# Making good for carbon emissions

## For external dissemination

## May 2025

Owner: Anke Friedrich, member of the Sustainability Committee

# Table of Contents

**In order to keep the focus on the main points and to simplify the complexity of the topic at least a bit, throughout this document no distinction is made between certain terms such as carbon, $CO_2$ and greenhouse gases, carbon removal is sometimes used interchangeably with carbon capture and some other terms such as neutralisation, elimination et al have been avoided.**

**The research undertaken for this document is UK centric and can be widened to a general European perspective.**

# 1 Introduction: Arriving at Net Zero

## 1.1 What is net zero? – Why is Financial Investment Needed to Achieve it?

The Paris Agreement states that in order to keep the average global warming to 1.5°C or well below 2°C, the yearly world emissions must reduce of 4 to 7% per year compared to a baseline. By 2030, emissions need to be reduced by 30 to 50%, and by 2050, the world must reach global Net Zero.

Net zero describes a state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere (see Figures 2.1 and 5.1). The term net zero is important because – for carbon at least – this is the state at which global warming stops.

The 'net' in net zero is important because it will be very difficult to reduce all emissions to zero on the timescale needed. The Intergovernmental Panel on Climate Change estimates in their average scenarios that 5 to 10% of yearly global emissions will be hard to reduce and are unlikely to be avoided, and therefore need to be captured, removed and stored, i.e. offset (see Chapter 3.2). Thus as well as deep and widespread cuts in emissions, the removal of carbon from the atmosphere needs to be sped up.

## 1.2 Surely, It is All Greenwashing!

There has been a lot of criticism around poor quality control and misleading claims, on offsetting schemes in particular. The problems identified are these

- Potential to slow down reduction efforts
- Overcounting: Some offset projects have been claimed to systematically overcount carbon credits
- Durability: The durability of offset credits is a concern. What happens when there is no more funding? In the case of nature based solutions, emissions might be released back into the atmosphere by deforestation.
- Speed: Given the urgency of the climate crisis, measures such as planting trees won't help reduce emissions as quickly as needed. Trees planted now become viable carbon offsets only around 2050.
- Additionality: Projects are not additional meaning they would have happened anyway even without the investment from the schemes
- Shift of responsibility/harm to local populations/global fairness: high emitting countries produce lots of emissions as they have developed infrastructure that runs on fossil fuels. Low-emitting countries want to keep developing a reliable infrastructure. - Carbon offset projects can harm local communities, resulting in violent conflicts, food insecurity, and displacement.
- Leakage: Emissions are shifted from one place to another, sometimes unintentionally - a common issue in forestry projects.
- Misleading claims: Exaggerated claims, intentional or unintentional, about the project's emission cuts. - Inflated baseline figures often can lead to exaggerated claims of a project's benefits. - Overestimation of avoided deforestation
- Limited Capacity of Carbon Capture and Storage: The capacity for industrial Carbon Capture and Storage and nature-based solutions is limited. There are constraints on land use for nature-based solutions, and industrial carbon capture and storage is not a mature technology yet. The capacity for carbon capture depends on the stabilization of temperatures. Thus, offsetting without reducing further limits the world's capacity to meet Net Zero.

Acknowledgement of these problems and further research have led to the creation of standards, certifications and validation schemes (see Chapter 4).

Among the lessons learned are these:

- Offsetting or any other strategy of paying money to make good must go together with substantial changes to operations and behaviour change
- Offsetting should be at least at the level of emissions caused
- Offsetting needs to be at a scale that disincentivises the continuation of carbon expensive practices

## 1.3 $CO_2$ Emission Reports as the Basis for Offsetting

The approach taken by the GHG Protocol is to measure - account – report – act. The first three steps are covered by earlier work done and resulted in a $CO_2$ Report including an Emission Inventory of all operations that generate carbon emissions as well as an Emissions Table. This table and the report lead into the acting step, of which Offsetting is one.

In line with the approach taken by the GHG Protocol, emissions are divided into scope 2 emissions which are indirect emissions derived from the production of purchased electricity, heating and cooling, and scope 3 emissions which are indirect emissions resulting from all other activities. An organisation may not produce any direct Scope 1 emissions.

| Inventory item | CO2e generated [t] |
|---|---|
| **SCOPE 2 Indirect Emissions** | |
| Gas use in the office | |
| Electricity use office | |
| Electricity Use of Networking Infrastructure | |
| **Total SCOPE 2 Indirect Emissions** | |
| | |
| **SCOPE 3 Indirect Emissions** | |
| **Business travel** | |
| Hotel | |
| Train | |
| Plane | |
| Ferry | |
| Taxis | |
| **Employee Commuting** | |
| Bus | |
| Train | |
| Motorbike | |
| Car | |
| **Total SCOPE 3 Direct Emissions** | |
| | |
| **TOTAL CO2e emissions** | |

**Table 1.1: Example of an Emissions Table**

A cumulative approach was used and this table does not yet cover all operations that generate carbon emissions. More items will be added in subsequent years as the methodology of data collections and analysis in the organisation improves. – Therefore, the real total emissions for that year are higher.

## 1.4 What this Document is About

This document is concerned with giving some background knowledge to enable informed decisions on how to make good for ongoing carbon emissions and possible historic ones as well.

It starts with looking into natural carbon cycles, i.e. the natural storage and release of carbon, and then continues with how existing surplus carbon can be removed from the atmosphere, working from the general approaches, their verification and standards developed to some varied examples of offsetting projects.

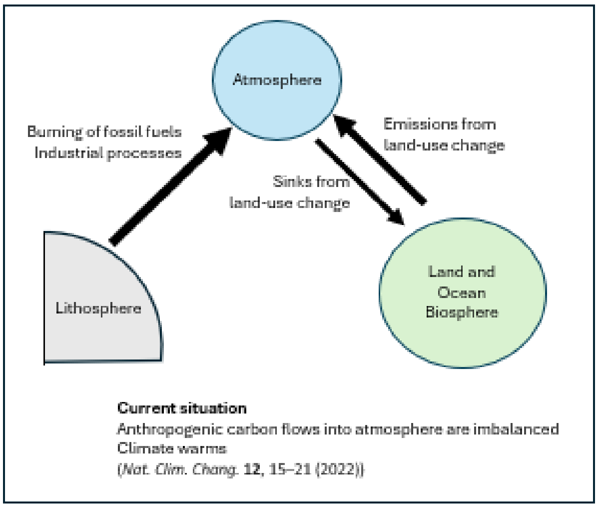
Finally, some scenarios are presented to focus the decision making on which approach will be taken towards carbon removal.

# 2 Carbon Storage and Release

In a nutshell, the problem that leads to climate change is that through man-made activities $CO_2$ is released into the atmosphere faster than it is stored. This is because of the burning of fossil fuels which essentially is an extremely fast release of carbon which had been stored for hundreds of millions of years. At present, there is no process that is able to remove and store $CO_2$ at the same speed or faster.

To achieve a state of durable net zero, many things need to happen:

- A reduction in the burning of fossil fuels
- A reduction in emissions from land-use change
- Capture/removal of $CO_2$ from the atmosphere and long-term geological storage
- Capture/removal of $CO_2$ in biomass followed by long-term geological storage



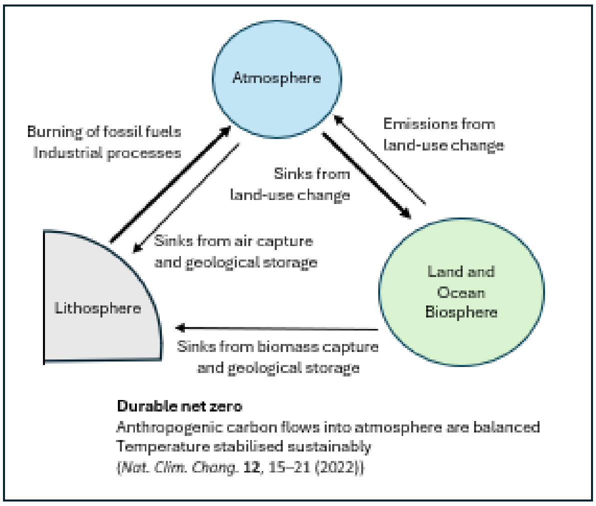




**Figure 2.1: $CO_2$ Storage and Release – Current Situation and Durable Net Zero**

| Slow carbon cycle | Fast carbon cycle |
|---|---|
| 100- 200 million years | <100 years |
| | |
| **Long term storage of carbon/carbon sinks** | **Short term storage of carbon** |
| Rocks (land and sea) | Photosynthesis → biomass (plants, algae, plankton) |
| Ocean (shells from shellfish and phytoplankton) | |
| Coal, gas, oil | |
| Soil and peat | |
| | |
| **Slow release of carbon into atmosphere** | **Fast release of carbon into atmosphere** |
| Weathering of rocks | Plant and animal respiration |
| Oceans ($CO_2$ from deep waters) | Burning of fossil fuels (natural and human activities) |
| | Oceans ($CO_2$ in surface water) |

**Table 2.1: The Slow and the Fast Carbon Cycle**
Timescale, storage and release of carbon

## 2.1 A Bit More on Carbon Stores

A carbon sink or store is a natural or artificial reservoir that absorbs and stores the atmosphere's carbon with physical and biological mechanisms. Coal, oil, natural gases, methane hydrate and limestone are all examples of carbon sinks. After long processes and under certain conditions, these sinks have stored carbon for millennia.

The table below gives another impression of the amount of carbon stored together with the duration. Though the amount of carbon in coal, gas and oil does not seem a lot, compared to the atmosphere it is 5.5 times as much. Today, carbon in the atmosphere is at least 1.5 times that compared to pre-industrialisation.

| Store | Amount stored [Billion Tonnes] | Duration of storage if undisturbed [years] |
|---|---|---|
| Sedimentary rocks and ocean sediments | 100,000,000 | >150,000,000 |
| Oceans | 39,000<br>(900 in surface waters) | >500 |
| Coal, gas, oil | 4,000 | >1,000,000 |
| Soil and peat | 1,500 | >10.000 |
| Atmosphere | 720 | >1,000 |
| Land plants (biomass) | 560 | 100 |

**Table 2.2: Natural Carbon Stores**

# 3 Dealing with Carbon Emissions

In their annual $CO_2$ reports, organisations take responsibility for a certain amount of $CO_2e$ emissions in that year. However, the total emissions are higher, taking into consideration that every organisation will have historic emissions from when they started and which are still lingering in the atmosphere.

Net zero refers to a state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere (Fig 2.1). The 'net' in net zero is important because it will be very difficult to reduce all ongoing emissions to zero on the timescale needed. As well as deep and widespread cuts in emissions, i.e. reduction and avoidance, removal and storage will need to be sped up. In order for net zero to be effective, these must be permanent.

There is no agreement yet on how to order the different approaches of dealing with emissions and the different technologies available and lots of different terms are used. The following follows a simple dichotomy of reduction/cutting/avoiding and removal and storage of carbon emissions. This approach mostly ignores some finer points made by others on whether these reductions and removals are made on the burning of fossil fuels or from land-use change, whether carbon comes directly from the atmosphere or from biomass before it goes into long-term storage and whether they relate to Scope 1, 2, or 3 emissions.

## 3.1 Reducing Carbon Emissions

Reduction of carbon emissions is achieved by the application of strategies to avoid carbon from going into the atmosphere in the first place. This is a great way of getting towards net zero as the organisation has direct influence on this. The target is to reduce to the level of absolute unavoidability, and offset (remove) the rest. Arriving at the absolutely unavoidable level of emissions will not be achieved over night and requires a good, quality multi-year strategy which is a separate piece of work.

Two more thoughts on reduction though: avoided emissions do not feature very prominently in the approach taken by the GHG Protocol. Recently, there are voices that call for avoided emissions to be reported separately as Scope 4 emissions with the caveat that they should not be used to adjust Scope 1, 2 or 3 reduction plans and emissions reporting but to inform mitigation policy design.

Reporting on Scope 3 emissions in essence means reporting on the emissions of the supply chain (specific lines are drawn on who reports what, but some double accounting is allowed here). Therefore, by investing and encouraging their supply chain to reduce their carbon, organisations help their own overall net zero goal and can start a chain reaction, making an even greater impact on the environment. This is known as insetting.

## *Example for insetting of business travel - PepsiCo*

*PepsiCo aimed to embed sustainability into each staff's decision making on travel by introducing the Business Travel Inset Program. The program collects a fee from each business unit that is directly linked to the greenhouse gas emissions generated by each associate's business-related air travel. They then invest those fees into regenerative agriculture projects within their supply chain to reduce and sequester an equal amount of carbon.*

*And while the "insetting" of the carbon is important, perhaps the most important aspect of the program is the addition of a step in the company's travel booking tools, which require their staff to confirm the business necessity of their travel before they can book it and acknowledge that a fee will be taken from their business' budget to balance out the carbon 'cost.'*

*This highly visible policy change serves as a regular reminder, and education moment, to employees throughout the business to be mindful of the true cost of the decisions they make, while helping to reduce PepsiCo's Scope 3 emissions in the process.*

## 3.2 Removal and Storage of Carbon

It is necessary to remove surplus carbon that has been released to the atmosphere since industrialisation began and also because of ongoing releases. Offsetting schemes (to offset GÉANT's unavoidable emissions) are based on these.

Carbon removal strategies cover everything from natural mechanisms like growing trees to novel technologies. Most of these technologies are based on the natural mechanisms of carbon removal through biomass, oceans and rock formation as described in Chapter 2. Over the last few years, carbon removal and storage technologies have grown from a niche concept to an accepted component, but problems around maturity and readiness for the market remain (Appendix B), indicating a need for further investment and development.

### 3.2.1 Removal

Please see Appendix A for a comparison of these technologies.

**1) Trees and Forests**

Expanding, restoring and managing tree cover to encourage more carbon uptake can leverage the power of photosynthesis, converting carbon dioxide in the air into carbon stored in wood and soils. Management approaches include Reforestation, Restocking, Silvopasture, Cropland agroforestry and Urban reforestation.

It usually takes between 31 and 46 trees to offset one tonne of carbon. But it's important to remember that this will depend on the size of the trees, and where they're planted.

<u>Benefits</u>: Trees are especially good at storing carbon removed from the atmosphere by photosynthesis. Additional flood/erosion prevention, additional ecological and health benefits

<u>Risks and limitations:</u> Major challenges are to ensure that forest expansion in one area doesn't come at the expense of forests somewhere else and are aligned with the interests of local people. – Also easily undone and short term storage.

**2) Farms and Soils**

Soils naturally store carbon, but agricultural soils are running a big deficit due to frequent plowing and erosion from farming and grazing, all of which release stored carbon. Because agricultural land is so expansive, even small increases in soil carbon per acre could be impactful. There are many practices that can increase the amount of carbon stored in soils, and scientists are developing crops with deeper roots while also depositing additional carbon into the soil for example from biochar.

Benefits: Many of the practices that increase soil carbon also improve soil health and can make agricultural systems more resilient to climate change.

Risks and limitations: The amount and duration of the carbon sequestered depend on regional climate and soil type, among other factors. - The efficacy of some soil carbon sequestration practices is subject to continued scientific debate; changing conditions or management practices from year to year could erase prior gains.

**3) Biomass Carbon Removal and Storage**

Biomass carbon removal and storage includes a range of processes that use biomass from plants or algae to remove carbon dioxide from the air and then store it for long periods of time. These methods aim to leverage the carbon storage capacity of plants beyond their natural lifecycles.

Methods include the creation of biochar or bio-oil, and storage in soil or permanent storage in geological vaults.

Benefits: Biomass carbon removal and storage can offer long-term carbon removal.

Risks and limitations: Not all processes necessarily provide a net carbon benefit. It's not always straightforward to determine whether biomass is truly sustainable. The use of purpose-grown crops needs to be disincentivized and waste biomass used instead.

**4) Direct Air Capture**

Direct air capture is the process of chemically scrubbing carbon dioxide from the ambient air and then storing it either underground or in long-lived products like concrete.

Benefits: It is relatively straightforward to measure and account for the climate benefits of direct air capture, and its potential scale of deployment is enormous.

Risks and limitations: As of today, the technology remains costly and energy-intensive. Cost estimates vary but generally range from around $100 up to more than $600 per ton of carbon removed.

**5) Carbon Mineralisation**

Some minerals naturally react with $CO_2$, turning carbon dioxide from a gas into a solid and keeping it out of the atmosphere permanently. This process is commonly referred to as "carbon mineralization" or "enhanced weathering".

Scientists are figuring out how to speed up the carbon mineralization process, especially by enhancing the exposure of these minerals to $CO_2$in the air or oceans. Other applications could sequester carbon and replace more emissions-intensive conventional production methods — for example, by using mineralization as part of concrete production.

Benefits: Scientists have shown that carbon mineralization is possible and a handful of start-ups are already developing approaches, including mineralization-based building materials.

Risks and limitations: There is more work to be done to map out cost-effective and prudent applications for scaled deployment and improve measurement of carbon sequestration.

**6) Ocean-Based Approaches**

A number of ocean-based carbon removal approaches have been proposed to leverage the ocean's capacity to sequester carbon. However, nearly all of these strategies are at early stages of development and require more research, and in some cases field testing, to understand whether they are appropriate for investment given potential ecological, social and governance impacts.

Each approach aims to accelerate natural carbon cycles in the ocean. Potential solutions include leveraging photosynthesis in coastal plants, seaweed, or phytoplankton.

Risks and limitations: Some ocean-based carbon removal options could provide co-benefits. For example, coastal blue carbon (carbon stored in mangroves, seagrasses, and salt marshes) and seaweed cultivation could remove carbon while also supporting ecosystem restoration, and adding minerals to help the ocean sequester carbon could reduce ocean acidification.

Risks and limitations: Much is still unknown about the broader ecological impacts of these approaches and further research is needed to better understand potential risks before these approaches are pursued at any scale.

### 3.2.2 Carbon Storage

The storage of carbon and its duration is a crucial when it comes to offsetting. Here a short introduction and please also see Appendix C.

Once carbon has been removed from the atmosphere, it needs to be stored to prevent it from re-entering for as long as possible. The idea is to stabilise carbon in solid and dissolved forms so that it doesn't cause the atmosphere to warm. There are two main types of carbon stoarage, biological and geological (See Figure 2.1)

Biological carbon storage is in vegetation such as grasslands or forests, as well as in soils and oceans.

Geological carbon storage is the process of storing carbon dioxide in geologic formations, or rocks. Typically, carbon dioxide is captured and injected into porous rocks for long-term storage or turned into charcoal and applied to fields.

(Technological carbon storage
Research is going into the use of carbon as a source in graphene production and other engineered molecules.)

# 4 Validity and Standards of Offsetting Projects

Learning from earlier mistakes that led to justified criticism of greenwashing is happening and research is directed here. As everything in this space, the setting of standards and certification is under development and subject to rapid developments and changes.

## 4.1 Validity of Offsetting Projects

Claims of any schemes are considered valid only under a rigorous set of conditions. Carbon reductions and removals in a quality offsetting scheme need to be

- additional, i.e. they would not have happened anyway, for example through a government programme
- verifiable
- not over-estimated
- exclusively claimed, i.e. claimed by only one party
- “like for like”, i.e. a source of emissions and an emissions sink correspond in terms of their warming impact, and in terms of the timescale and durability of carbon storage. This means that not all offsetting schemes are applicable to all sources of emissions
- monitored: e.g. no leakage in storage of carbon

## 4.2 Standards for Offsetting Projects

A plethora of standards have been developed by different organisations to quality mark offsetting schemes based on the above criteria and further aspects. A number of them are listed in Appendix B for further information

All of the standards listed in Annex B have themselves received additional external accreditation against the Carbon Crediting Endorsement Criteria by ICROA (International Carbon Reduction and Offset Alliance).

# 5 Examples of Offsetting Projects

## 5.1 UK-based Offsetting Scheme: Verified Woodland Carbon Credits

According to the Environment Agency, there are currently only two accredited carbon offsetting standards in the UK: the Woodland Carbon Code and the Peatland Code.

As trees take a while to grow and store carbon dioxide, the Woodland Carbon Code offers two types of units.

Pending Issuance Units

A Pending Issuance Unit is a promise to deliver a Woodland Carbon Unit in the future. It can't be used to report against UK-based emissions, but help companies to plan for compensating future UK-based emissions. There are over 4.7 million Pending Issuance Units available. Projects are verified at least every ten years and if the woodland is found to be performing well the Units are converted to Woodland Carbon Units.

Woodland Carbon Units

A Woodland Carbon Unit is a tonne of carbon dioxide equivalent which has been removed from the atmosphere by a Woodland Carbon Code project. It has been independently verified and is guaranteed. Companies can use Woodland Carbon Units to report against UK-based emissions or to make claims about their net zero journey. They can't be used to compensate for overseas emissions or emissions from international aviation or shipping.

There are currently a limited number of Woodland Carbon Units available (approximately 800). More Woodland Carbon Units will become available as woodlands grow and mature.

What happens if a project isn't performing as planned?

About 80% of the projects have passed verification at year 5 without any major concerns. If there are concerns at verification, these projects have to provide a remedial plan. The remaining risk of Pending Issuance Units being cancelled are mediated by a buffer of 20% spare credits. As a buyer, it means your verified credits and any claims you make are protected.

## 5.2 Single Project: Use of a Joint Venture to enable local carbon removal industry and enter the carbon credit market as a seller

Shropshire Council invested £2 million on the installation of a pyrolysis unit in a joint venture with a local pyrolysis unit manufacturer. The unit is expected to be running from late 2024. It will sequester more than 1600 tonnes of $CO_2$ per annum and generate electricity. The biochar can be applied to land and other applications. For the Council, it will create an estimated annual return of £115,000 per annum from the sale of biochar and carbon credits. The Council is now working with consultants to develop a framework and roadmap of documents and guidance that would enable other local authorities or businesses to adopt this approach in a quicker and more cost-effective manner. – not verified

## 5.3 Grouped Projects: Off the shelf offers, traders

**Carbon Neutral Britain**

- Mangrove Restoration
- Wind Farm Mongolia
- Forest Creation England
- Hydroelectric Power Brazil
- Stove Kenya
- Solar Power India
- Wind farm Philippines etc

**Climate Partner**

All verified by the Carbon Standard (VCS), the Gold Standard, and the Clean Development Mechanism (CDM).

- Nature based solutions
- Social Impact: People in poorer countries are the most vulnerable to the effects of climate change. This makes it all the more important to involve people in these regions in climate action. Social impact projects are climate projects that not only reduce greenhouse gas emissions, but also focus on people. They aim to improve local living conditions by tackling health problems, creating jobs, or developing local infrastructure. The projects use a variety of technologies, such as improved cookstoves, water filters, and solar lights.
- Renewable energy
- Technical solutions
- Combined projects

**Ecologi**

- Biochar: Location unclear. Verified by Puro Earth. Biochar is a substance with many soil benefits, not just removing and storing carbon from the atmosphere. Created through a process called pyrolysis (burning waste plant matter in the absence of oxygen), biochar is a really stable form of carbon, that will not degrade for a long time, keeping the carbon locked safely away for hundreds of years. £195/t
- Regenerative agriculture carbon removal
- Enhanced rock weathering removal: Scotland, verified by Puro Earth. Crushed silicate rock such as basalt is spread on local agricultural land. When the rock comes into contact with rainwater, it is slowly dissolved, locking up the $CO_2$ from the atmosphere as a solid bicarbonate, whilst safely releasing nutrients and minerals into the soil to help the farmer improve soil and crop health. £245/t
- Blue carbon removal: Mexico, Pakistan, verified by Gold Standard, VCS. £50/t
- UK Climate and Nature Fund: This is a portfolio of UK based projects. Verified by UN SDG 13 - Climate Action, UN SDG 15 - Life on Land, Puro Earth.
- Et al

# 6 Summary and Scenarios

## 6.1 Summary

As demonstrated above, the field of carbon emissions, reduction, removal and storage together with all the associated areas of technology development, accounting, validation and standard setting of offsetting projects is complex, in rapid development and constantly changing and improving.

In order to make an informed decision about how to go about offsetting it is therefore necessary to agree on the general strategy which will influence which removal technology and scheme the organisation will use.

To emphasize the importance of reducing an organisation's emissions and its interconnection with removal, each of the three scenarios below starts with reduction before moving on to removal/offsetting of emissions. Obviously, the scenarios are not set in stone and elements from each can be combined.

## 6.2 Scenarios

**Scenario 1 Green Washing – Happy with the quick 'solution'**

Accept climate change

- Limited commitment to making further emission reductions across all of GÉANT's operations
- No further or limited development of a proper short term/medium term strategy for reduction and removal of emissions
- Budget for offsetting is set at an amount of perceived affordability
- Doing some off-the shelf offsetting without aiming for reductions in particular areas like business travel

**Scenario 2 Good Citizen - Fulfilling our duties**

Aim for net zero

- Developing a reduction strategy with defined targets
- Developing a quality short and a flexible medium term strategy
- Developing a funding mechanism to remove current and future emissions
- Dedicating more resources to investigate the best and most appropriate offsetting schemes
- Going for certification/accreditation

**Scenario 3 The Trailblazer - Example setting in the network and the wider industry**

Aim for durable net zero

- Maximum reduction strategy, even where it inconveniences and hurts
- Developing a short, medium and long term strategy with repeated reviews and updates taking into consideration the latest developments
- Developing a funding mechanism to in the long run remove historic, current and future emissions
- Applying bespoke, innovative initiatives for removals within the organisation and reductions/removals within the value chain as well as the community
- Going for certification/accreditation

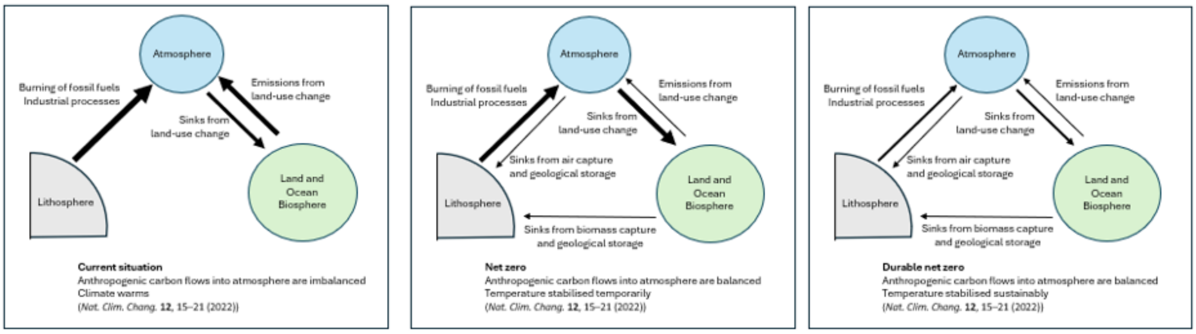



**Figure 5.1: $CO_2$ storage and release – Current Situation, Net Zero and Durable Net Zero**

## References

Disclaimer: Links were accesses in May 2025. Not all links may be in the correct section below. My apologies for this.


**Chapter 1 : Introduction**

https://globalcarbonbudget.org/fossil-fuel-co2-emissions-increase-again-in-2024/

https://ghgprotocol.org/

https://netzeroclimate.org/what-is-net-zero-2/

https://www.unglobalcompact.org.uk/wp-content/uploads/2021/12/Carbon-offsets-25-Nov.pdf

https://www.theguardian.com/environment/2023/sep/19/do-carbon-credit-reduce-emissions-greenhouse-gases

**Chapter 2: Carbon Storage and Release**

https://www.alevelgeography.com/carbon-cycle/

https://earthobservatory.nasa.gov/features/CarbonCycle/

(*Nat. Clim. Chang.* **12**, 15–21 (2022))

*https://www.sustainable-markets.org/terra-carta-impact-report/case-studies/inset-business-travel/*

**Chapter 3: Dealing with Carbon Emissions**

https://www.bgs.ac.uk/discovering-geology/climate-change/carbon-capture-and-storage/

https://www.wri.org/insights/6-ways-remove-carbon-pollution-sky

https://netzeroclimate.org/what-is-net-zero-2/

https://plana.earth/glossary

https://www.sustainable-markets.org/terra-carta-impact-report/case-studies/inset-business-travel/

https://www.cam.ac.uk/research/news/carbon-dioxide-can-be-stored-underground-for-ten-times-the-length-needed-to-avoid-climatic-impact

**Chapter 4 Validity and Standards of Offsetting Projects**

https://www.teamenergy.com/consultancy/net-zero-and-carbon-reduction-consultancy-experts
https://carboncredits.com/what-is-scope-4-emissions-a-critical-aspect-of-carbon-accounting/
https://www.wri.org/insights/6-ways-remove-carbon-pollution-sky

https://www.ucdavis.edu/climate/definitions/carbon-sequestration

**Offsetting**

https://www.unglobalcompact.org.uk/wp-content/uploads/2021/12/Carbon-offsets-25-Nov.pdf

https://www.theguardian.com/environment/2023/sep/19/do-carbon-credit-reduce-emissions-greenhouse-gases

**Chapter 5: Examples of Offsetting Projects**

https://taxfoundation.org/data/all/eu/carbon-taxes-europe-2024/

https://sandbag.be/carbon-price-viewer/

https://assets.publishing.service.gov.uk/media/6093ab72d3bf7f013dea69fa/Achieving_net_zero_-_a_review_of_the_evidence_behind_carbon_offsetting_-_infographic.pdf

https://assets.publishing.service.gov.uk/media/60cc698cd3bf7f4bcb0efe02/Achieving_net_zero_-_a_review_of_the_evidence_behind_carbon_offsetting_-_report.pdf

https://www.fsb.org.uk/resources-page/carbon-offsetting-a-guide-for-small-businesses.html

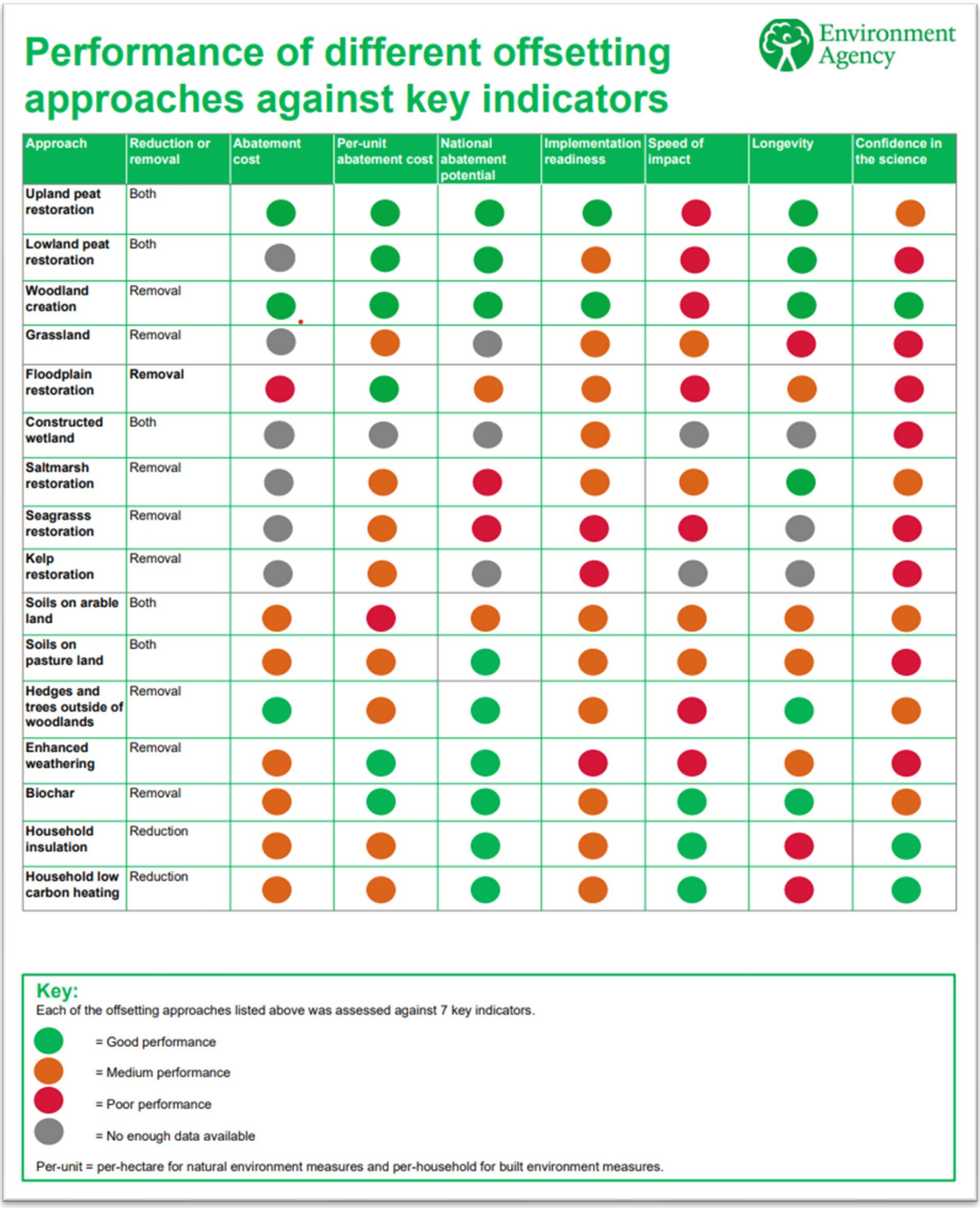
**Standards**

https://ecosecurities.com/wp-content/uploads/2025/01/EcoSecurities_Standards-Overview.pdf

https://carbonneutralbritain.org/blogs/news/verified-carbon-offsetting-standards-overview?

https://icroa.org/about/

# Annex A UK Based Offsetting Approaches



## Performance of different offsetting approaches against key indicators

Environment Agency

| Approach | Reduction or removal | Abatement cost | Per-unit abatement cost | National abatement potential | Implementation readiness | Speed of impact | Longevity | Confidence in the science |
|---|---|---|---|---|---|---|---|---|
| **Upland peat restoration** | Both | Green | Green | Green | Green | Red | Green | Orange |
| **Lowland peat restoration** | Both | Grey | Green | Green | Orange | Red | Green | Red |
| **Woodland creation** | Removal | Green | Green | Green | Green | Red | Green | Green |
| **Grassland** | Removal | Grey | Orange | Grey | Orange | Orange | Red | Red |
| **Floodplain restoration** | **Removal** | Red | Green | Orange | Orange | Red | Orange | Red |
| **Constructed wetland** | Both | Grey | Grey | Grey | Orange | Grey | Grey | Red |
| **Saltmarsh restoration** | Removal | Grey | Orange | Red | Orange | Orange | Green | Orange |
| **Seagrasss restoration** | Removal | Grey | Orange | Red | Red | Red | Grey | Red |
| **Kelp restoration** | Removal | Grey | Orange | Grey | Red | Grey | Grey | Red |
| **Soils on arable land** | Both | Orange | Red | Orange | Orange | Orange | Orange | Orange |
| **Soils on pasture land** | Both | Orange | Orange | Green | Orange | Orange | Orange | Red |
| **Hedges and trees outside of woodlands** | Removal | Green | Orange | Green | Orange | Red | Green | Orange |
| **Enhanced weathering** | Removal | Orange | Green | Green | Red | Red | Orange | Red |
| **Biochar** | Removal | Orange | Green | Green | Orange | Green | Green | Orange |
| **Household insulation** | Reduction | Orange | Orange | Green | Orange | Green | Red | Green |
| **Household low carbon heating** | Reduction | Orange | Orange | Green | Orange | Green | Red | Green |

**Key:**

Each of the offsetting approaches listed above was assessed against 7 key indicators.

- Green = Good performance
- Orange = Medium performance
- Red = Poor performance
- Grey = No enough data available

Per-unit = per-hectare for natural environment measures and per-household for built environment measures.

# Annex B Comparison of Some Standards

https://ecosecurities.com/wp-content/uploads/2025/01/EcoSecurities_Standards-Overview.pdf

The **Verified Carbon Standard** (VCS) Program is the world's most widely used voluntary greenhouse gas (GHG) crediting program. It aims to drive finance toward activities that reduce and remove emissions, improve livelihoods, and protect nature.

**Plan Vivo** Vivo certifies projects against the Plan Vivo Carbon Standard (PV Climate) and the Plan Vivo Biodiversity Standard (PV Nature). Plan Vivo was born out of a desire to help smallholders Chiapas (Mexico) plant trees and generate the world's first carbon credits. Since then, Plan Vivo has used its ideology and network of stakeholders to evolve into a system that can help provide environmental and social benefits to communities around the world.

**SOCIALCARBON** is a holistic international Greenhouse Gas (GHG) standard focused on Nature-Based Solutions. Projects using this standard go beyond carbon, embedding meaningful social, environmental and economic benefits to the projects and their local stakeholders to foster true permanence.

**BioCarbon** is globally recognized as an ICROA-endorsed GHG Program. This milestone is a worldwide recognition of the high-quality of the Standard and the integrity, credibility, and reliability of the approach for issuing and reporting GHG emissions reductions and removals. In addition, the confirmed commitment of BioCarbon to sustainability and climate change targets.

**ARTTREES** The REDD+ Environmental Excellence Standard (TREES) is ART's standard for the quantification, monitoring, reporting and verification of Greenhouse Gas (GHG) emission reductions and removals from REDD+ activities at a jurisdictional and national scale.

**Gold Standard for the Global Goals** (GS4GG), or Gold Standard was established in 2003 by the World Wildlife Fund for Nature (WWF) and other non-governmental organisations. It is one of the most prominent voluntary standards in terms of credits issued. Projects in this standard tend to be more community-based and is one of the first standards to include mandatory criteria for demonstration of other social or environmental co-benefits beyond climate mitigation. Site l Registry l Documents

The **Global Carbon Council** (GCC) is among the more recent players in the international carbon scene established in 2016 by the Gulf Organisation for Research and Development (GORD). The GCC drew interests from the international carbon market when it was approved for the CORSIA pilot phase, representing an alternative for projects that could no longer be served by VCS or Gold Standard, such as large-scale renewable energy power plants. Based in Qatar, it is the only standard in this review based in the MENA region. Site l Registry l Documents
**Puro Earth** Although its activity is still in early stages, Puro.earth gained recognition as one the first standards to cater exclusively to long-term carbon removal projects. Based in Finland, its projects use novel removal methods, such as biochar, carbonated materials, enhanced rock weathering, geologically removed carbon, and terrestrial biomass storage. Projects in this standard are mostly located in the Global North, which is uncommon when compared with other registries.

**CDM and PACM** The Clean Development Mechanism (CDM) was the first UN-run carbon offset scheme, originally conceived to help countries meet their emissions targets by supporting projects in developing countries. The CDM has the highest number of approved methodologies covering a variety of technologies and its rules and procedures have inspired many of the other standards. Although it is no longer operational, its decisions still impact the voluntary carbon market today. The Paris Agreement Crediting Mechanism (PACM) is expected to inherit the position previously occupied by CDM.

**Cercarbono** started in 2016 in Colombia following the creation of the carbon tax scheme and is authorized to work in the carbon market. It has a partnership with EcoRegistry, the projects registration platform. Cercarbono has certified not only project in Colombia, but in other countries in Latin America, Africa and Asia.

# Requirements

Carbon standards establish specific requirements to guarantee the integrity and transparency of projects, such as the need for prior communities' consent, consultations with local and global stakeholders, analysis of risks of non-permanence and the implementation of environmental and social safeguards. The following table provides an overview of the main requirements demanded by each standard.

All the standards have a tool or a way of assessing the risk of projects not being successful for projects with risk of permanence. The criteria for risk analysis vary from standard to standard and generally the analysis results in a risk rate (%) that must be deducted from the credits generated by the project. These discounted credits are retained in a buffer account in the standard and serve to cover the risk of non-permanence associated with projects.

| Requirements | CDM | VCS | GS | GCC | Plan Vivo | Puro.earth | SocialCarbon | Biocarbon | Cercarbono | ART Trees | PACM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prior communication required | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | NF | ✓ | ✓ | ✓ |
| Global Consultation | ✓ | ✓ | ✓ | ✓ | ✓ | NF | X | ✓ | X | ✓ | ✓ |
| Local Consultation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Non-Permanence Risk | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Safeguards Assessment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

NF = Information not found



# Eligible Technologies

Each carbon standard has a specific list of project technologies and scopes that are accepted for carbon credit certification. These scopes define which types of activities can generate credits within the standard's system. Each standard sets clear criteria regarding the methodologies and categories of eligible projects, ensuring that projects meet the specific requirements for the issuance of valid carbon credits. The table below indicates the acceptance of some specific technologies in each standard.

| Technologies | CDM | VCS | GS | GCC | Plan Vivo | Puro earth | SocialCarbon | Biocarbon | Cercarbono | ART Trees | PACM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nature-Based Solutions (NBS) | ARR and Agriculture | ✓ | ARR, agriculture and blue carbon | ✓* | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industrial process and fugitive emissions | ✓ | ✓ | ✓ | ✓ | X | X | X | X | ✓ | X | ✓ |
| Cookstoves | ✓ | ✓ | ✓ | ✓ | X | X | ✓ | ✓ | ✓ | X | ✓ |
| Waste management | ✓ | ✓ | ✓ | ✓ | X | Only carbon removal (Biochar and Terrestrial Wood Storage) | X | ✓ | ✓ | X | ✓ |
| Renewable energy | ✓ | ✓ | ✓ | ✓ | X | Only combined with carbon removal (BECCS) | ✓ | ✓ | ✓ | X | ✓ |

* Accepted, but no approved methodologies available yet.

## Project Scale, Permanence and Grouping

Carbon standards accept both single and grouped projects, covering different scales and complexities. Single projects can focus on specific activities, while grouped projects bring together several similar initiatives in a single certification, facilitating management and efficiency. In addition, these standards accommodate projects of different sizes, from small local initiatives to large-scale interventions, broadening the possibilities for participation in the carbon credit market. From the standards analyzed in this article, only Puro earth and GCC do not accept grouped projects or programs.

Permanence (or longevity) refers to the period in which the project must keep the monitoring system in place to demonstrate that the issued credits remain in the carbon pool of the project. The table below summarizes standard criteria regarding scale, permanence and grouping.

| Standards | Microscale | | Small Scale | | | | | Large Scale | Permanence in years (Sector) | Project Grouping or Program |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area (ha) | tCO2e/yr | Renewable Energy (installed capacity MW) | Energy Efficiency (MWh/yr) | tCO2e/yr General | tCO2e/yr Forestry | tCO2e/yr Agriculture | tCO2e/yr | | |
| CDM | - | 20,000 | 15 | 60,000 | 60,000 | - | - | - | 20 (CCS) | Yes |
| VCS | Regular Projects | | | | | | | > 300,000 | 40 (AFOLU) | Yes |
| GS | 500 | 10,000 | 15 | 60,000 | 60,000 | 16,000 | 60,000 | - | - | Yes |
| GCC | Methodology thresholds must be followed | | | | | | | | 100 (AFOLU) | No |
| Plan Vivo | - | 10,000 | Macroscale | | | | | | - | Yes |
| Puro earth | N/A | | | | | | | | - | No |
| SocialCarbon | - | - | 15 | 60,000 | 60,000 | - | - | - | 50 | Yes |
| Biocarbon | - | 20,000 | 15 | 60,000 | 60,000 | - | - | - | - | Yes |
| CerCarbono | - | 10,000 | Regular Projects | | | | | | 30 | Yes |
| ART Trees | No scale thresholds apply to national participants. The total subnational accounting area must be comprised of a total forest area of at least 2.5 million hectares. | | | | | | | | - | Yes |
| PACM | Rules yet to be defined | | | | | | | | - | Yes |

Carbon Standards Differences and Similarities 15

## Endorsements and linkage between voluntary and compliance

Many standards have sought to receive external accreditations against guidelines from independent sector bodies, such as the ICROA's Carbon Crediting Endorsement Criteria or the ICVCM's Core Carbon Principles. ICROA endorses both independent and UN/government standards. This is more relevant credits transacted in the voluntary market, which is often hurt by concerns of credit integrity and quality.

Linkage with compliance or domestic markets provides another layer of credibility for standards, as well as a larger market for credit units. The table below shows the assessment status of CORSIA eligible units as of June 2024. It also summarizes the requirements and measures in place that allow credits to transact in international compliance markets (CORSIA or Article 6 mechanisms). Voluntary standards can achieve this in part by acquiring a Letter of Authorization (LoA).

| | VCS | Gold Standard | GCC | Plan Vivo | Puro.earth | Cercarbono | Social Carbon | Biocarbon | ART Trees | CDM | PACM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ICROA Accredited | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| iC Integrity Council | ✓ | ✓ | X | X | Assessment in progress | X | Assessment in progress | X | ✓ | Not applicable | Not applicable |
| CORSIA | ✓ (First phase) | ✓ (First phase) | ✓ (First phase) | X | X | X | ✓ (First phase) | X | ✓ (First phase) | ✓ (Pilot phase) | X |
| Mandatory Host country approval and authorization of participants | X | X | X | X | X | X | X | X | ✓ (subnational participants) | ✓ | ✓ |
| Measures to ensure host party authorization and no double counting for Article 6 use | ✓ | ✓ | ✓ | X (Reviews national frameworks case-by-case) | ✓ | ✓ | ✓ | ✓ | ✓ | - | ✓ |

Note on CORSIA: Certain project types are excluded such as large-scale REDD, A/R, CCS, nuclear energy, HFC-23 abatement, planned/early credit units, and crediting period start date before 2016. Some standards, (e.g. Gold Standard, VCS, Puro.earth) are under conditional approval or still being assessed by the ICAO Technical Advisory Body (TAB). A second assessment is expected in the second half of 2024.

Carbon Standards Differences and Similarities 18

## Additional Labels or Products

| Standard | Additional Co-benefits | Market labels |
|---|---|---|
| VCS | Climate, Community, Biodiversity (CCB)<br>Sustainable Development Verified Impact Standard (SD Vista) | ABACUS<br>Reduction or Removal<br>CCP<br>CORSIA<br>Article 6<br>Crown Standard<br>Social Carbon |
| Gold Standard | Water Benefit Certificate<br>Renewable Energy Label<br>Averted Disability Adjusted Life Years (Adalys)<br>Gender Impacts<br>Black Carbon/Short-lived Climate Pollutants (Slcps)<br>Reduction Statements | NA |
| GCC | Environmental No Net Harm (E+);<br>Social No Net harm (S+);<br>Sustainability Standard (SDG+) | NA |
| Plan Vivo | PV Nature | NA |
| Puro.earth | - | CORC100+ and CORC 1000+ |
| Cercarbono | Cercarbono's Biodiversity Certification Programme | NA |
| Social carbon | Sustainable Development Goals (SDGs) | NA |
| Biocarbon | Standard for the Certification and Registration of Biodiversity Conservation Initiatives | NA |
| ART TREES | NA | Performance label (percent emission reduction achieved)<br>High Forest Low Deforestation (HFLD) credits<br>Removals |

Market labels are used to identify particular credit attributes, such as removals or duration of the credit, or alignment to another standard or mechanism, such as CCP or Article 6.

It is worth mentioning that not tagging credit units in the registry with a particular label does not necessarily imply that the standard does not cater to that market attribute. For example, Gold Standard and Social Carbon units may be Article-6 aligned or CCP aligned, but these standards have not implemented measures to tag such attributes in their respective registries.

*SOCIALCARBON labels will only be applied to VCUs with a monitoring period end prior to 1 January 2024, and only for projects using SOCIALCARBON Version 5 or previous.

Carbon Standards Differences and Similarities 20

# Annex C Regulation of Geological Carbon Storage

Where geological underground $CO_2$ storage is used already, regulations require that storage operations be rigorously monitored for a number of reasons, including:

- verifying the amount and composition of $CO_2$ being put into underground storage
- understanding how the $CO_2$ is behaving once underground
- providing early warning if things are not going as planned
- providing assurance of long-term storage integrity
- measuring any leakage that might occur

Regulatory frameworks governing geological $CO_2$ storage are being developed worldwide. In Europe, an EC Directive says that the issues of leakage and potential long-term stewardship of storage sites must be addressed if the potential for $CO_2$ capture and storage to provide substantial reductions in atmospheric $CO_2$ emissions is to be realised.

# Annex D The Costs of One Tonne of $CO_2$

Following are some examples of attempts to put a monetary value against emissions.

**Offsetting costs**

**Ecologi**

| | |
|---|---|
| • Reforestation in UK. From | £100/t |
| • Biochar | £195/t |
| • Regenerative agriculture carbon removal. No certification. | £56/t |
| • Enhanced rock weathering removal | £245/t |
| • Blue carbon removal: Mexico, Pakistan, Gold Standard, VCS. | £50/t |
| • Afforestation. Gold Standard. | £30/t |

**Carbon Taxes in Europe, 2024**

In recent years, several countries have taken measures to reduce carbon emissions, including instituting environmental regulations, emissions trading systems (ETSs), and carbon taxes. In 1990, Finland was the world's first country to introduce a carbon tax. Since then, 23 European countries have implemented carbon taxes, ranging from less than €1 per metric ton of carbon emissions in Ukraine to more than €100 in Sweden, Liechtenstein, and Switzerland.

| | |
|---|---|
| UK | £21.04/t |
| Netherlands | €66.50/t |

**Carbon Price Viewer**

The Carbon Price Viewer shows the historical price of emitting 1 tonne of CO2-equivalent for a European industrial installation or airline covered by the Emissions Trading System. European Allowances are traded between buyers and sellers. Since 2021, the price shown is based on the future contract with delivery in the nearest December traded on New York Mercantile Exchange.

For 2025:
€82.08
£69.55