, accredited carbon removals to offset residual emissions and the increasing availability of those negative emissions
- how companies should build negative emissions into their Net Zero strategies, as negative emissions become available at scale during this decade

It is designed to give an overview of the emerging negative emission industries and make it easier for companies to plan to incorporate negative emissions into their Net Zero strategies, confident that the market is evolving and an adequate supply of negative emissions will emerge during this decade.

It recommends a way forward that is urgently needed to underpin the industry and the growth of robust negative emissions, that can make a significant contribution to reducing climate disintegration and can reduce companies' risks in relation to carbon pricing and regulation.

Paul Davies

Coalition for Negative Emissions, May 2023

Coalition for
Negative Emissions

Contents

Coalition for Negative Emissions

Executive Summary

Carbon removals are critical to limiting global warming

The world is currently emitting over 60 gigatons (CO_2 equivalent) of greenhouse gases per year, with the Intergovernmental Panel on Climate Change (IPCC) estimating that we only have 500 gigatons of emissions to go before we will be on a trajectory to exceed 1.5 degrees of global warming, in the absence of subsequent carbon removals to reverse any subsequent emissions. We will probably pass that point by 2030.

The IPCC and other bodies have emphasised the growth of negative emissions will be increasingly important to achieve our climate ambitions; delivering the three key roles of lowering net emissions immediately, mitigating residual emissions, and delivering net negative emissions, whereby the level of CO_2 in the atmosphere will need to be reduced to mitigate historic emissions released after the 1.5 degrees tipping point.

The key sources of negative emissions

'Negative Emissions' ("NEs") refer to the result of any process where the amount of greenhouse gases in the atmosphere is reduced, through actual removal of CO_2 from the atmosphere. They include Direct Air Capture, Bioenergy with Carbon Capture and Storage, and a variety of Nature-Based Solutions, that use different natural processes to extract and store carbon. All NE sectors are needed at scale given the scale of the decarbonisation challenge the world faces.

Negative emissions are set to ramp up in scale globally during this decade, so that corporate purchases of negative emissions as part of a Net Zero strategy will become both realistic and affordable for companies.

Emission reductions or carbon removals?

The need for emission reductions outweighs the need for carbon removals 10:1; only through massive reductions in emissions do we stand any chance of meeting climate targets. Negative emissions are not therefore a 'get out of jail free' card; the focus must be on emission reductions, while we need to grow the negative emissions industry so that companies can offset hard-to-abate residual emissions.

As an emitter, the biggest challenge for any company is reducing emissions, but as a purchaser, when a company is looking to offset hard-to-abate residual emissions, purchasing negative emissions (as certified carbon removals) should trump merely investing in credits for the emissions reductions of others.

Corporate planning for Net Zero and the use of Negative Emissions

The market has yet to properly understand and price the full risks and costs of climate disintegration. There is a high probability of increasing regulation, legislation and shareholder activism that will force companies to accelerate their path to carbon neutrality.

In line with global plans to limit global warming, and in light of these growing global pressures, we recommend all companies should have clear Net Zero strategies as soon as possible with targets to become carbon neutral by 2035-40 at the latest depending on their carbon intensity, for all but the most carbon intensive, hard-to-abate industries, such as aviation. This will necessarily involve the purchase of negative emissions by companies to mitigate their residual emissions. We recommend companies should gear up to the purchase of negative emissions at their long-term sustainable levels quickly (purchasing negative emissions at levels that offset their forecast hard-to-abate residual emissions), to underpin the carbon removal market's development while benefiting from falling costs.

The growth of a deep negative emissions industry provides opportunities for purchasers as well as producers

There is a growing breadth of negative emission industries under development across engineered solutions with geological storage, through BECCS and energy from waste to nature-based solutions. The technologies are ready and investable, but currently lack the funding to launch at scale; strong corporate demand for negative emissions is needed to underpin the market's growth

We predict that by 2030, negative emissions will be available for companies to buy at scale. Corporate pre-purchases of negative emissions and the act of incorporating negative emissions into their Net Zero plans will in turn encourage investment in negative emission production. There will be a virtuous relationship between the supply of, and demand for, negative emissions.

The need for robust standards to underpin the carbon removals industries

There is a need for agreed robust standards that define carbon removals (over and above emission reductions) and give assurance to corporate purchasers looking to buy offsetting carbon removals that those negative emissions will fully mitigate their residual emissions over the long-term.

There are currently a number of international standards agencies who can accredit carbon removals, however, some do not distinguish reductions and removals and others have conflicting views on issues like permanence and additionality, which could be confusing for a purchaser.

Every form of carbon removal does have to consider some unwanted consequences from land and energy use, source of feedstock, knock-on effects and whether removals are permanent (in the time frames needed

to address climate change). Those consequences should be disclosed and mitigated as far as possible.

Increasing influence from international bodies such as the Integrity Council for Voluntary Carbon Markets, means there is a path to greater clarity, understanding and conformity, so that corporate purchasers will be able to buy future certified negative emissions with confidence.

There should be a virtuous link between the developing voluntary carbon market, government-sponsored projects and the longer term regulated and/or compliance markets, where purchases of negative emissions are allowed as offsets to carbon taxes and pricing.

Early endorsement by governments of the negative emissions of chosen projects and sectors will increase demand from the voluntary sector for those negative emissions from the voluntary market and may help firm up the emerging consensus on how to define robust negative emissions, ultimately allowed as regulatory offsets.

Conclusions

In what may seem a bewildering sector to outside companies, the actual path for companies is clear and will become easier over time and can be summarised as follows:

- To stay within 1.5 degrees will require huge reductions in emissions in the next decade and investment in substantial negative emissions thereafter
- Companies have a crucial role to play: the more companies that invest in negative emissions, the greater the likelihood we stay within 1.5 degrees of global warming
- All businesses should have a clear strategy to reduce carbon emissions and decarbonise their operations as soon as possible, with targets to become carbon neutral by 2030-40 depending on their carbon intensity, or by 2050 for particularly hard-to-abate sectors
- They will need to determine the likely level of negative emissions needed to mitigate their residual hard-to-abate long-term emissions
- They should ramp up to purchasing those long-term levels of negative emissions by 2030, giving industry the time to mobilise and reduce costs
- A plan that incorporates investing in negative emissions will allow visionary companies to adopt strategies now to become either carbon neutral or net negative
- Private sector participation in negative emissions will provide the funding for the infrastructure needed to deliver permanent carbon removals

Coalition for
Negative Emissions

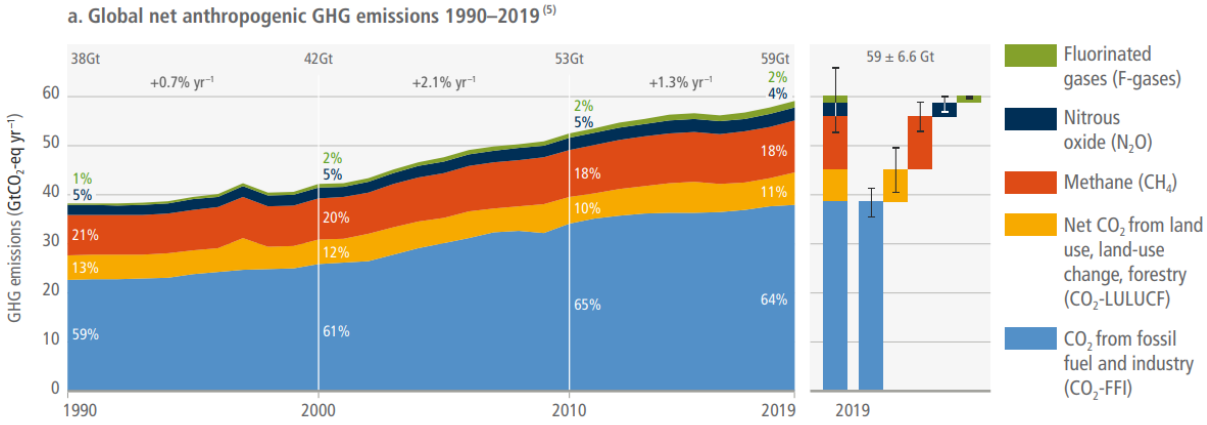
Chapter 1: How are carbon removals critical to limiting global warming?

The world is currently emitting over 60 gigatons (CO_2 equivalent) of greenhouse gases per year, with the Intergovernmental Panel on Climate Change (IPCC) estimating that we only have 500 gigatons of emissions to go before we will be on a trajectory to exceed 1.5 degrees of global warming in the absence of subsequent carbon removals to reverse any subsequent emissions. We will probably pass that point by 2030.

The IPCC and other bodies have emphasised the growth of negative emissions will be increasingly important to achieve our climate ambitions; delivering the three key roles of lowering net emissions immediately, mitigating residual emissions, and delivering net negative emissions, whereby the level of CO_2 in the atmosphere will need to be reduced to mitigate historic emissions released after the 1.5 degrees tipping point.

The current trajectory

The world is currently emitting over 60 gigatons tons of Greenhouse Gases, principally carbon dioxide (CO_2), but also methane and other gases. They are termed greenhouse gases because as they increase in the atmosphere, they increase the retention of heat in the atmosphere from the sun, much like a greenhouse roof keeps its contents warm. It is the cumulative amount of historic fossil fuel emissions that is leading to climate disintegration. And these emissions are not decreasing; since the 1990s when the problems of climate change were understood and the first COPs (United Nations Climate Change 'Conference of the Parties') had been convened, global annual emissions have increased 50%.



Historic net CO_2 emissions from 1850 to the 2019 date in the above chart were around 2,400 $GtCO_2$, of which 42% have been emitted since only 1990. The IPCC has estimated that we can only emit another 500 $GtCO_2$ before the probability is we will exceed 1.5 degrees of global warming - which we will probably have emitted by 2030 - and 1150 $GtCO_2$ before we will exceed 2 degrees without

subsequent carbon removals to reverse any subsequent emissions. Without a strengthening of policies, the IPCC forecasts median global warming of 3.2 degrees by 2100.

This is not the place to describe the dire consequences of such climate disintegration, but the words of the IPCC are perhaps a useful summary:

> "Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability. Across sectors and regions, the most vulnerable people are disproportionately affected. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt. (*high confidence*)
>
> Climate change is a threat to human well-being and planetary health. Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all.
>
> Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (*very high confidence*)."
>
> **IPCC**

The need for and role of Negative Emissions

With that context in mind, it is first essential for countries and companies to eliminate their emissions. But in addition, there is growing recognition of the need to increase focus on 'negative emissions' ("NEs") (or 'carbon dioxide removals' - "CDR") to contribute to addressing the problem, where CDR refers to any activity that removes CO_2 from the atmosphere and stores it durably in geological, terrestrial, or ocean reservoirs, or in products.

> "CDR is a key element in scenarios that likely limit warming to 2 degrees C or 1.5 degrees by 2100"
> IPCC 2022

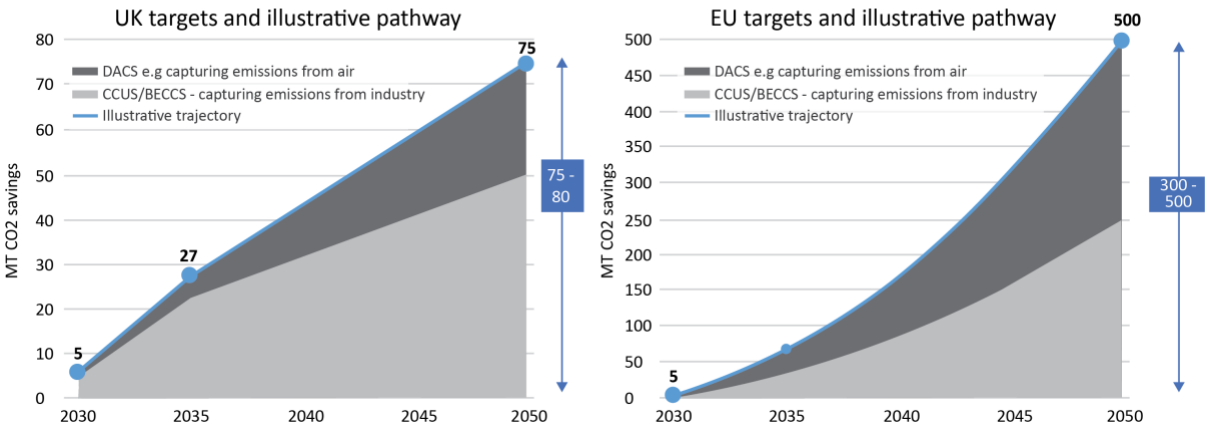
The importance of Negative Emissions - for both countries and companies - is for three reasons:

- lowering net emissions in the near term
- counterbalancing "hard-to-abate" residual emissions
- achieving net negative emissions in the long term if deployed at levels exceeding residual emissions

"To incentivise CDR deployment, a political commitment to formal integration into existing climate policy frameworks is required, including reliable measurement, reporting and verification of carbon flows."
IPCC 2022

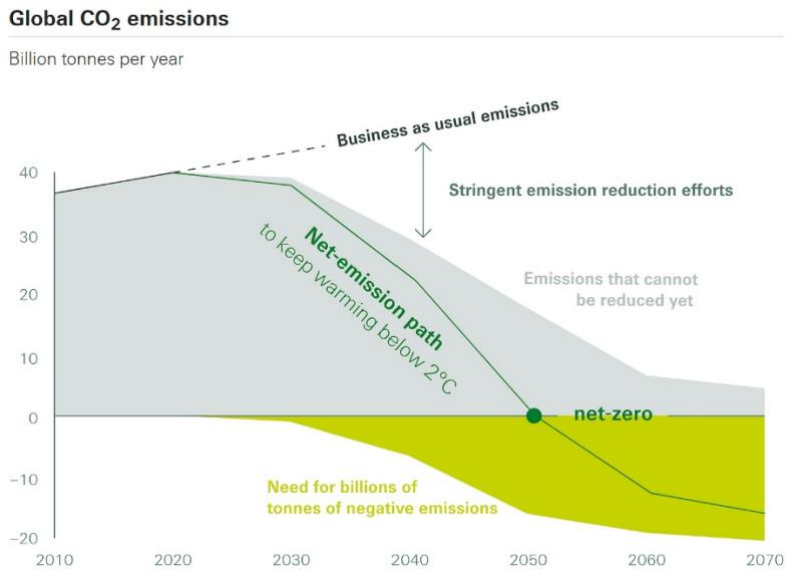
UK and EU governments aim to increase and regulate supply

2030 and 2050 targets have been set. The EU is also aiming for 310MT of nature-based removals by 2030. Standards, delivery mechanisms and pathways are still being shaped.



"To reach the climate neutrality objective of the EU Climate Law, carbon removals will have to be fully integrated into EU climate policy."
European Commission, Sustainable Carbon Cycles Communication, 2021

The IPCC estimates that globally 10 Gigatons of carbon removals are required annually by 2050, rising thereafter. So, a huge industry, equal to 1/6th of current global emissions, is needed. And the sooner the better to accelerate the reduction in overall emissions.



This already represents a massive industry that has yet to come into existence. But that industry may need to be even greater in size, in the event that we fail to meet emission reduction targets; huge investment will be necessary to compensate for those historic failures.

The key point is that without substantial and growing negative emissions, the rise in global temperatures will have been set in stone through current emissions; only through increasing carbon removals offsetting both ongoing and historic emissions, will we be able to reverse that otherwise inevitable trajectory. The projected size of the CDR industries necessary to mitigate climate change is daunting, even if all emission reduction targets are met; it would be unwise to rely on its existence at even higher scales to solve the climate crisis. The quicker emission reductions can be made and the faster the CDR industry can get going, the more chance we have of staying within our global targets.

We find a gap between how much CDR countries are planning and what is needed in scenarios to meet the Paris temperature goal. The size of the "CDR gap" differs across scenarios, depending on how we choose to transform the global economy towards net-zero emissions. However, there are currently few plans by countries to scale CDR above current levels, exposing a substantial shortfall - CO2RE Report: The State of Carbon Dioxide Removals

We looked at 1,200 possibilities for the planet's future……. [Of these only 11 are within the 1.5 degree target with no or minimal overshoot]…These 11 scenarios require us to be able to subtract over 7 billion tons per year from the atmosphere by 2050. Washington Post/Potsdam Institute analysis 2022

Can't we just do less instead?

Rightly so, there is much environmental campaigning aimed at curtailing our behaviour and lifestyles that lead to the greatest emissions.

We should fly less (or not at all), eat no meat or dairy (particularly given the propensity of cattle to emit methane!), super-insulate our homes, or reduce our use of air conditioning.

While clearly we should all consider our lifestyles and how we can personally contribute to lowering emissions, doing less will not be enough:

- 'less' is not Zero; lots of small changes by us individually will lead to small changes collectively. Unless we completely desist from the activity in question, it will still contribute to climate change
- Some of the activities caught up in this line of argument have huge economic benefit. Making the concrete to build essential infrastructure emits CO_2. Flying, with its associated business and tourism, brings economic, social and political advantages, often particularly to lesser developed countries
- We need to consider both climate justice and inter-generational issues; should we deny those activities to developing countries and future generations because of our current inability to mitigate their consequences?

As ever it is a nuanced argument. Clearly humans have to be far more aware of the consequences of their actions. We need a far greater awareness of the climate impacts of our consumer choices, from the car we drive, how we heat our homes, where and how frequently we travel, what we consume; and choose wisely and less.

But many of our activities inherently emit carbon dioxide. We are therefore faced with a choice; stop doing those activities with all of their associated economic and recreational benefits, or ensure that whenever we do those activities, perhaps at lower levels, their environmental impact is completely mitigated either through investment in technologies to reduce their carbon footprint (renewables, recycling, new aircraft, etc) or through investing in robust negative emissions.

Given it is unlikely humanity in aggregate will be persuaded to give up those activities, but more importantly it is not actually desirable that they do (notwithstanding we might do them less in the future), then the only sustainable way forward is to both invest in emissions reductions and ensure we have developed a deep, global and sustainable negative emissions industry that can compensate for residual emissions.

> The science is clear. No matter which IPCC pathway humanity will follow, holding the global average temperature increase below 1.5°C will require removing increasing amounts of CO_2 from the atmosphere. Firstly, hard-to-abate greenhouse gas emissions will have to be balanced with removals in order to achieve net-zero CO_2 emissions in less than thirty years.
>
> **Artur Runge-Metzger, Former Director, European Commission, Directorate-General for Climate Action – CO2RE Report, The State of Carbon Dioxide Removals Jan 2023**

The next decade is crucial for novel CDR, in particular, since the amount of CDR deployment required in the second half of the century will only be feasible if we see substantial new deployment in the next ten years - CO_2RE Report, The State of Carbon Dioxide Removals Jan 2023

Chapter 2: What are the key sources of Negative Emissions?

'Negative Emissions' ("NEs") refer to the result of any process where the amount of greenhouse gases in the atmosphere is reduced. They include Direct Air Capture, Bioenergy with Carbon Capture and Storage, and a variety of Nature-Based Solutions, that use different natural processes to extract and store carbon. All NE sectors are needed at scale given the size of the decarbonisation challenge the world faces.

Negative emissions are set to ramp up in scale globally during this decade, so that purchases of negative emissions as part of a Net Zero strategy will become both realistic and affordable for companies.

'Negative emissions' refer to the result of any process where the amount of greenhouse gases in the atmosphere is reduced. They will be provided by a variety of industries that will be needed to offset (hopefully massively declining) ongoing emissions and even compensate for historic emissions.

The term **'carbon dioxide removals' or 'CDR'** is another term often used, which essentially is the same thing, but focused on the CO_2 element, which is the largest problem to address. Alternatively, the phrase **'Greenhouse Gas Removals' or 'GGR'** is used, which by definition is trying to consider all emissions that contribute to climate change. This paper will use all three terms interchangeably.

> "CDR refers to anthropogenic activities that remove CO_2 from the atmosphere and store it durably in geological, terrestrial, or ocean reservoirs, or in products."
> IPCC 2022

As outlined in our CNE report, The Case for Negative Emissions released in June 2021, negative emissions include:

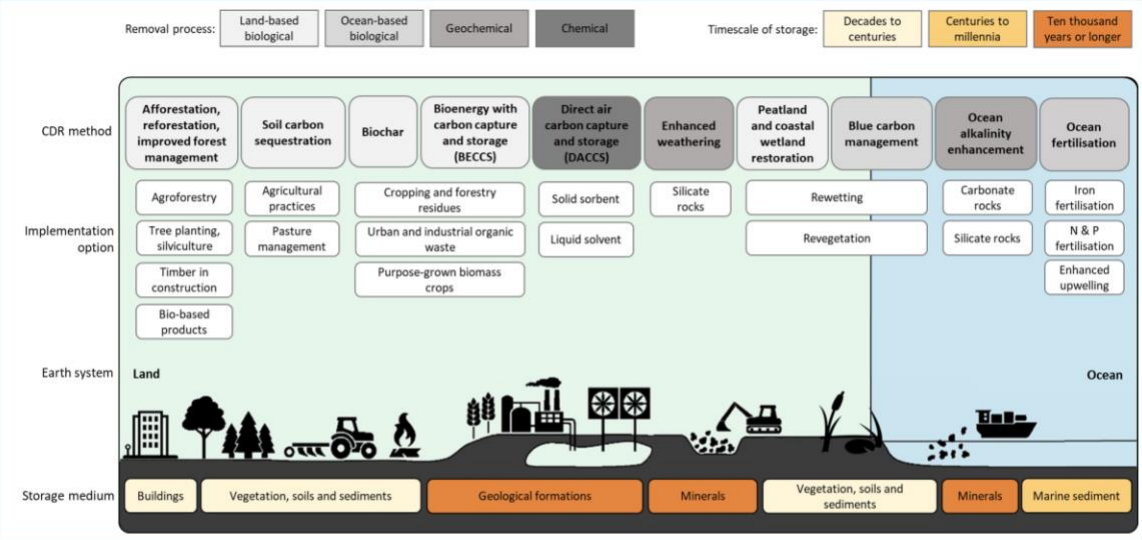
- **Natural Climate Solutions/Nature Based Solutions (NBS)** - restoring or improving ecosystems to remove CO_2 from the atmosphere. These may involve afforestation, habitat restoration, and soil sequestration. NBS typically involve not just carbon dioxide removal, but a wider range of environmental benefits, including enhancing biodiversity and flood risk mitigation, such as through the expansion of mangrove swamps. NBS deliver carbon removals in the land use, land-use change, and forestry (LULUCF) sector.
- **Bioenergy with Carbon Capture and Storage (BECCS)** - technologies that use organic materials (which have captured carbon dioxide as they grow) to produce electricity, biofuel, heat, or hydrogen, where the carbon dioxide produced in the process is captured and permanently stored. BECCS projects may use biomass residues or wastes from agriculture or forestry, or purpose-grown biomass feedstocks. Alternatively, in the example of Energy from

Waste plants with CCS, typically 50 percent of the CO_2 produced in incineration is from biogenic sources and therefore delivers negative emissions.

- **Direct Air Carbon Capture and Storage (DACS)** - technologies that pass air through a filter where chemicals (such as amines and sodium hydroxide) capture carbon dioxide from the air, which is then stored.
    - With NBS, the captured CO_2 is stored either in the plants themselves or in the soil, although wider NBS solutions are being developed. With BECCS, DACS and energy from waste, the CO_2 is typically geologically stored, such as in depleted gas fields, saline aquifers, or alternatively permanently stored within new carbon products like carbon-enhanced cement.

The common feature is that through carbon removals they all lead to an actual reduction in CO_2 in the atmosphere, creating negative emissions that compensate for those sectors that cannot decarbonise at pace, stabilising CO_2 emissions, and addressing historic carbon emissions. They represent the 'net' in achieving any government's 'Net Zero' target.

The Intergovernmental Panel on Climate Change 2022 report gives a fuller description of the full array of emerging negative technologies in the following picture:



Cross-Chapter Box 8, Figure 1 | Carbon dioxide removal taxonomy. Methods are categorised based on removal process (grey shades) and storage medium (for which timescales of storage are given, yellow/brown shades). Main implementation options are included for each CDR method. Note that specific land-based implementation options can be associated with several CDR methods, for example, agroforestry can support soil carbon sequestration and provide biomass for biochar or BECCS. Source: adapted from Minx et al. (2018).

Detailed examples of proposed negative emission projects from members of the Coalition for Negative Emissions are included in chapter 5 below.

The delivery of negative emissions is set to ramp up in scale globally during this decade, so that purchases of negative emissions as part of Net Zero strategies will become both realistic and affordable for companies.

But while negative emissions are an essential element of the fight against climate change, they are not without their challenges. Are these carbon removals permanent and durable (or at least long enough to get us past the immediate climate crisis), does creating negative emissions itself have unwanted consequences such as impacts on the environment or the power they use, and will the success of negative emissions lead to industry 'taking the foot off the gas' from their endeavours to reduce emissions? (it would seem the use of fossil fuels is even embedded as a positive in our language!)

This report therefore considers these challenges and what standards we need to have in place to ensure these potential adverse impacts are properly accounted for. Businesses need to ensure that when they purchase negative emissions, they are truly that; that measured in the round they have led to a reduction in greenhouse gases for the long term and truly offset their residual emissions. The more robust we can be on this, erring on the side of the conservative at this formative stage, the more likely negative emissions will grow in importance and most importantly will get regulatory recognition and funding to expand.

Chapter 3: Which are better; emission reductions or carbon removals?

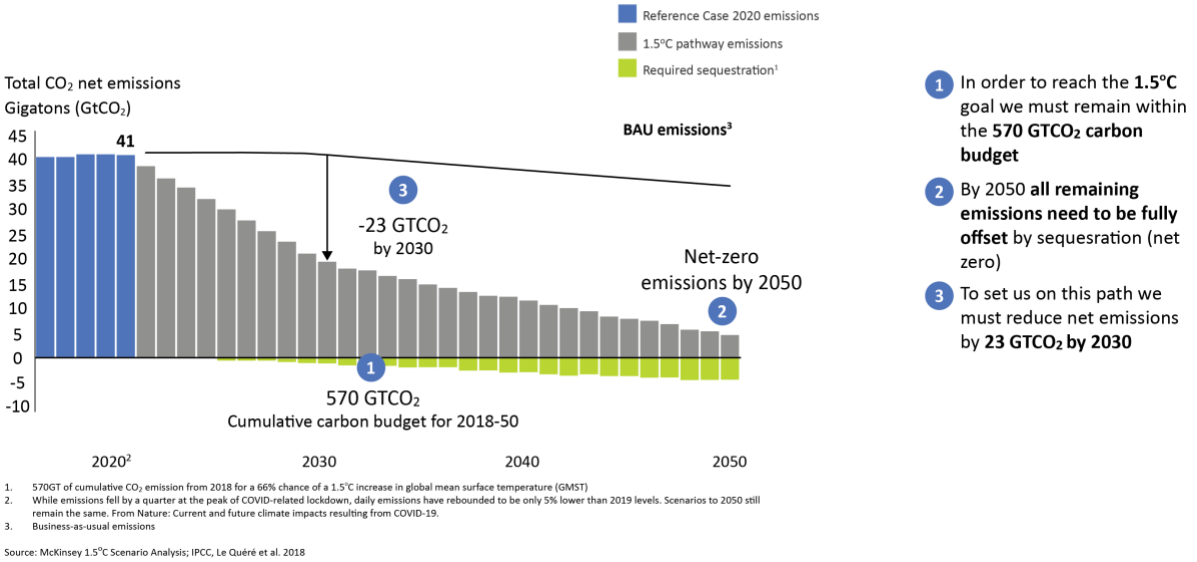
According to the SBTi's Net Zero Standard (Science-Based Targets Initiative, www.sciencebasedtargets.org), the need for emission reductions outweighs the need for carbon removals 10:1; only through massive reductions in emissions do we stand any chance of meeting climate targets. Negative emissions are not therefore a 'get out of jail free' card; the focus must be on emission reductions, while we need to grow the negative emissions industry so that companies can offset hard-to-abate residual emissions.

As an emitter, the biggest challenge is reducing emissions, but as a purchaser looking to offset residual emissions, negative emissions (as certified carbon removals) should trump emissions reductions.

There has been much debate about whether a focus on negative emissions risks taking the eye off the ball; the moral hazard that if a company can economically offset their emissions, why target any reductions? This has led some to recommend that companies and governments only think about negative emissions after maximising the reduction in their emissions. This conclusion is a mistake. As long as one is clear about how negative emissions fit into the wider picture, and they do not diminish focus on achievable emission reductions, they should form part of every company's decarbonisation strategy from now on, ramping up to the long term levels they require in their business during this decade. This will be considered further in the next section.

How do we reach that conclusion? It is absolutely clear that the quantum of emission reductions needed to meet climate targets hugely outweigh the levels of negative emissions required in the long term, as demonstrably shown in the following IPCC table:

EXHIBIT 6: 1.5°C PATHWAY EMISSIONS



1. 570GT of cumulative CO_2 emission from 2018 for a 66% chance of a 1.5°C increase in global mean surface temperature (GMST)
2. While emissions fell by a quarter at the peak of COVID-related lockdown, daily emissions have rebounded to be only 5% lower than 2019 levels. Scenarios to 2050 still remain the same. From Nature: Current and future climate impacts resulting from COVID-19.
3. Business-as-usual emissions

Source: McKinsey 1.5°C Scenario Analysis; IPCC, Le Quéré et al. 2018

This relationship is roughly the same at the corporate level, although will differ markedly between industries, depending on the ability of that industry to invest in decarbonisation and technically and economically their hard-to-abate emissions can be addressed.

The relationship shows that if carbon emission reductions are not delivered, regardless of what can be achieved in the negative emissions market, we haven't a prayer of meeting climate targets.

But it also shows that unless we also have introduced negative emissions into country and company strategies, Net Zero will not be achieved. And that deferring a focus on negative emissions until emission reductions are achieved (which may be never at the current rate!) will prevent the development of the negative emissions market; both its ability to grow to the scale required and to drive down costs through investment and focus.

> "Sequestration is the poor relation of emissions reductions in climate change strategies. It shouldn't be. Done naturally, as part of a comprehensive environmental policy, it has the potential only to make net zero an achievable goal, but to do this in a way that produces multiple other benefits."
> **Dieter Helm, 'Net Zero – How we can stop causing climate change'**

> "Unless we develop carbon dioxide emission [reductions] rapidly and on large scale - closing the gap in both ambition and funding between today's minimal level and what we need - it will be impossible to limit global warming to 1.5C."..... "It's not either or - deep decarbonisation or carbon dioxide removals. Both are essential, rapidly and at scale, if we are to avoid enormous harm to people across the world."
> **Lord Adair Turner, Chair of the Energy Transitions Commission**
> Mind the gap: How Carbon Dioxide Removals Must Complement Deep Decarbonisation to Keep 1.5 Degrees Alive - March 2022

So, while it is clear that the overall level of emission reductions far outweighs the need for removals, it is also clear that substantial negative emissions will be needed at both country and company level. And that to develop that market to become deep and affordable, negative emission purchases need to start at scale by the end of this decade, as they become far more freely available.

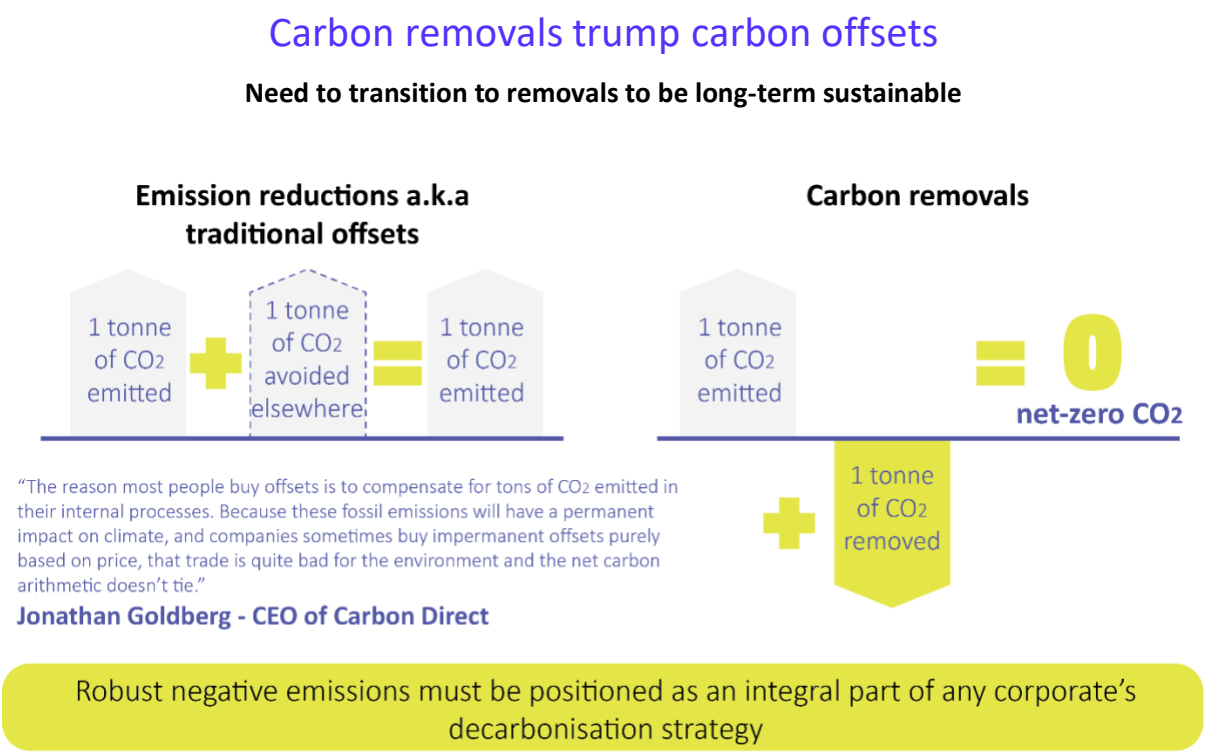
The moral hazard of using carbon removals to avoid emission reductions is solved by following the principle:

As an **emitter**, the biggest challenge is **reducing emissions**, but as a **purchaser** looking to offset residual emissions, **negative emissions** should trump emission reductions.

Both can be pursued simultaneously; the first to reduce one's own emissions, the second as a purchasing strategy to buy offsets for remaining, hard-to-abate emissions

As to the nature of offsets a company looks to purchase, there needs to be a speedy migration away from paying for others to reduce emissions - something they should be doing anyway due to increasing regulation and carbon pricing - and a new focus on purchasing robust negative emissions.

Carbon offsets have historically focused on paying for avoided emissions rather than carbon removals and have cost as little as \$3-5/ tCO_2. If there is no distinction between avoided emissions (and this may be as simple as paying for the prevention of logging) and robust carbon removals, then this situation will prevail, and we will not develop the support and funding for a real carbon removals market.



As the above simple diagram looks to illustrate, if a company has residual emissions to offset, buying emission reductions elsewhere still means a net ton of CO_2 is emitted into the atmosphere.

> "The reason most people buy offsets is to compensate for tons of CO_2 emitted in their internal processes. Because those fossil emissions will have a permanent impact on climate, and companies sometimes buy impermanent offsets purely based on price, that trade is quite bad for the environment and the net carbon arithmetic doesn't tie."
> Jonathan Goldberg, CEO of Carbon Direct.

Where a company is looking to offset its hard-to-abate emissions, therefore, it should be looking to purchase robust carbon removals rather than pay for someone else's carbon emission reductions. (Contrast this to 2022, when only 3% of carbon credits issued were for pure carbon removal projects.)

This of course leads to the question of what constitutes 'robust' negative emissions, which is considered later in this paper.

The Oxford Principles

The need for purchasers to transition from carbon emission reductions to carbon removals is reflected in the 'Oxford Principles' from the Smith School of Enterprise and the Environment, a group of academics focused on carbon removals at Oxford University - The Oxford Principles for Net Zero Aligned Carbon Offsetting, which recommend a four stage approach:

1. Prioritise reducing your own emissions first, ensure the environmental integrity of any offsets used, and disclose how offsets are used.

2. Shift offsetting towards carbon removal, where offsets directly remove carbon from the atmosphere

3. Shift offsetting towards long-lived storage, which removes carbon from the atmosphere permanently or almost permanently

4. Support the development of a market for Net Zero aligned offsets

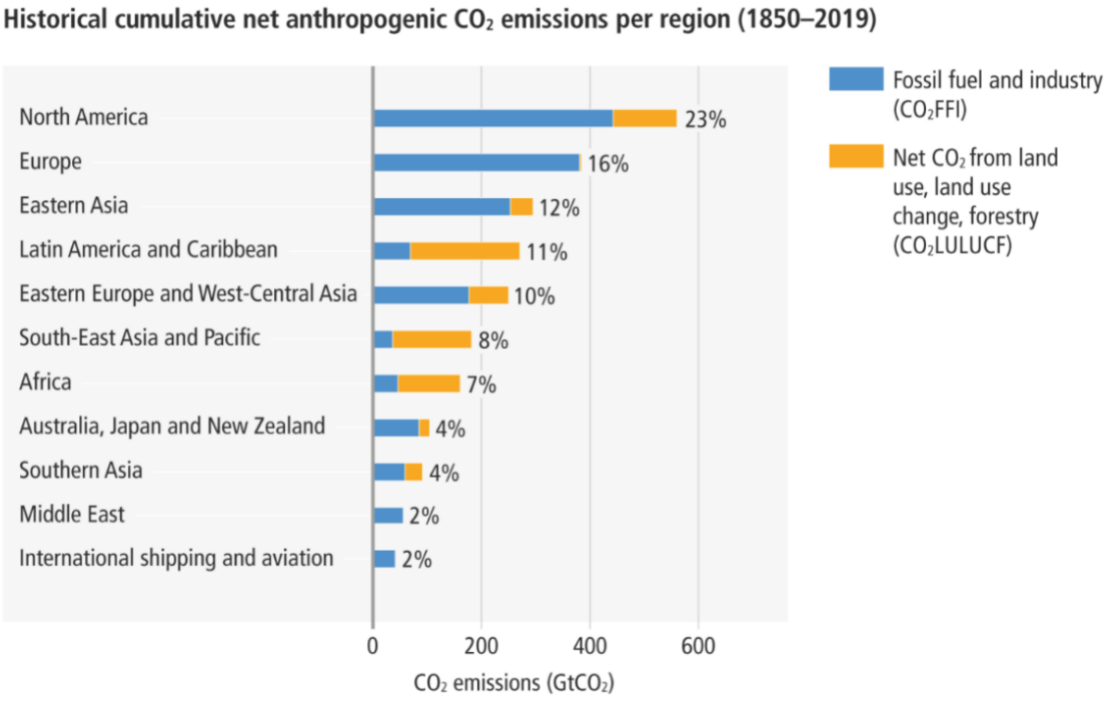
Chapter 4: Corporate Planning for Net Zero and the use of Negative Emissions

The market has yet to properly understand and price the full risks and costs of climate disintegration. There is a high probability of increasing regulation, legislation and shareholder activism that will force companies to accelerate their path to carbon neutrality.

In line with global plans to limit global warming, and in light of these growing global pressures, we recommend all companies should have clear Net Zero strategies as soon as possible to become carbon neutral by 2035-40 at the latest, depending on their carbon intensity, for all but the most carbon intensive, hard-to-abate industries, such as aviation. This will necessarily involve the purchase of negative emissions by companies to mitigate their residual emissions. We recommend companies should gear up to the purchase of negative emissions at their long-term sustainable levels quickly (purchasing negative emissions at levels that offset their forecast hard-to-abate residual emissions), to underpin the carbon removal market's development while benefiting from falling costs.

Government targets

An IPCC historical view of which countries have been responsible to date for cumulative emissions from fossil fuel and agricultural emissions is illuminating. It perhaps will set expectations as to which countries should take the lead in looking to address climate change:



While this chart by its nature understates the ongoing impact of emissions from growing economies such as China and India, who need to address their emissions as their economies expand, clearly the

US and Europe should take that lead having been the greatest emitters historically; reaching Net Zero should be seen as a bare minimum for both. Given their historic emissions, which have been fundamental building blocks in creating their wealth, their ambition should be to become net negative to compensate for historic emissions, or should focus in addition on helping less well developed countries achieve Net Zero; or probably both.

With that context, it is therefore commendable how the UK and many of those European countries have now put in place the ambition to become Net Zero by 2050.

However, given the IPCC forecast that emissions that will create 1.5 degrees of warming will already have been emitted by 2030, it also is questionable how politically sustainable adopting a 2050 Net Zero ambition will be; there will be mounting pressure at the government level to both accelerate that date and to become net negative, with carbon removals compensating for historic and ongoing emissions This is likely to be at the government and corporate level.

Corporate targets

In 2019, approximately 34% of GHG emissions came from the energy sector, 24% from industry, 22% from agriculture and 15% from transport; it is largely the corporate sector that contributes to those national emissions.

So, if governments are likely to be committing to increasingly demanding Nationally Determined Contributions, or are falling behind on delivering existing commitments, it will largely be through the corporate sector that they will look for these targets to be delivered.

The implication is clear; either companies should take the lead to implement decarbonisation strategies, ahead of government targets, or it is only a matter of time before regulation and legislation will be used to mandate reductions; but not necessarily in ways companies would have chosen!

Given that context, it is relatively surprising that a significant proportion of companies have no Net Zero plans in place. At a recent KPMG conference of over 200 companies, a survey showed 30% had plans to be carbon neutral by 2030, 33% by 2050, but over 30% had no plans whatsoever. Similarly, PwC's 2021 Global CEO survey found just 40% of CEOs have factored climate change into their risk-management strategies.

While the requirements from the Task Force on Climate-related Financial Disclosures (TCFD) will shortly come into effect, under which companies will have to increase their reporting of financial risk, there is no actual requirement for companies to have any accompanying mitigation or Net Zero commitments and strategies. They do however force all companies with more than 500 employees to disclose governance and processes for identifying climate-related risks, report the risks and their possible impacts, targets and KPIs to manage those risks. Disclosure without a clear mitigation plan will become increasingly difficult over time.

So, given the lack of any legal requirement currently, why should companies introduce Net Zero strategies?:

- **Because it is the right thing to do.** Clearly companies have an important leadership role in addressing climate change. This has led some, most notably Microsoft, to commit to not only carbon neutrality, but to become carbon negative; actually aiming to mitigate all of the carbon it has emitted since inception. (Microsoft plans to be carbon negative by 2030 and, by 2050, aims to have removed all of the emissions it put into the atmosphere since its founding in 1975. It has already purchased 1.4 million metric tonnes of carbon removals from 15 suppliers to help achieve this)
- **Reducing risk.** Increasing numbers of companies will become susceptible to climate risks from a number of areas:
    - legislative and regulatory, where authorities will take control of decarbonisation of their sectors
    - climate risks; insured losses for natural catastrophes rose to USD 112 billion in 2021 for property damage alone, not including consequential business disruption (PwC 2022)
    - technical - the threat of substitute products and industries that will shift demand and customers
    - customer demand - shifting preferences towards decarbonised products
    - costs - increased cost of and availability risk through the supply chain

> "Companies with strong ESG programs are seen as less risky and can earn higher credit ratings. And "green bonds" that are issued specifically for environmental projects typically have coupons 10 to 45 basis points below those of other corporate debt."
> KPMG research 2022

The disclosure requirements of the TCFD will increase pressure on companies to have a long term, credible Net Zero strategy, including how to manage scope 3 emissions of their related businesses, where direct action may be difficult, so offsetting carbon removal purchases may be required. *(See for instance the Implementation Guidance of the Transition Plan Taskforce launched by the UK Treasury in 2022 to develop 'the gold standard' for private sector climate transition plans)*

- **Increasing shareholder action and public pressure.** An increasing trend from shareholders to require the implementation of carbon neutral strategies. This is compounded by targeted protestor action focused on companies with the poorest record or direct involvement with fossil fuel production, such as from Just Stop Oil and Extinction Rebellion that make strong cases for radical change.
- **Valuation benefits.** Reflecting the combination of an increasing volume of ESG-focused funds, greater investor focus on carbon neutrality, and the perception of increasing risks of those companies that have not addressed climate risks, has led to clear valuation benefits to companies with a clear Net Zero strategy. The precise valuation benefits are hard to determine accurately as there is a lack of counterfactual - what would a company's value have been had it not implemented such a strategy? - but a recent KPMG study estimated a

10-20% valuation premium for companies with a high ESG rating. Driving Value Through ESG - KPMG March 2022

- **Growing willingness of customers to pay.** A transition to Net Zero is not without cost. Where this is imposed through regulation, then industries may together raise prices to customers (although there are clear cross-border issues to consider here). But in many sectors, there is a clear willingness of customers to pay for a decarbonised product. For instance, local authorities for decarbonised energy from waste, or airline customers looking for a total offset of the emissions of their flight. A strong focus will be needed on developing demand for decarbonised products.
- **Staff recruitment, retention and motivation.** Companies do not operate outside of the real world. Their employees want to work for companies that are making a real difference and are playing their part.

> "Research shows that employee engagement is higher in companies with strong ESG programs and, according to analysis by Gallup, companies with highly engaged business units and teams have 14 percent higher productivity and are 23 percent more profitable than peers."
> KPMG research 2022

Put simply, by introducing a plan to achieve carbon neutrality, companies can take control, with the best people and deliver the highest corporate value.

Industry organisations such as Chapter Zero are therefore making the strong case for boards and NEDs to encourage the introduction of Net Zero plans. In a recent paper, Carbon Gap makes the case how companies, in particular low-emitting companies in the tech and finance sectors have a huge potential to catalyse carbon removals through their support of the industry through pre- and post purchases, offtake agreements, philanthropy and equity investments. *(Bridging the Ambition Gap: A framework for scaling corporate funds for carbon removal and wider climate action)*

Given all of these factors, but also, given the earlier context that it is almost certain we will pass the point of 1.5 degrees of warming by 2030, where without subsequent carbon removals that degree of global warming will have occurred by the end of the century, then the expectation is that these factors will increase in intensity; the pressure will be on companies to decarbonise sooner.

The precise date by which a company should target Net Zero should depend on the industry, its technologies, age of assets, ability to pass costs to customers and the impact of carbon pricing, but broadly we recommend;

- **low emitters should target carbon neutrality by 2030.** This may primarily entail offsetting secondary carbon emissions such as travel, heating of buildings and ensuring energy efficiency and sourcing of green energy, but may also entail product switching. product change, and switching energy sources.

- **most high emitters should target carbon neutrality by 2040.** High emitters will include power companies, energy from waste, refineries, transport companies. These companies will have large investments in fossil-fuelled assets that may have several years of remaining

useful life and where the technology has not yet progressed to replace them with energy efficient or differently powered alternatives, or those technologies are not yet affordable.

But these companies are the ones most likely to be subject to increasing carbon pricing and customer and stakeholder demands. So, the funding and pressure to upgrade assets to carbon neutral ones as they are replaced will be strong.

Initiatives such as the Mission Possible Partnership have been set up by the World Economic Forum and partners precisely to help key sectors such as cement, shipping, aviation, chemicals and steel address hard-to-abate residual emissions.

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Decarbonisation of the airline industry will be particularly challenging. Given the huge economic and social benefits of flying, a solution is required, but is technically difficult.

The route to decarbonisation will involve a balance of three factors:

- Investment in new assets; more efficient aircraft or using new power sources such as hydrogen
- Use of sustainable aviation fuels; increased usage of carbon neutral fuels, for instance from CO_2 sourced from carbon removals blended with hydrogen
- Purchases of carbon removals at scale to mitigate residual emissions

The balance of these factors will depend on the availability, feasibility and cost of each, but will require investment in each at scale, including a substantial and growing demand for carbon removal offsets. Given the huge investment required across three separate industries, through CORSIA the airlines have committed to achieve carbon neutrality by 2050, in line with the leading countries' Net Zero commitments.

The role of Negative Emissions in Corporate Net Zero Strategies

So where should Negative Emissions sit within a company's Net Zero strategy?

Carbon removals will play an increasingly important, but always secondary, part of a company's decarbonisation strategy. The primary focus should always be on the decarbonisation of existing operations. But companies should already be thinking about their long-term need for offsetting carbon removals and incorporating them early into their plans.

We recommend:

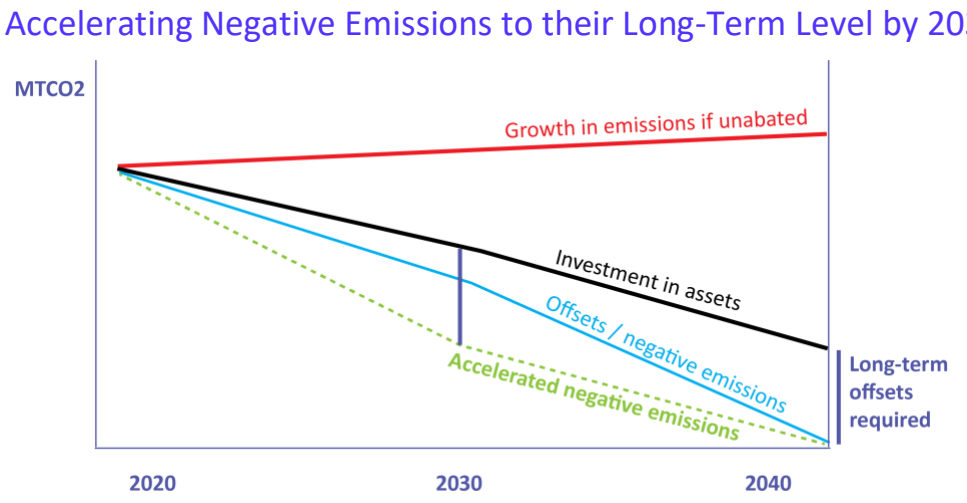
1. All companies should have a strategy and execution plan to reduce carbon emissions, both direct and indirect, and decarbonise their operations to become carbon neutral.

2. Companies that are asset intensive may take longer to replace and upgrade their assets, according to their natural life cycles. In such cases, it may be more economic to purchase robust carbon removals in the interim to advance faster to carbon neutrality.

3. Most companies will have long-term, hard-to-abate emissions, either because the technology of that sector will inherently produce CO_2, despite technological improvements, or known solutions are unaffordable. Those companies' decarbonisation strategies will therefore have to include investment in mitigating carbon removals equal to those remaining, hard-to-abate emissions.

4. Companies should purchase their long-term forecast level of negative emissions as soon as practical, recognising that part of the business that needs to be offset. Those purchases will immediately offset those hard-to-abate parts of the business, and at the same time help underpin nascent, but increasingly economic and competitive, negative emissions markets, making the long-term strategy of the company more reliable, robust and affordable.

An indicative overall strategy for high emitters is shown in the diagram below:



The fundamental two elements of a Net Zero plan are therefore:

- Developing an understanding of how investment in new assets (replacement technologies, conversion to sustainable energy, implementing carbon capture and storage etc) will reduce current emissions, by when
- Understanding what negative emissions will be needed to offset residual emissions and accelerating the purchase of that level of negative emissions to 2030

> "For some sectors like aviation and agriculture, residual emissions remain where emissions can't be captured at source of release as they would be with CCUS, or where no further feasible action can be taken to reduce emissions. It is therefore essential that the UK normalises the use of engineered greenhouse gas removal methods (GGRs) which capture emissions directly from the atmosphere if we are to meet our Net Zero 2050 target."
> UK Government's "Skidmore Review" 2023
> **Mission Zero: Independent Review of Net Zero**

Is there a 'moral hazard' of encouraging investment in negative emissions?

Some have expressed concern over the risk that encouraging investment in NEs could reduce incentives on companies to decarbonise their businesses.

That risk is removed if companies follow the strategy above:

- Every company should have clear path to carbon neutrality. If this can be achieved without carbon removals, then this is the path they should target
- If that business will need NEs in the long term, they should begin purchasing negative emissions, building up to their long-term sustainable level by 2030
- NEs are therefore a small, but important part of an overall decarbonisation strategy

A further 'moral hazard' may be avoided by following the recently-advanced principle of like-for-like balancing of emissions and removals. This further refinement of the Oxford Principles recommends that nature-based carbon removals should be directed towards offsetting deforestation and other land-based emissions, while fossil-fuel emissions must be counterbalanced by more robust and long-lived engineered removals. This matching is needed to sustain net zero over many years and decades in the future, rather than just hitting net zero by a specific date like 2040 (Allen, M.R. et al., 2022. Annual Review of Environment and Resources 47, 849-887.)

The availability and robustness of Negative Emissions

For companies to be able to incorporate the purchase of negative emissions into their corporate strategy presumes two key things; that NEs are available to purchase at scale and that they are robust, true offsets.

The following chapters consider these two questions.

Chapter 5: The growth of the negative emission industries and the future availability of negative emissions for purchasers

There is a growing breadth of negative emission industries under development across engineered solutions with geological storage, through BECCS and energy from waste to nature-based solutions. The technologies are ready and investable, but currently lack the funding to launch at scale.

We predict that by 2030, negative emissions will be available for companies to buy at scale. Corporate pre-purchases of negative emissions and the act of incorporating negative emissions into their Net Zero plans will in turn encourage investment in negative emission production. There will be a virtuous relationship between the supply of, and demand for, negative emissions.

There is growing recognition from governments as to the need for carbon removals, building them into their Net Zero strategies.

> "GGRs are vital to the delivery of the Net Zero Strategy. The Strategy committed to deploying at least 5MtCO$_2$ per year of engineered removals by 2030, with modelling suggesting this could need to rise to 23MtCO$_2$ per by 2035."
>
> "Engineered GGRs have significant potential to create a carbon negative economic sector with novel export potential and could create swathes of green jobs."
>
> "However, the UK needs to accelerate development of the GGR industry if it is to capture the 40 to 100 MtCO$_2$ p/a of residual emissions expected to remain in 2050."
>
> UK Government's "Skidmore Review" 2023
> [Mission Zero: Independent Review of Net Zero]

With this backdrop of a recognised need and an increasing impetus behind Government's support of carbon removal industries, a large number of negative emission projects are under development.

The following projects are some current UK examples of projects under development, which will be the source of negative emissions for growing corporate demand.

$7CO_2$ Hub

A hub for dispersed sites in the Southwest, South Wales and West Midlands

$7CO_2$ is being developed as a regional hub that can receive CO_2 by either pipeline from local emitters or by rail from regional dispersed sites.

A large number of regional energy from waste plants will access the $7CO_2$ carbon storage hub at Avonmouth docks for onward shipment to geological storage.

$7CO_2$ has the potential for shipping over $2MTCO_2$pa from energy from waste alone, 50% of which is from biogenic waste and therefore will be negative emissions.

Forward purchases of those negative emissions by corporates looking for carbon offsets will bring funding to the sector and accelerate the pace at which energy from waste can both decarbonize generally and contribute to carbon removals at scale quickly. They will also lessen the cost of Government contractual support to the introduction of CCS, increasing their ability to support additional projects.

Project Carbon Harvest

Founded in 2008, Future Biogas is one of the UK's largest producers of biomethane, injecting over 500 GWh of green gas into the grid each year – enough to heat over 40,000 homes.

Future Biogas is leading the development of Project Carbon Harvest – a venture to design and operate the UK's first anaerobic digestion (AD) plants to operate subsidy-free, and deliver Bioenergy with Carbon Capture and Storage (BECCS).

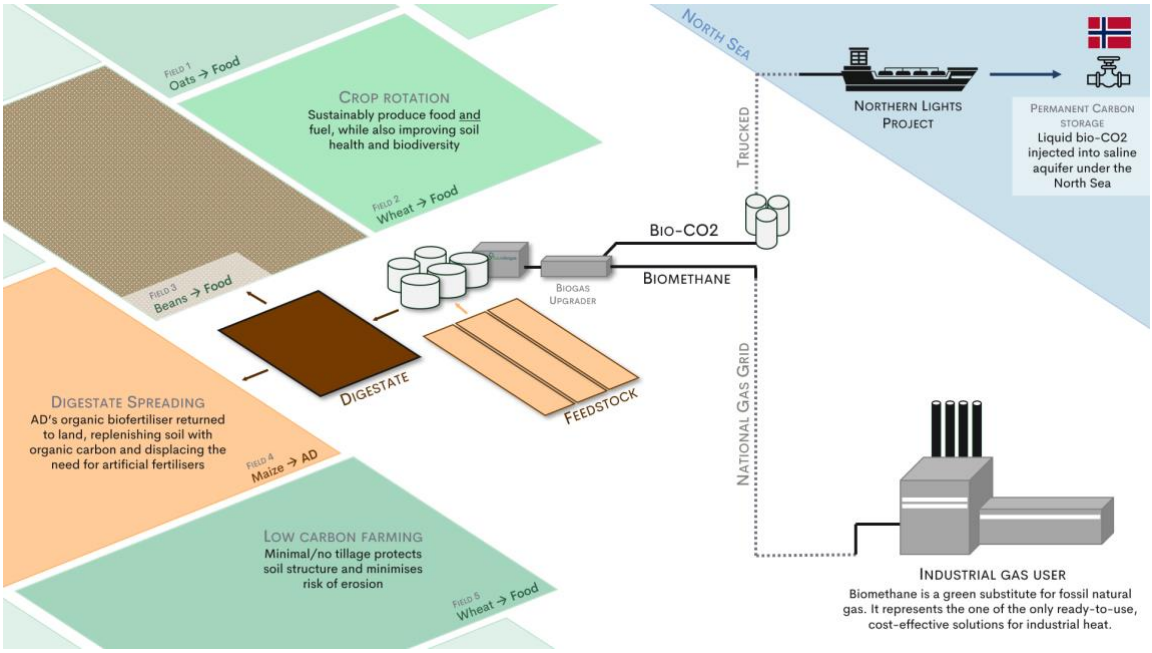
All AD plants produce biogas: a gaseous mix of biomethane (~55%) and bio-CO_2 (~45%). Biogas can split into these component gases – aka upgraded – such that biomethane can be injected directly into the national gas grid. As the only viable means of decarbonising the grid, government subsidies have historically focused on the production of this renewable green gas – overlooking the resultant stream of highly concentrated CO_2.

By unlocking the value of this CO_2 stream, Future Biogas's new BECCS plants will operate without government subsidies – breaking the industry's dependence on support. All CO_2 produced from AD will be captured and transported to the Humber, ready for geological storage. Initially, it will be collected and

stored kilometres beneath the North Sea basin by Northern Lights, a Norwegian project offering commercial-scale CCS.

This pathway delivers robust, permanent GHG removals, with negligible risk of reversal. Consequently, it represents a high-value market for bio-CO_2, where companies are already seeking high quality removals to offset their unavoidable emissions.

Each BECCS plant will produce 100-150 GWh of biomethane, and 14-21 kt of bio-CO_2 every year:



Future Biogas' BECCS plants will be primarily fed by locally grown maize, grass and whole crop rye. All feedstocks will be grown under long-term contracts with local farmers. Crucially, all biomass is grown using sustainable, low-carbon practices, designed to decarbonise the farm and build soil carbon. These include:

- Longer crop rotation. Fundamental to sustainable agricultural, crop rotations deliver multiple benefits to the farmer and environment – improved soil fertility, increased soil carbon, greater crop yields – while also helping to control the spread of pests and disease. Biomass grown as part of the rotation can be digested to produce biogas. In Project Carbon Harvest, such crops will be grown in between several conventional crops thus minimising impact on food production, diversifying agricultural income and improving soil health.
- Minimal/no tillage. This minimises the risk of soil erosion and mitigates risks of soil compaction while encouraging health soil microbiome including greatly increased worm counts.
- Spread digestate to land. Displacing demand for artificial fertilisers, returning organic carbon, trace nutrients and an active biology to soils and kick-starting the increase in soil organic matter.

Overall, Project Carbon Harvest aims to grow crops with a carbon intensity between -5 and +5 kgCO2e/MJ – i.e., potential to be carbon negative. Any sequestration on-farm will be monitored after rigorous baselining so that it can be quantified and accredited, such that the farmer will be able to claim credits and further diversify income.

enfinium

enfinium is one of the largest energy to waste operators in the UK, with a portfolio of six assets that by 2025 will transform over 3 million tonnes of non-recyclable waste into energy every year. As over 50% of enfinium's feedstock is biogenic, there is a significant opportunity for enfinium to become a leading producer of carbon removals in the UK.

enfinium have recently signed a Memorandum of Understanding (MoU) to collaborate on the development of one of the UK's first 'Rail to Zero' carbon capture rail corridor, that would enable dispersed industrial sites to permanently store their emissions. This project would transport carbon dioxide (CO2) captured at enfinium's Ferrybridge waste facilities in West Yorkshire to Navigator's storage facilities in Teesside using rail freight. The CO2 would then be transported safely offshore for permanent storage. Bechtel, a global leader in engineering, construction, and project management, has been selected to support the feasibility work underpinning the concept.

The pioneering project would enable enfinium to decarbonise the UK's largest energy from waste site. By permanently storing the biogenic emissions captured from its waste stream, the Ferrybridge site would also generate around 700,000 tonnes of carbon removals every year – making a significant contribution towards the UK Government's target to produce 23 million tonnes of negative emissions per year by 2035 to remain on track to achieve a 'Net Zero' economy by 2050.

Bioenergy Infrastructure Group

Bioenergy Infrastructure Group (BIG) is a developer, owner and operator of waste wood and energy from waste (EfW) plants, with five operational assets currently in the portfolio ranging from 10 – 25MW electrical capacity, using a combination of standard combustion and gasification technologies.

Three of BIG's plants use post-recycled waste wood biomass, and two use Refuse Derived Fuel (RDF) made from household and commercial waste that can no longer be re-used or recycled. BIG is actively exploring implementing CCUS across its portfolio, including on its pathfinder project at Ince Bio Power Ltd.

Ince Bio Power is an operational 22MW waste wood gasification power plant in the North West of the UK, which is developing commercial-scale carbon capture storage (CCS) as a retrofit to the existing waste wood power project. The project - known as InBECCS – could be operational in the late 2020's, subject to establishing a viable route to market that will underpin the project's business case.

Ince Bio Power's feedstock is locally sourced grade C waste wood that has reached the end of its usable life and can no longer be recycled into panel board or safely used in animal bedding. Instead of going to landfill or being exported, energy is recovered from it and used to generate low carbon electricity, compliant with the UK Government's biomass sustainability criteria, and supportive of the circular economy more broadly.

Ince is in very close proximity to the Hynet industrial cluster CO_2 transport and storage network, which has been prioritised for funding by the UK Government and is forecast to be operational by the mid 2020's. CO_2 captured by InBECCS and injected directly to the main Hynet infrastructure will be transported to depleted oil and gas fields in the Irish Sea by pipe where it will be geologically stored.

By sequestering biogenic CO_2 derived from sustainable sources, InBECCS will be able to deliver in excess of 200,000 tonnes per annum of robust carbon dioxide removals. As a commercial-scale CCS retrofit to a waste wood gasification power project, this would be a first of a kind project for the UK.

Viridor

Viridor's Carbon Capture Plant at Runcorn is the largest opportunity to accelerate deployment of CCS to decarbonise the waste sector.

The UK Government announced in March 2023 that Runcorn Energy Recovery Facility's CCS Project has been shortlisted for the final stage in the Government's industrial carbon capture (ICC) sequencing process. The proposed plant will be one of the first carbon capture projects on an EfW facility in the world.

Developing CCS at Runcorn will kick start a world leading carbon capture industry in the UK. The project alone will capture c.900,000 tonnes of CO_2 each year. Half of the captured CO_2 will be from biogenic sources, effectively removing 450,000 tonnes from the atmosphere annually and driving the development of a critical source of negative carbon emissions.

Runcorn CCS project will provide stable baseload supply to the HyNet industrial carbon capture cluster in the North West and create net additional impact to the UK economy of 1,300 person-years of employment in design and construction, and c. 60 high permanent jobs in operation and maintenance.

The availability of robust Negative Emissions

The case studies above show the immediate and imminent supply of negative emissions at scale; both nature-based solutions with an existing, growing biochar market, and geological storage with the coming onstream of DACS, BECCS and energy from waste projects.

It is this emerging supply of robust emissions that can allow companies to confidently include the purchase of mitigating carbon removals as part of their integrated strategies to become carbon neutral.

Chapter 6: The need for robust standards to underpin the carbon removals industry

There is a need for agreed robust standards that define carbon removals (over and above emission reductions) and give assurance to corporate purchasers looking to buy offsetting carbon removals that those negative emissions will fully mitigate their residual emissions over the long-term.

There are currently a number of international standards agencies who can accredit carbon removals, however, some do not distinguish reductions and removals and others have conflicting views on issues like permanence and additionality, which could be confusing for a purchaser.

Every form of carbon removal does have to consider some unwanted consequences from land and energy use, source of feedstock, knock-on effects and whether removals are permanent (in the time frames needed to address climate change). Those consequences should be disclosed and mitigated as far as possible.

Increasing influence from international bodies such as the Integrity Council for Voluntary Carbon Markets means there is a path to greater clarity, understanding and conformity, so that corporate purchasers will be able to buy future certified negative emissions with confidence.

The need for robust international standards for negative emissions

The current market for carbon credits is unregulated, has self-appointed review bodies, and in a large number of cases is ascribing carbon credits to projects which at face value will not contribute to addressing climate change.

Many 'carbon reduction' projects have questionable 'additionality' as they would have happened anyway (due to regulation) or are payments to prevent actions such as deforestation, rather than paying for new removals. These projects thereby offer carbon credits at low prices and allow purchasers to claim carbon neutrality at low cost, despite the dubious impacts of those investments. This devalues our whole industry and dampens demand for, and public support of, carbon credits. (For a humorous, but excruciating and rather fruity take on the ineffectiveness of carbon credits, try Carbon offsets: Last Week Tonight with John Oliver)

The quicker a robust overarching structure is accepted for only negative emissions, (whose methodology would bring into question marginal carbon emission reduction projects), the more the carbon removals industry will be seen as a robust contributor to addressing climate disintegration.

Key to this should be a differentiation between carbon reduction projects and carbon removals, as described in chapter 3 above, which has not been the focus of most standards agencies to date.

Robust Negative Emissions

Why does the accounting for negative emissions need to be robust?:

- the history of carbon credits for projects of questionable additionality means we need a reboot; negative emissions should be seen as robust if we are to build demand
- equally, negative emissions will only form an integral part of companies' Net Zero strategies if they are confident that those NEs will more than offset their residual emissions
- different carbon removal industries have different issues to address, requiring a framework that captures their possible shortcomings

What key issues do emerging standard need to address?

Permanence

What is the risk of stored carbon being re-released into the atmosphere?

Additionality

Would that carbon be captured and stored if the carbon removal credit wasn't generated?

Sustainability

Are the wider impacts of that carbon removal method understood and accounted for?

Verification

Can the offset be verified through a registry and science-based methodology? What enduring legal protections are necessary?

A comprehensive summary of the additionality, recommended accounting methodology, harms and benefits, permanence, environmental justice, monitoring and verification needs of each of the main forms of negative emissions is given in an excellent paper by Carbon Direct and Microsoft - Criteria for high-quality carbon dioxide removal

Without looking to recreate that extensive paper, below we consider below the key issues of permanence and additionality.

The permanence and durability of negative emissions

For negative emissions to be robust, it is critical that the carbon is stored for material periods; i.e. for centuries which therefore significantly contribute to addressing impending climate change. This is known as 'permanence' or 'durability' of the carbon removal.

The permanence of carbon removals placed into geological storage from DACS, BECCS and energy from waste with CCS, as well as biochar and ocean storage, are clearly a distinguishing factor, in particular to carbon reduction investments.

But both geological storage and nature-based solutions can address permanence, albeit in different ways, considered below.

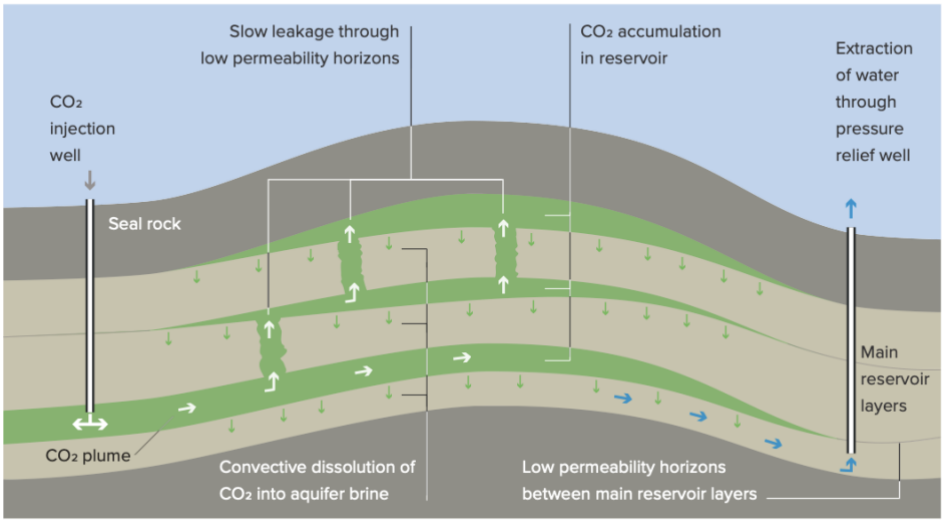
> "The removal and storage of CO_2 through vegetation and soil management can be reversed by human or natural disturbances; it is also prone to climate change impacts. In comparison, CO_2 stored in geological and ocean reservoirs (via BECCS, DACCS, ocean alkalinisation) and as carbon in biochar is less prone to reversal."
>
> IPCC 2022

The permanence of geological storage

The permanence of geological storage has attracted much attention; its low risk is perhaps best considered in the context of the very real and imminent risks of climate disintegration. As the Royal Society has summarised:

> "The chance of CO_2 escaping the reservoir is low, and well-regulated wells are estimated to retain 98% of their CO_2 over 10,000 years. Measures to ensure CO_2 is injected safely include:
>
> - Using an injection rate suitable for the site-specific geology to avoid fracturing seal rocks
> - Using pressure relief wells to reduce sub-surface pressure
> - Continuous monitoring to detect and rectify leaks"
>
> Royal Society
> Geological Carbon Storage October 2022

Illustration showing what happens to CO_2 when injected underground.
A typical 'anticline' reservoir for CO_2 with multiple layers of porous rock separated by thin layers of mudstone.

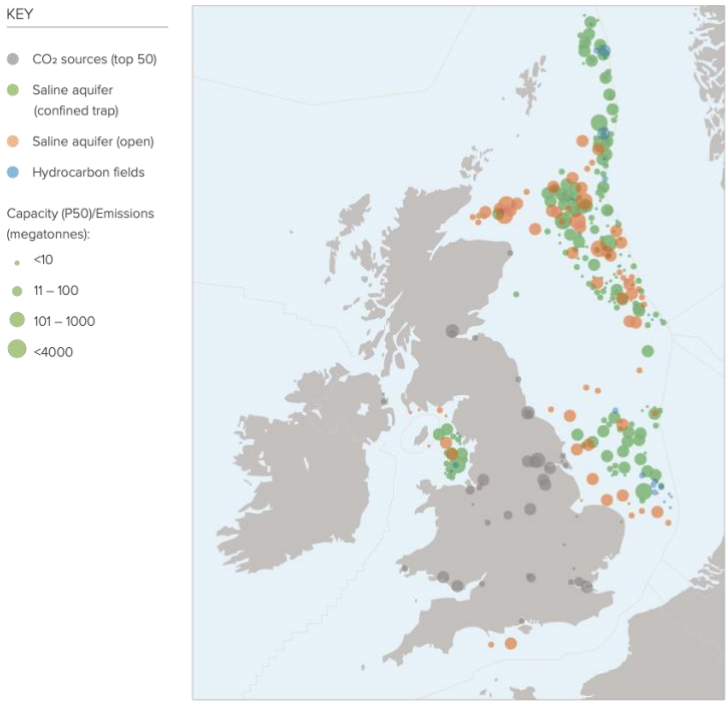


Royal Society October 2022

Geological storage therefore can safely store CO_2 for thousands of years using either natural formations or alternatively depleted oil and gas fields, which by definition had stored hydrocarbons for millions of years.

The following map shows the potential storage areas around just the UK, which has particularly suitable geology. The potential for massive amounts of storage for negative emissions is clear.

Theoretical CO_2 storage capacity in the UK[27].



Given the low probability of leakage from geological storage, but particularly given the stringent existing regulatory requirements that are placed on storage owners and operators, and robust regulatory controls on CO_2 storage in jurisdictions leading in storage, with clear liabilities on owners, then any audit verification of the robustness of geological storage should be able to rely on those regulatory controls.

The permanence of nature-based solutions

Nature-based solutions offer a very fast, low-cost, non-infrastructure-dependent way of investing in negative emissions. They key issue for NBS to address is therefore whether those carbon removals are long-term in the context of the climate change they are looking to mitigate:

> "Afforestation ("AR") can be highly efficient in delivering CDR, up to 95–99% under optimal conditions...The CO_2 leakage associated with the establishment and the ongoing management of forests is negligible in comparison to the CO_2 sequestration potential of AR, and that even over millennial time period.... However, regional bio-geophysical factors, such as the near-term relatively slow and limited forest growth in cold climates, or the long-term exposure to natural disturbances, e.g. wildfires in warm and dry climates, substantially reduces the overall CO_2 removal efficiency of afforestation."
>
> Energy and Environmental Science Journal 2022
>
> A comparative analysis of the efficiency, timing, and permanence of CO_2 removal pathways

Nature-based solutions have clear advantages:

- They offer an immediate, cheap and highly effective way to remove carbon from the atmosphere. Afforestation clearly has wider biodiversity benefits and can contribute to regional cooling, increased rain and therefore agricultural benefits.
- The effectiveness of growing trees and mangrove swamps is of course far higher in warm climates and therefore investment in afforestation offers great potential for the transfer of funds from developed to developing countries as companies look for carbon removal investments.
- Afforestation can immediately happen at the local level without the need for enabling infrastructure and investment. It can attract focused funding with immediate impacts.

The Achilles Heel of afforestation is whether its permanence can be guaranteed. Can it lock away carbon for periods sufficiently long to contribute to addressing climate change? It is important that we have agreed methodologies to address permanence so as to not undermine a growing demand for nature-based carbon removals through a lack in confidence as to their permanence and durability.

There is not necessarily one approach to addressing NBS permanence. Three alternatives are frequently discussed:

- **Separate policies for different removals**. Policies and targets are set in different sectors. In particular, land based negative emissions should only be used to offset land-based emissions, not fossil fuel. So the permanence of the offset has equivalence to the emissions.
- **Volume discount.** The probability of reversal is determined at the outset, with an assessment of local conditions, governance, laws and protections, impacts of climate

change, and quality of management. Carbon credits are therefore issued at a discount; several tons of NBS storage are needed for one ton of offset. This approach is relatively simple and benefits from not requiring substantial governance thereafter. The key issue to consider is whether the right incentives are created for maintenance given the credits are given upfront.

- **Permanence equivalence.** With this approach, the purchaser is under a long-term obligation to maintain that carbon store. So any degradation has to be made good in the future. That obligation is ongoing. The key issue to consider here is the effectiveness of any such obligation in the context of climate change; can governance last that long?

These alternative approaches are well described in Bellona's paper: Addressing differences in permanence of CDRs. Carbon Direct makes a similar distinction between volume discount and permanence equivalence in their 'vertical stacking' (over-buying tons now, so effectively applying a discount) and 'horizontal stacking' (buying over time to replace degraded stores): Accounting for short-term durability in carbon offsets

The additionality of negative emissions

A key differentiator of negative emissions over emission reductions is their additionality. Whereas carbon reductions should be happening anyway - due to regulations, legislation and companies investing in carbon neutrality - negative emissions are essentially a waste disposal activity that will only happen if incrementally funded; carbon removal is paid for by the negative emission revenues.

Without that funding, those removals would not take place. They are therefore clearly additional.

But as ever, there are complexities to consider:

- Nature-based solutions need to consider any displacement activities. Does, for instance, new afforestation lead to consequential deforestation or other land use change emissions elsewhere? The governance needs to ensure this is not the case or is accounted for.
- Some agencies question the additionality of government-supported projects. If government support for a project is already in place, then can the consequential negative emissions be additional?

  This accounting approach does not recognise the actual framework under which that support is given and would present a real barrier to the development of negative emission projects if it is not changed. In the UK, for instance, contractual support for negative emission projects is being given by Government on the presumption that the project will sell negative emissions and reduce the cost to Government of its support and encourage development of the NE market so that the sector becomes increasingly self-funding. Their fundamental presumption is that the NEs from those projects are additional. If this is not recognised by the accounting, then those projects will not be able to benefit from government support and will never get off the ground.

  An approach is needed that aligns government-supported projects with contributions from the voluntary carbon market. (See, for instance, Financing Engineered Carbon Removal with the Voluntary Carbon Markets - Eve Tamme, Climate Principles)

The ICVCM and European Union Emerging Guidance and Proposed Certification Process

All negative emission approaches do have possible risks and impacts that need to be considered and mitigated to ensure the carbon removal is truly additional. The IPCC lists some key factors for each technology shown in the table below.

Table 0-1: summary of status, costs, potentials, risk and impacts, co-benefits, trade-offs and spillover effects and the role in mitigation pathways for CDR methods. TRL = Technology Readiness Level.[1]

CDR option	Status (TRL)	Cost (USD tCO_2^{-1})	Mitigation Potential ($GtCO_2$/yr)	Risk & Impacts	Co-benefits	Trade-offs and spill-over effects
DACCS	6	100–300 (84–386)	5–40	Increased energy and water use.	Water produced (solid sorbent DAC designs only).	Potentially increased emissions from water supply and energy generation.
Enhanced weathering (EW)	3–4	50–200 (24–578)	2–4 (<1–95)	Mining impacts. Air quality impacts of rock dust when spreading on soil.	Enhanced plant growth, Reduced erosion, enhanced soil carbon, reduced pH, soil water retention.	Potentially increased emissions from water supply and energy generation.
Ocean alkalinity enhancement	1–2	40–260	1–100	Increased seawater pH and saturation that may impact marine life, possible release of nutritive or toxic elements and compounds, mining impacts.	Limiting ocean acidification.	Potentially increased emissions of CO_2 and dust from mining, transport and deployment operations.
Ocean fertilisation	1–2	50–500	1-3	Nutrient redistribution, restructuring of the ecosystem, enhanced oxygen consumption and acidification in deeper waters, potential for decadal-to-millennial-scale return to the atmosphere of nearly all the extra carbon removed, risks of unintended side effects.	Increased productivity and fisheries, reduced upper ocean acidification.	Subsurface ocean acidification, deoxygenation, altered meridional supply of macronutrients as they are utilised in the iron-fertilised region and become unavailable for transport and utilisation in other regions, fundamental alteration of food. Webs and biodiversity.
Blue carbon Management in coastal wetlands	2–3	Insufficient data, estimates range from ~ 100 to ~ 10000	<1	If degraded or lost, coastal blue carbon ecosystems are likely to release most of their carbon back to the	Provide many non-climatic benefits and can contribute to ecosystem-based adaptation, coastal protection, increased	If degraded or lost, coastal blue carbon ecosystems are likely to release most of their carbon back to the atmosphere. The full

[1] IPCC Working Group III report: The land sector and climate mitigation Appendix-1. https://zerocarbon-analytics.org/wp-content/uploads/2022/04/IPCC-Working-Group-III-report_-The-land-sector-and-climate-mitigation-Appendix-1.pdf

				atmosphere, potential for sediment contaminants, toxicity, bioaccumulation and biomagnification in organisms, issues related to altering degradability of coastal plants, use of subtidal areas for tidal wetland carbon removal, effect of shoreline modifications on sediment redeposition and natural marsh accretion, abusive use of coastal blue carbon as means to reclaim land for purposes that degrade capacity for carbon removal.	biodiversity, reduced upper ocean acidification, could potentially benefit human nutrition or produce fertiliser for terrestrial agriculture, anti-methanogenic feed additive, or as an industrial or materials feedstock.	delivery of the benefits at their maximum global capacity will require years to decades to be achieved
BECCS	5–6	15–400	0.5–11	Competition for land and water resources to grow biomass feedstock, biodiversity, and carbon stock loss if from unsustainable biomass harvest.	Reduction of air pollutants, fuel security, optimal use of residues, additional income, health benefits and, if implemented well, can enhance biodiversity, soil health and land carbon	Competition for land with biodiversity conservation and food production
Afforestation/ Reforestation	8–9	0–240	0.5–10	Reversal of carbon removal through wildfire, disease, pests may occur. Reduced catchment water yield and lower groundwater level if species and biome are inappropriate.	Enhanced employment and local livelihoods, improved biodiversity, improved renewable wood products provision, soil carbon and nutrient cycling. Possibly less pressure on primary forests	Inappropriate deployment at large scale can lead to competition for land with biodiversity conservation and food production.
Biochar		10–345	0.3–6.6	Particulate and GHG emissions from production, biodiversity, and carbon stock loss from unsustainable biomass harvest.	Increased crop yields and reduced non-CO_2 emissions from soil, and resilience to drought.	Environmental impacts associated particulate matter, competition for biomass resource.
Soil carbon sequestration in croplands and grasslands	8–9	45–100	0.6–9.3	Risk of increased nitrous oxide emissions due to higher levels of organic nitrogen in the soil, risk of reversal of carbon sequestration.	Improved soil quality, resilience, and agricultural productivity.	Attempts to increase carbon sequestration potential at the expense of production, net addition per hectare is very small, hard to monitor.
Peatland and coastal wetland restoration	8–9	Insufficient data	0.5–2.1	Reversal of carbon removal in drought or future disturbance, risk of increased methane emissions.	Enhanced employment and local livelihoods, increased productivity of fisheries, improved biodiversity, soil carbon and nutrient cycling.	Competition for land for food production on some peatlands used for food production.
Agroforestry	8–9	Insufficient data	0.3–9.4	Risk that some land area lost from food production; requires high skills	Enhanced employment and local livelihoods, variety of products improved soil quality, more resilient systems.	Some trade-offs with agricultural crop production, but enhanced biodiversity and resilience of the system.
Improved forest management	8-9	Insufficient data	0.1-2.1	If improved management is understood as merely intensification involving increased fertiliser use and introduced species, then it could reduce biodiversity and increase eutrophication	In case of sustainable forest management, leads to enhanced employment and local livelihoods enhanced biodiversity, improved productivity.	If it involves increased fertiliser use and introduced species, it could reduce biodiversity and increase eutrophication and upstream GHG emissions.

As a potential purchaser, the issues to consider may seem daunting.

However, there is an emerging consensus from standards agencies and international bodies, including the EU, of how to account for negative emissions to ensure they are robust.

In particular, the Integrity Council for the Voluntary Carbon Markets is trying to encourage a universal approach to the voluntary carbon markets that will help accelerate a just transition. The ICVCM is an international governance body with the objective of establishing accepted robust governance. While its remit is wider than just negative emissions, covering all carbon credits, adopting its Core Carbon Principles will be a significant step to ensuring the robustness of future negative emissions. ("Build integrity and scale will follow").

Described in their recent consultation, ICVCM - Core Carbon principles, Assessment Framework and Assessment Procedure, the ICVCM recommend key guiding principles;

The ICVCM Core Carbon Principles

Additionality

The greenhouse gas emission removals from the mitigation activity shall be additional, i.e. they would not have occurred in the absence of the incentive created by carbon credit revenues.

Mitigation activity information

The carbon crediting programme shall provide comprehensive and transparent information on all credited mitigation activities, publicly available and accessible to non-specialists audiences.

Permanence

The removals shall be permanent or if there is a risk of reversal, any reversal shall be fully compensated.

Programme governance

The carbon crediting programme shall have effective governance to ensure transparency accountability and overall quality of carbon credits.

Registry

The programme must uniquely identify record and track activities and carbon credits issued to ensure credits can be identified securely and unambiguously.

Robust independent third-party validation and verification

The carbon crediting programme shall have program level requirements for robust independent third-party validation and verification of mitigation activities.

Robust quantification of emission reductions and removals

The GHG emission reductions or removals from the mitigation activity shall be robustly quantified, based on conservative approaches, completeness and sound scientific methods.

Sustainable development impacts and safeguards

The carbon crediting programme shall have clear guidance, tools and Compliance procedures to ensure mitigation activities conform with or go beyond widely established best industry practices on social and environmental safeguards, while delivering on net positive sustainable development impacts

Transition towards net zero emissions

The mitigation activity shall avoid locking in levels of emissions, technologies or carbon intensive practices that are incompatible with achieving net zero emissions by mid-century.

The ICVCM core principles are helping to set the benchmark for determining what are robust negative emissions.

While the ICVCM is to some extent following excellent standards development work by alternative agencies, its intervention is helping to align standards and the associated governance surrounding carbon removals.

> "Robust governance requires that carbon-crediting programs demonstrate transparency about who oversees the carbon-crediting program and that roles, responsibilities and the relationship to competencies for all levels of decision making are assigned and discoverable. Robust governance requires that all key documentation and information relevant to decision-making is publicly available…including standards, methodologies, procedures, tools, guidelines, supplementary information and project documentation."
>
> ICVCM 2022

Similarly, in November 2022, the European Commission issued proposals for a voluntary framework for removals, very much mirroring the approach advocated by ICVCM:

> "Today the European Commission adopted a proposal for a **first EU-wide voluntary framework to reliably certify high-quality carbon removals**. The proposal will boost innovative carbon removal technologies and sustainable carbon farming solutions, and contribute to the EU's climate, environmental and zero-pollution goals. The proposed regulation will significantly improve the EU's capacity to quantify, monitor and verify carbon removals. Higher transparency will ensure trust from stakeholders and industry, and prevent greenwashing. Carbon removals can and must bring clear benefits for the climate, and the Commission will prioritise those carbon removal activities which will provide significant benefits for biodiversity. Moving forward, the Commission, supported by experts, will develop tailored certification methods for carbon removal activities delivering on climate and other environmental objectives.
>
> To ensure the transparency and credibility of the certification process, the proposal sets out **rules for the independent verification of carbon removals**, as well as **rules to recognise certification schemes** that can be used to demonstrate compliance with the EU framework. To ensure the quality and comparability of carbon removals, the proposed regulation establishes **four QU.A.L.ITY criteria**:
>
> - **Qu**antification: Carbon removal activities need to be measured accurately and deliver unambiguous benefits for the climate;
> - **A**dditionality: Carbon removal activities need to go beyond existing practices and what is required by law;
> - **L**ong-term storage: Certificates are linked to the duration of carbon storage so as to ensure permanent storage;
> - Sustainabil**ity**: Carbon removal activities must preserve or contribute to sustainability objectives such as climate change adaptation, circular economy, water and marine resources, and biodiversity.
>
> European Commission 2022

The key point for independent purchasers of carbon removals is that the industry is rapidly aligning in its framework, methodology and governance. Within a couple of years, there will be a high degree of consensus amongst standards agencies over the definition of robust negative emissions and residual emissions can be mitigated with confidence.

There may also be a trend towards 'bundling' of negative emission projects across sectors into CDR units; so, for instance, including some DACS, EfWs, BECCS and NBS in a single unit of CDR. This approach would:

- make it easier for companies to access the negative emissions marketplace without the need to become subject matter experts
- blend different industries so that their relative strengths come through and weaknesses are mitigated
- allow for a standard set of governance and integrity review across sectors
- simplify the due diligence process for purchasers

(See, for instance, Regulating removals: Bundling to achieve fungibility in GGR 'Removal Units' - Macinante and Ghaleigh, University of Edinburgh, April 2022)

Leading Standards Agencies

There are several independent agencies in the sector, and that number is increasing. Some have been predominantly focused on wider carbon credits rather than negative emissions and each has their own particular policy on issues like permanence, additionality and whether negative emissions should be invested in now to develop the market or only after a company has completed its decarbonisation investment.

The leading agencies and registries include:

puro • earth	Puro Earth Owned by NASDAQ and focused purely on carbon removals
VERRA	Verra – The Verified Carbon Standard A global GHG crediting programme
CLIMATE ACTION RESERVE	Climate Action Reserve Global offset registry
Gold Standard	Gold Standard Established in 2003 by the WEF and other NGOs to recommend the best standards for climate and sustainable development

	American Carbon Registry Established in 1996 as the first voluntary GGR registry in the world
	CCS+ Looking to develop robust accounting principles particularly focused on CCS
	BeZero Carbon Global carbon ratings and risk analytics

The Coalition for Negative Emissions can provide contacts and referrals for companies wishing to get accounting standard guidance, as well as provide insight into individual project opportunities.

Chapter 7: The voluntary, Government-sponsored and Regulated market – a virtuous relationship

There will be a virtuous link between the developing voluntary carbon market, government-sponsored projects and the longer term regulated and/or compliance markets, where purchases of negative emissions are allowed as offsets to carbon taxes and pricing.

Early endorsement by governments of the negative emissions of chosen projects and sectors will increase demand from the voluntary sector for those negative emissions from the voluntary market and may help firm up the emerging consensus on how to define robust negative emissions, ultimately allowed as regulatory offsets.

Companies that are or will be subject to carbon pricing such as the Emissions Trading Scheme should anticipate that robust negative emissions will be recognised as appropriate offsets to a portion of those obligations by the mid 2020s and plan their Net Zero strategies accordingly. Such a regulatory allowance will accelerate investment in negative emission industries, as companies look to offset the emissions from the hard-to-abate parts of their business.

The developing NE industry can anticipate funding from three interrelated areas:

- **Voluntary market** – a growing number of companies and investors are looking to buy high-integrity carbon removal credits to meet their own Net Zero targets
- **Government-supported market** – Government tax breaks (such as under the US IRA act), grant funding or long-term concessions will underpin early NE investment, where the NE price in voluntary markets alone is not high enough to underpin investment
- **Regulated/compliance market** – as NEs become accepted in regulation as an additional method to meet companies' carbon tax or regulatory commitments to reduce emissions, companies will be incentivised to purchase certified NEs. They should be willing to pay up to their avoided regulatory/tax costs, or possibly higher if they want to both offset regulatory commitments and deliver on more exacting corporate decarbonisation targets.

These three areas have a virtuous relationship:

- The voluntary markets are focused on developing standards that can be adopted by the government and regulated markets in due course
- Government supported projects will create a greater supply of NEs for investors and provide momentum to the inevitable fall in costs that comes with production at scale
- Once negative emissions are allowed as a partial offset to regulated markets, this will unleash substantial funding of benefit to voluntary and government-backed schemes
- Voluntary and regulated/compliance purchase of NEs from projects will reduce the level of support required from government to any particular project

- By giving guidance on their position on negative emission standards and that individual projects meet those standards, governments will deliver a positive impact, as the very act of Government endorsement will increase demand for those negative emissions; there is a high degree of latent demand from voluntary markets for robust emissions, pending that level of formal endorsement as to their robustness

This virtuous relationship is underway now, with the first government-sponsored projects already operational in the US and anticipated in the UK within 18 months.

For companies to now include negative emissions as a legitimate part of their decarbonisation strategy to 2030 and beyond, including carbon tax mitigation, is therefore now a sound strategy, in the expectation of wide availability of negative emissions and an ability to offset carbon liabilities.

Chapter 8: Summary and conclusions

In what may seem a bewildering sector to outside companies, the actual path for companies is clear and will become easier over time and can be summarised as follows:

- To stay within 1.5 degrees will require huge reductions in emissions in the next decade and investment in substantial negative emissions thereafter
- Companies have a crucial role to play: the more companies that invest in negative emissions, the greater the likelihood we stay within 1.5 degrees of global warming
- All businesses should have a clear strategy to reduce carbon emissions and decarbonise their operations as soon as possible, with targets to become carbon neutral by 2030-40 depending on their carbon intensity, or by 2050 for particularly hard-to-abate sectors
- They will need to determine the likely level of negative emissions needed to mitigate their residual hard-to-abate long-term emissions
- They should ramp up to purchasing those long-term levels of negative emissions by 2030, giving industry the time to mobilise and reduce costs
- A plan that incorporates investing in negative emissions will allow visionary companies to adopt strategies now to become either carbon neutral or net negative
- Private sector participation in negative emissions will provide the funding for the infrastructure needed to deliver permanent carbon removals
- Investors will soon have the confidence that extensive carbon removals are available and are high quality, verifiable, permanent, and additional