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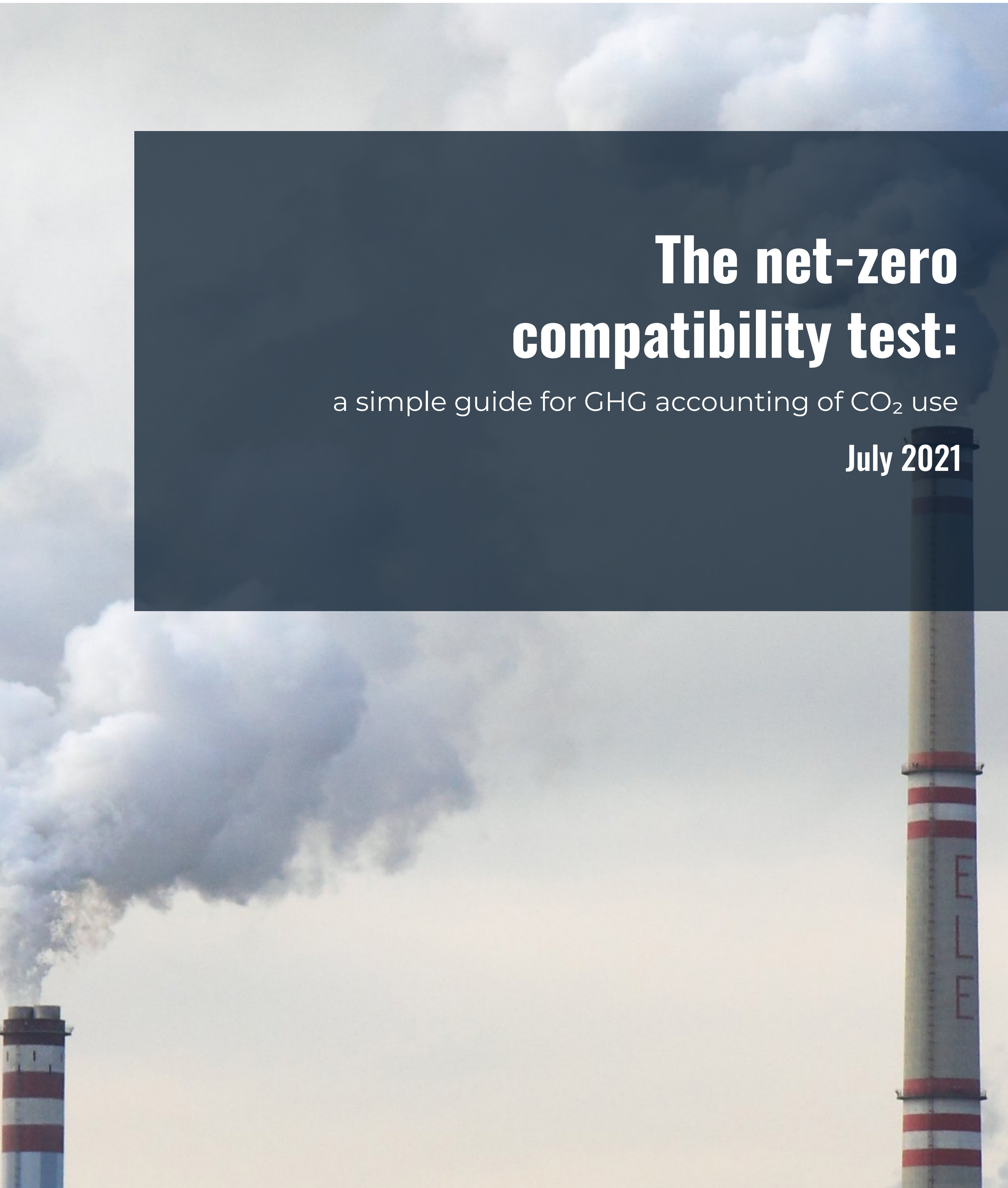

The net-zero compatibility test:

a simple guide for GHG accounting of CO_2 use

July 2021

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Introduction

Synthetic fuels and chemicals which use CO_2 are a manufactured copy of liquid or gaseous fossil fuels and fossil products. The synthetic fuels and chemicals produced by using CO_2 are also often referred to as e-fuels or synthetic hydrocarbons and fall into the category of so-called 'Power-to-X' products.[i] Synthetic fuels and chemicals are manufactured from two basic 'ingredients':

1. Electricity:

- Generally converted into hydrogen. This provides the Hydrogen component in the synthesis of Hydrocarbons.

2. Carbon:

- Generally in the form of Carbon Dioxide (CO_2) captured from Atmospheric or Geological sources.

The source of the electricity (low- or high-carbon) and the source of carbon (atmospheric of geological) are the two key metrics needed to assess the full climate impact of synthetic fuels.

The proposed applications of e-fuels include all sectors which are powered by fossil fuels today, from passenger cars and domestic heating, all the way to shipping and aviation fuels. E-fuels are normally marketed as a drop-in fuel replacement for the transport sector (e.g., e-kerosene in the aviation sector). E-fuels were historically marketed and sold by Audi for personal road transport.[ii] They have been proposed as solutions for shipping and freight with products including synthetic methane and methanol.[iii] E-methane, also known as synthetic methane or renewable gas, is proposed as a solution for the European gas transmission network. It is proposed that the conversion of renewable electricity into synthetic methane would allow the existing gas grid and gas users to transport and burn 'renewable gas' with zero disruption to the climate or to existing infrastructure.[iv] The scale of synthetic methane required would be very large (in 2017 natural gas demand was 4,600 TWh and total EU consumption was approximately 13 000 TWh of energy[1V]).

Non-fuel uses of synthetic hydrocarbons are dominated by proposals from the chemical industry. Here synthetic hydrocarbons would be converted into synthetic plastics and synthetic chemicals. For Europe, a full conversion to synthetic production of chemicals would require 140% of Europe's anticipated electricity capacity.[v]

1. Figures for final energy consumption in 2017 converted from millions of tonnes of oil equivalent (1122 Mtoe total energy consumption 2017, 1 mtoe = 11.63 TWh).

Accounting CO_2 use in the EU ETS

The use of CO_2 often includes the capture and use of CO_2 from installations covered by the EU ETS. Since these installations produce fossil/geological CO_2, their delayed should be considered an emission under EU ETS and allowances should be surrendered for those emissions unless they are stored in a storage site. It is important that this CO_2 is accounted for and the cost for it is allocated to the source installation.

Carbon flows in synthetic e-fuels

Unlike other electricity-derived fuels such as Hydrogen (H2) or Ammonia (NH3), synthetic E-fuels or synthetic hydrocarbon chemicals require a source of carbon (in the form of CO_2 captured from the atmosphere or from an industrial point source). This captured carbon will be released as CO_2 to the atmosphere upon combustion of the e-fuel or the disposal of a product (e.g., plastics).

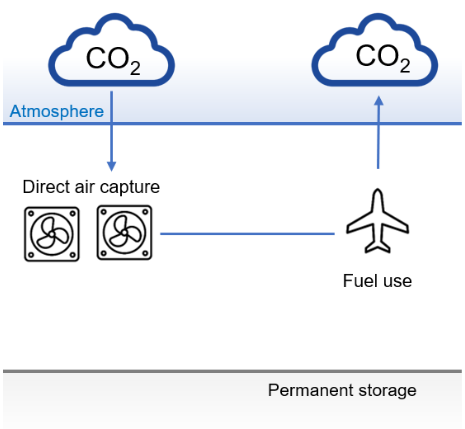
Growing CO_2 concentrations in the atmosphere are the primary driving factor of the greenhouse effect and irreversible global warming. It is for this reason that the correct accounting and distinction of different CO_2 sources based on their effect in changing the concentration of atmospheric CO_2 must be a foundational function in assessing the overall climate impact of short-lived synthetic fuels and chemicals.

Example of synthesis and use of synthetic methane:
1. CO_2 + H2 (deriving its energy from renewable electricity) = CH_4 (Methane)
2. Methane (CH_4) is combusted in an engine = Energy + H2O + CO_2 emitted to the atmosphere

Atmospheric CO_2 as carbon feedstock

A source of atmospheric CO_2 means that the CO_2 is captured directly from the atmosphere. This is known as Direct Air Capture (DAC). Despite having emitted billions of tonnes of CO_2, the rapidly rising concentration of CO_2 in the atmosphere is relatively low and dispersed (0.4%). As a result, selectively capturing and separating CO_2 from the atmosphere is energy intensive.

- **Capturing CO_2 from the atmosphere and using it to produce a synthetic fuel or synthesise chemicals has the potential to be carbon neutral – the same amount of CO_2 captured from the atmosphere will be released back to the atmosphere when the fuel is combusted[2] 2or when the carbon embedded in the products is emitted.** The atmospheric concentration of climate change causing carbon dioxide will be unchanged.
- By capturing and using CO_2 from the atmosphere and ultimately releasing that CO_2 back into the atmosphere, a circular carbon process is achieved. CO_2 has not been removed nor added to the atmosphere and the process can, under the right conditions[3], achieve carbon/climate neutrality.



2. Energy (e.g. electricity) required to capture and convert the atmospheric CO_2 into a fuel will add CO_2 emissions to the process making it less than carbon neutral. These associated emissions must be included in the overall emission balance.
3. See footnote above

Fossil/Geological CO_2 as Carbon feedstock

Unfortunately, the world has no shortage of relatively concentrated sources of fossil or geologically derived CO_2 that could be captured at a lower cost than directly capturing and separating CO_2 from the atmosphere.

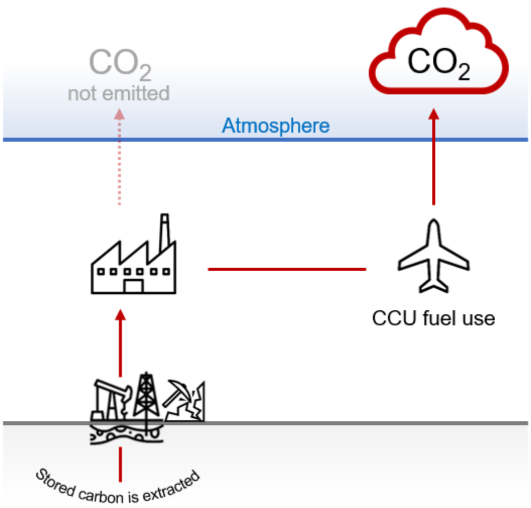
Industrial CO_2 point sources include all of the major contributors to growing atmospheric CO_2 concentrations, including coal and gas power plants, steel, cement, fertiliser and chemical plants along with end-of-life treatment of fossil products such as waste incineration. All of these have been considered as potential "Point source capture" options to provide CO2 for the manufacture of synthetic e-fuels. In addition, all of these point sources in Europe are within the Emissions Trading Scheme (ETS)[4].

- **Releasing fossil / geological carbon** causes global warming. Carbon (e.g. coal, oil, limestone used in cement production) is mined from geological stores where it was permanently isolated away from the atmosphere. The carbon is then combusted or released in a production process (e.g. clinker production in cement), thereby releasing the carbon in the form of carbon dioxide to the atmosphere. The increasing concentration of fossil/geologically sourced CO_2 in the atmosphere is the primary driver of climate change.

Many e-fuel and synthetic chemical production projects in Europe which have been proposed or are currently competing for funding intend to use CO_2 captured from these 'point sources'. This is rational from a technological maturity and economic perspective, but will have implications on the overall climate effectiveness of e-fuel manufacturing and use, and **will also require active oversight to prevent double counting of emission reductions by both the CO2 provider (industrial point source, e.g. cement plant) and the CO_2 user/emitter (ultimately the user of the E-Fuel).** Labelling the CO_2 captured in a point-source as fossil/geological derived (in contrast to atmospheric CO_2) will make it easier to assess the ultimate climate impact of the product or fuel.

- Capturing geologically-derived CO_2, such as from a cement plant, and using it to produce a synthetic fuel has the ability to reduce emissions **but can never be carbon neutral,** unlike a fuel produced by using atmospheric CO_2.

- **Ultimately, the Fossil/Geological CO_2 is released into the atmosphere, contributing to increased atmospheric concentrations of CO_2 and worsening climate change.**



4. Waste incineration is included in the ETS for some Member States, at their discretion.

- Using Fossil/Geological CO_2 in the manufacture of an e-fuel can theoretically "substitute" virgin fossil fuel extraction, providing a degree of emissions reductions.
  - In this case, where there was once **2 CO_2 emissions to the atmosphere** (1 from the cement plant and 1 from the airplane) now there is **1 CO_2 emission shared between both processes.** [5]
  - The result is a maximum theoretical emissions reduction of **50% shared between both processes.**[6]

  - Allocation of all the emission savings to one process is possible. As such, the E-fuel may be allocated all of the emissions reduction, resulting in a 100% emissions reduction or carbon neutrality of the E-Fuel, but conversely **no emissions reduction may be accredited to the cement plant** (or vice versa).

Industry (point sources capturing and selling their CO_2 emissions for use) regard synthetic e-fuel manufacture as a method for industrial decarbonisation[vii, viii] – resulting in a double counting of emission 'reductions' from the outset.

For an e-fuel produced with fossil/geological CO_2 to be considered "low-carbon", **the CO_2 provider (Point Source capturing the CO_2) must be regarded as having emitted all the CO_2 it has provided.** Due to the allocation of the emissions reduction to the used CO_2/e-fuel, no benefit can be allocated to the carbon intensive process producing the CO_2 and no emissions reduction for that stakeholder can be claimed through the capture and use of CO_2.

The current policy landscape of CCU

- CCU (Carbon Capture & Utilisation): The process of capturing and using CO_2 from an industrial point source is, from the point of view of the industry, generally described as CCU and may often be used interchangeably with CCUS or CCS (Carbon capture and storage).
  - CCU is promoted (in the EU) by industry stakeholders (e.g. Cement, Lime, Steel, and Chemicals) as a direct climate change mitigation method to reduce the emissions of their factories and products.
  - CCU is a catch-all term, but most often refers to: the manufacture of synthetic e-fuels and synthetic hydrocarbons (for synthetic plastics); the direct use of CO_2 in greenhouses; or the reaction of CO_2 with materials such as olivine (a mineral) or cement.
  - CCU is an attractive narrative for industry as it offers the potential to "valorise" CO2 emissions (which are currently a liability) and to ultimately have the use of a ton of CO_2 to equate to the mitigation (non-emission) of a ton of CO2 no matter the fate of the product or the CO_2 contained within the product (e.g. CO_2 emission resulting from the combustion of an E-fuel).
  - **Double counting of emissions reduction is the stated goal.** There have been requests from cement and chemicals associations to have all CO_2 use, such as the production of synthetic e-fuels, count as a "non-emission" under the European Emissions Trading Scheme, thereby foregoing the need to surrender or purchase allowances.

5. This assumption is valid for the theoretical calculation of potential emission reductions from the production of low-carbon fuels. However, in a complex global economy, the production of a low-carbon fuel does not necessarily substitute virgin fuel production.
6. Additional indirect emissions from the energy or electricity would further limiting the theoretical potential emission reduction.

Distinction of Carbon source – Carbon Emission, Carbon Neutral, Carbon Removal

Identifying the carbon source and the ultimate fate of the carbon allows for a preliminary assessment of whether a process has the potential to be carbon neutral or indeed remove carbon from the atmosphere. In short, asking the question of where the CO_2 is from, and where it goes.

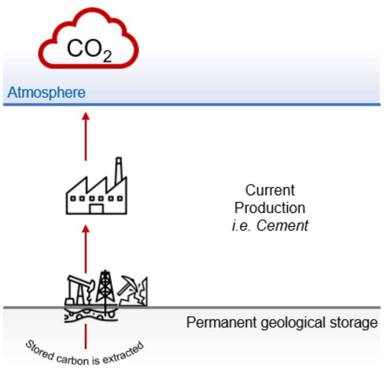
- Is the CO_2 atmospheric or Fossil/geological?
- Is the CO_2 released back into the atmosphere (as in the case of an E-Fuel) or is it permanently stored (as is the case with the mineralisation of CO_2)?

How carbon source and carbon destination are influential in the climate effect

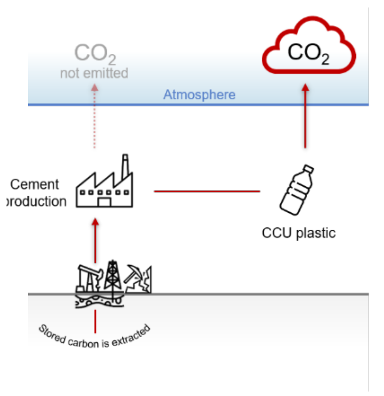
Placing Fossil/Geological (e.g. lime) carbon into the atmosphere adds to the stock of CO_2 in the atmosphere. Growing concentrations of CO_2 in the atmosphere exacerbate climate change.

Fossil Carbon (Geological)
+
Emission to Atmosphere
=
Global Warming

*Highly idealised carbon flow, excluding energy emissions, capture rate, leakage etc.



Traditional production process with emissions to the atmosphere. No capture technology is applied.

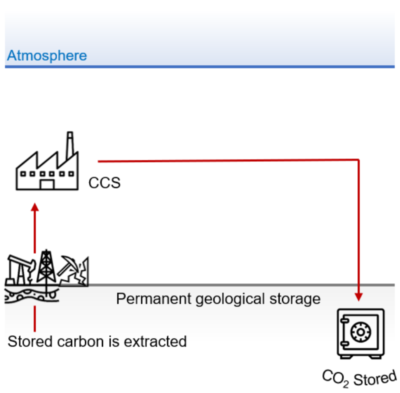


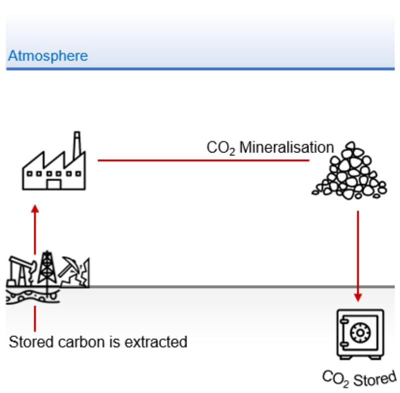
Geological CO_2 is captured and converted in a product that when used will emit directly CO_2 to the atmosphere.

Extracting Fossil/Geological carbon and subsequently preventing the carbon from entering the atmosphere can prevent increasing concentrations of CO_2 in the atmosphere. This can help mitigate human impact on the climate.

Fossil Carbon (Geological)
+
No Emission to Atmosphere
=
Climate Neutral

*Highly idealised carbon flow, excluding energy emissions, capture rate, leakage etc.



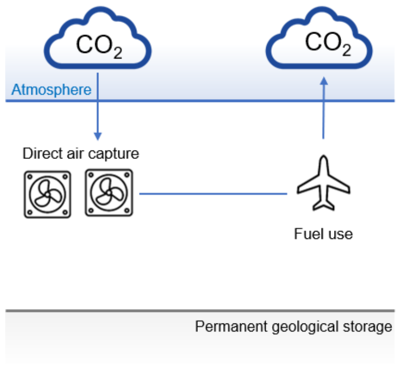


Carbon capture in industry followed by geological storage or use in a product with permanent storage.

Capturing atmospheric carbon and subsequently returning that carbon to the atmosphere results in no change in the concentrations of CO_2 in the atmosphere. This can help mitigate human impact on the climate.

Atmospheric Carbon
+
Emission to Atmosphere
=
Climate Neutral

*Highly idealised carbon flow. E.g. excluding energy emissions for CO_2 capture & synthesis of e-fuels.

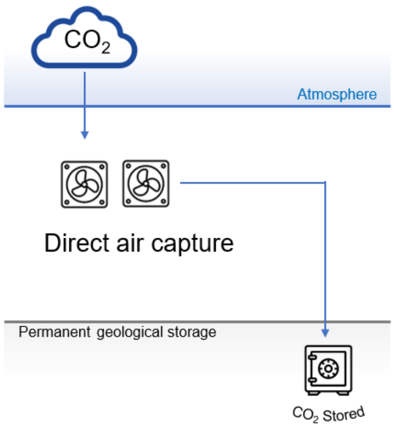


Atmospheric CO_2 is captured and converted into a product (e-fuel) that when used will emit CO_2 directly to the atmosphere.

Capturing atmospheric carbon and permanently storing it so it never enters the atmosphere results in a removal of CO_2 from the atmosphere. The concentrations of CO_2 in the atmosphere is reduced, helping to mitigate human impact on the climate.

Atmospheric Carbon
+
No Emission to Atmosphere
=
Carbon Dioxide Removal (CDR)

*Highly idealised carbon flow, excluding energy emissions, land use change, leakage etc.



Direct Air Capture of CO_2 to permanent storage.

Policy recommendations: which policies can help regulate and monitor the CO_2 source in synthetic hydrocarbon fuels, chemicals and products?

Given the fact that the CO_2 source and the CO_2 user are sometimes not covered in the same sector, the CO_2 source issue needs to be addressed in several major legislative files:

The EU ETS

▪ **The ETS must require allowances to be surrendered for all emissions, including greenhouse gases that are not directly released into the atmosphere.** The only means to circumvent the surrender of allowances must be that the CO_2 is permanently stored in a way that it does not enter the atmosphere. This can be met though compliance with the Directive 2009/31/EC or when the CO_2 is permanently chemically bound into a product that will never release CO_2 to the atmosphere on use or disposal.

▪ **In the case of reusing CO_2 from an ETS installation, where the use of that CO_2 does not result in permanent storage, the ETS installation must continue to surrender allowances for the captured emissions.** Any emissions reduction resulting from the re-use of the CO_2, if any, can thus be allocated to the CO_2 user (e. g. synthetic fuel producer).

The Renewable Energy Directive

- To ensure that atmospheric CO_2 use is incentivised and the emission of fossil CO_2 is counted in the system, the **Renewable Energy Directive Delegated Act on GHG methodology of Renewable Fuels of Non-Biological origin (in this paper referred to as e-fuels and synthetic fuels) and Recycled Carbon Fuels[7] should enforce the differentiation between atmospheric and fossil CO_2.**
- To safeguard robust emissions accounting, the **RED should also ensure that credit is not given for CO_2 which has already received an emission reduction credit under other provisions of the law.** To avoid double counting, all of the relevant climate policies must be harmonised.

ReFuelEU Initiative

- To ensure policy coherence, the **ReFuelEU Initiative should use the same GHG calculation methodology defined under the Renewable Energy Directive delegated act and differentiate between fossil and atmospheric carbon.**
- To ensure that sustainable aviation fuels reduce emissions by 80%, **the Initiative should heavily favour the use of fuels produced with atmospheric carbon sources.**

Sustainable Product Initiative and the Circular Economy Action Plan

- For products which are manufactured with synthetic hydrocarbons, such as plastics, **the origin of the carbon should be disclosed.** If fossil carbon is used in its production and the product is disposed, it's final disposal could result in an emission of that carbon to the atmosphere. Therefore, it's important to inform the stakeholders handling the product at its end-of-life.

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7. See FAQ on page 9

FAQ

- **''Renewable Fuels of Non-Biological Origin''** - Under the EU Renewable Energy Directive II (REDII), Synthetic Fuels (E-Fuels) for use in transport are classified as 'Renewable Fuels of Non-biological Origin', along with hydrogen and ammonia. All of these fuels are meant to be generated with a renewable electricity source (while the synthetic hydrocarbons also require a CO_2 source). In other words, the 'renewable' energy content of these fuels derives from the renewable electricity used to produce them.

- **''Recycled carbon fuels''** – Renewable Fuels of Non-Biological Origin should not be confused with 'Recycled Carbon Fuels', formerly known as 'Waste Based Fuels' in the REDII. These fuels are generally produced from fossil-derived gases or materials that can burn as a fuel and contain carbon (releasing the CO_2 upon combustion). These fuels can never be carbon neutral if they are manufactured using fossil waste. A simple example is the conversion of fossil-derived plastics back into simple fossil fuels via processes such as gasification or pyrolysis.

- **"Unavoidable emissions"** – the concept that under any circumstance the CO_2 would have been emitted from the point source. It is often argued that if the CO_2 was "unavoidably" going to enter the atmosphere, then capturing it at the point source is akin to capturing if from the atmosphere. This is often used in Life-Cycle Assessments to make fossil-derived CO_2 look like atmospheric CO_2.

◊ With Net-Zero targets it is illogical and dysfunctional to have arbitrary sectoral emissions classified as "unavoidable". All of the fossil/geological point sources described above have European (ETS) and National (ESR) targets to greatly reduce emissions in line with the European Climate Law. Numerous technologies exist for the direct decarbonisation or replacement of cement, steel and chemicals which are in line with a net zero world.

◊ Regardless, even if a fossil CO_2 point-source is classified as "unavoidable", capturing that CO_2 cannot be considered as equal to capturing CO_2 from the atmosphere. If theoretical "unavoidable" CO_2 of fossil/geological origin is added to the atmosphere, then it will ultimately contribute to worsening climate change.

- **"Life Cycle Assessment (LCA) with narrow boundaries"** – the results of LCAs are highly dependent on the boundaries used. A common example of selectivity in this regard is for the combustion of the E-fuel to be excluded or left outside of the assessment. Instead of seeing the ultimate fate of the carbon (e.g. to exit the exhaust of an engine and be added to the atmosphere), a selective LCA turns a blind eye to the climate impact and we are left with a barrel of carbon-containing E-Fuel.

◊ Further to this, combining this narrow assessment with CO_2 from an atmospheric source would make the E-Fuel wrongfully look like Carbon Dioxide Removal.

- **Claim that using a fossil/geological CO_2 to manufacture a fuel avoids the need to extract carbon elsewhere and is therefore equivalent to permanent CO_2 storage - This comment is generally made by CO_2 point sources/industries.** To be valid, this should assume the full allocation of emissions reduction to the CO_2 provider and would, conversely, require the synthetic fuel produced to be treated as a conventional full carbon fossil fuel. However, the comment is never used to engage with the emissions resulting from the use of the fuel. Instead, the intent is to say that any CCU, regardless of the fate of the CO_2, is always comparable to CCS and should therefore be treated equally in emissions accounting and the ETS.

- ◊ This highlights the difficulty in correctly accounting emissions (and to keep emissions accounted correctly year after year of ongoing lobbying campaigns) along such value chains that include industrial emitters, fuel manufacturers and diverse users such as the aviation sector, who all have an interest in saying that they are the ones who are abating all of their emissions in the same process.

- **"Waste CO2"** – In LCAs, the term waste is particularly powerful, as it allows the LCA practitioner to attribute the environmental footprint to the primary product and thus classify the waste, regardless of its composition, as "carbon neutral". This has particularly large effects in the GHG accounting of "waste-based" or "Recycled Carbon Fuels".

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