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White paper

Capture of Carbon Dioxide from mixed Sources: Operator Flexibility as a Solution to complex regulatory Challenges

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WHITE PAPER

CAPTURE OF CARBON DIOXIDE FROM MIXED SOURCES: OPERATOR FLEXIBILITY AS A SOLUTION TO COMPLEX REGULATORY CHALLENGES

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1 Background

Carbon dioxide capture for permanent storage (CCS) or for use as a feedstock (CCU) is playing an increasingly important role in concepts for future carbon management. Industrial CO_2 capture is currently being discussed as an urgently needed option for installations in the cement and lime industries as well as for thermal waste treatment installations. A common feature of these installations is that

- these installations are already subject to the EU Emissions Trading System (EU ETS) pursuant to Directive 2003/87/EC, or are foreseen for complete[1] inclusion in the EU ETS,
- the CO_2 generated in these installations originates from "mixed" carbon sources, i.e., from carbon that is partially assigned an emission factor of zero in the EU ETS (such as biomass), and
- there is no physical separation between zero-rate and fossil carbon input materials, nor would such a separation even be possible.

In the case of capturing a portion of the generated CO_2 and allocating sub-quantities of the captured CO_2 for geological storage on the one hand and for use as a production feedstock on the other, the question arises as to how the assessment "originating from zero-rated carbon"[2] should be applied to the sub-quantities. This rating is of crucial importance for a possible deduction of the captured CO_2 quantity from the obligation to surrender emission allowances by the operator of the CO_2-generating installation, as well as for the subsequent use of the carbon dioxide. The challenge arises from the split and applies equally to a "physical split" of CO_2 quantities or streams, partly for use and partly for storage, as well as to a "declaratory split" as in the case with geological storage if fossil CO_2 and zero-rated CO_2 is stored at the same time.
This analysis examines the implications of the CO_2 rating[3] for storage and subsequent use and outlines a proposal on how to achieve the greatest possible economic freedom of action for the involved stakeholders without jeopardizing climate protection goals.

2 Significance of CO_2 rating for geological storage

Permanent geological storage of fully fossil CO_2 captured from an EU ETS installation result in the stored CO_2 quantity remaining exempt from allowance surrender obligations; this quantity is deducted from the installation's emissions in accordance with Article 49(1) of Commission Implementing Regulation (EU) 2018/2066, known as the "MRR."
Permanent geological storage of fully zero-rated CO_2, on the other hand, is currently outside the scope of the EU ETS. Such storage would instead be covered by the CRCF Regulation (EU) 2024/3012 as a form of permanent CO_2 removal from the atmosphere (CDR).
Since the application of the CRCF Regulation and the ETS Directive is mutually exclusive with respect to a specific quantity of CO_2 captured for permanent storage, it is important to be able to clearly assign such a quantity of CO_2 captured for permanent storage to the scope of one or the other regulation. The consequences of this assignment differ accordingly (certification as a CO_2 removal or deduction in the EU ETS). There is currently no explicit regulatory basis for a "co-consideration" of the other regulation in the case of CO_2 storage from mixed carbon.

[1] Since 2024, municipal waste incineration plants have been subject to the emission monitoring and reporting requirements set forth in Articles 14 and 15 of Directive 2003/87/EC but are not yet subject to the obligation to surrender emission allowances under Article 12(3).

[2] "Zero-rated" is used below as a shorthand term in reference not only to carbon but to CO_2, too.

[3] In this analysis, the term "CO_2 rating" serves as a shorthand for the proportional attribution of the characteristic "derived from zero-rated carbon" to CO_2 quantities and CO_2 flows. The CO_2 rating lies between the extremes of "0% zero-rated" and "100% zero-rated".

A "mathematical" allocation of a stored CO_2 quantity from mixed carbon to either of the two regulations is therefore indispensable. A classification based on "physical separation" would neither be possible nor necessary, since the CO_2 is chemically identical.

3 Significance of CO_2 rating for CO_2 use

Captured carbon dioxide used to produce synthetic fuels or fuels under the regime of

- the Renewable Energy Directive (EU) 2018/2001, "RED," as *renewable fuels of non-biological origin* (RFNBO), or
- Directive (EU) 2014/1788 as *synthetic low-carbon fuels* (sLCF),

is subject to additional requirements regarding the origin of carbon. These requirements arise indirectly from calculation rules for greenhouse gas savings under Delegated Regulations (EU) 2023/1185 for RFNBO and 2025/2359 for sLCF. From 2041, only zero-rated CO_2 will be usable to produce eligible synthetic fuels, even if fossil CO_2 were available for which emission allowances have already been surrendered in the EU ETS.
For the future user of a supplied CO_2 quantity, it will therefore be crucial that a legal mechanism has been established to report this amount in full as zero-rated. In the case of CO_2 capture from mixed carbon, as already explained above, this will only be possible through a mathematical allocation of the "zero-rated" feature to a captured sub-quantity and the "non-zero-rated" feature to a different sub-quantity, not through physical separation of fossil and biogenic carbon or of the resulting CO_2.

4 Significance of the calculated allocation for products made from mixed carbon

When mixed carbon is used as a feedstock in a production installation subject to the EU ETS, where the actual product is produced directly, i.e., without CO_2 as an intermediate state of the carbon finally contained in the product, but where carbon dioxide is also generated in the process, some of which is released into the atmosphere and some of which is captured for geological storage, the situation becomes even more complicated.
In this case, conflicting provisions of the MRR require, on the one hand, that (at least) all zero-rated carbon in input materials be reported as zero-rated carbon in the resulting carbon-containing product (Article 25(3)), and, on the other hand, stipulate that the captured and stored CO_2 must be considered non-deductible in the EU ETS on a *pro rata* basis corresponding to the proportion of zero-rated carbon in the input materials (Article 49(6)).

5 Summary of the Issue

The preceding explanations make it clear that, whenever

- mixed, partially zero-rated carbon is used in EU ETS installation,
- CO_2 is produced in the installation as a result, among other things, and
- several carbon-containing streams leave the installation,
- possibly even in the form of captured CO_2,

a numerical allocation of the "zero-rated carbon" specification across the various outgoing streams becomes indispensable. The calculation methods developed in the EU ETS and specifically in the MRR have not been designed for meeting the specific requirements in such cases. In particular, the current regulatory framework for producers of CO_2 from mixed carbon lacks a clearly defined option to classify sub-quantities of the captured carbon dioxide, according to their own allocation, as *fully zero-rated* or *fully fossil*, and to certify this to the user of the CO_2.

6 Proposed Solution

An obvious conclusion from the foregoing is that the operators of EU ETS installations who are at the same time users of mixed carbon and producers of carbon dioxide should be permitted to allocate the total amount of zero-rated carbon in the input across all material streams leaving the installation[1] *at their own discretion*.
This allocation must be carried out as part of an accounting and monitoring system that ensures that the total amounts of carbon entering the installation (zero-rated and fossil) match the corresponding total amounts of carbon leaving the installation, which are found in products, waste, CO_2 captured for storage, CO_2 transported, and CO_2 released into the atmosphere.
In short, no fossil carbon entering the installation may disappear from the accounting system, and no more zero-rated carbon may fictitiously leave the installation than actually enters it. The MRR already provides comprehensive tools for monitoring, reporting, and verification in this regard. Otherwise, however, under this solution approach, the allocation decision would be left to the operators of the ETS installations.

- This would eliminate some of the ambiguities outlined above, which arise from provisions in the current version of the MRR.
- This would enable the provider of captured CO_2 to report sub-quantities as *fully fossil* or *fully zero-rated*, which could significantly facilitate the assessment of both geological storage and subsequent use of the relevant sub-quantities across regulatory frameworks (EU ETS, CRCF, RED).
- Continued comprehensive monitoring would ensure that no loopholes arise, e.g., for the unlawful reduction of allowance surrender obligations. At the same time, this would align with the fundamental principles of cost-effective and economically efficient reduction of greenhouse gas emissions (Article 1 of the EU ETS).

[1] in the form of carbon-containing products or waste, captured and transported CO_2, or CO_2-containing exhaust gas streams etc.

7 Discussion of the proposed solution approach: Conceivable Objections (O) and Counterarguments (C)

O:
The EU ETS and the MRR have worked without any problems so far, so why should we change the existing and proven mechanisms?

C:
Precisely because these mechanisms *can* no longer function once the outlined examples are actually implemented, including partial capture of CO_2 from mixed carbon sources with varying permanent storage of CO_2 quantities. So far, the existing contradictions and ambiguities have simply not yet manifested themselves to a significant extent in practice. However, due to the associated legal uncertainty, they are already hindering important investment decisions today, particularly in the cement and lime industries as well as in thermal waste treatment.

O:
If the proposal were implemented, ETS installation operators could arbitrarily shorten their reportable emissions that require allowance surrender by fictitiously attributing zero-rated carbon to the released CO_2; this must be prevented under all circumstances.

C:
Shorten—relative to which assumed reference?
In the case of mixed processing, there is no "naturally correct" allocation of the zero-rated carbon input to the carbon-containing streams that leave the installation; thus, any type of allocation would necessarily be "arbitrary", even a *pro rata* allocation.

Arbitrary shortening is not possible simply because the mass balance must still hold true for both the total carbon and the zero-rated carbon. Operators could merely decide, within the limits of the mass balance, to which of the outgoing streams they would prefer to allocate the zero-rated carbon, i.e., maximizing "green product", "zero-rated transferred CO_2," or "zero-rated CO_2 in the exhaust stream," which would always result in correspondingly higher "non-zero-rated quantities" in the other streams.

If the obligation to surrender allowances were to decrease compared to previous calculation rules, this might be the case because the previous calculation entailed an unjustified disadvantage for some operators, which would now simply be removed.

O:
The *total* CO_2 generated in the ETS installation, which is divided between the "capture" and "direct release into the atmosphere" pathways, must be assigned a zero-rating in both pathways corresponding to the proportion of zero-rated carbon in the total carbon input; this is logically required by the principle known as the *pro rata* approach.

Only at a later stage could the captured CO_2 be divided by the operator into sub-streams with differently declared zero-rated C content on a mass-balance basis.

C:
The "*pro rata* approach" referred to here is a mathematical construct in the MRR that was introduced to prevent *the EU ETS* from generating *ineligible negative emissions* (i.e., "negative values for reported emissions"). However, this aim can also be achieved in other ways that place a significantly lesser burden on economic actors; in this respect, the *pro rata* approach

could be *disproportionate in a legal sense* and therefore potentially incompatible with overarching European law.

Furthermore, there is no reason to assume the universal validity of such a *pro rata* approach: The ISO 22095:2020 standard ("Chain of Custody") clearly distinguishes between the *pro rata approach*, referred to there as the "controlled blending model," and the *mass balance approach* ("mass balance model"), in which different proportions of the monitored property can be assigned to individual product streams.

O:
Under the suggested proposal, operators of ETS installations that receive carbon *in a mixed form* would potentially be at an advantage compared to operators who also use zero-rated and non-zero-rated carbon but keep them completely separate within the installation. In such cases, it would be clearly defined technically, and thus not at the operator's discretion, whether CO_2 generated and released into the atmosphere is considered to have a zero rating or not.

C:
A valid point—if this were perceived as a disadvantage in the case of technically separated carbon streams in an EU ETS installation, it would be a simple matter to also grant operators of such installations the *option* to apply the mass balance methodology in accordance with the proposal suggested here. This would eliminate the formal disadvantage.

An operator of an ETS installation in which fossil carbon compounds are converted into products and the process heat required for this is generated by burning zero-rated biomass may report the CO_2 released with the exhaust gas from the combustion installation as a zero-rated emission. However, this applies only if there is complete physical separation of the material streams. If the carbon-containing materials used were to mix, the operator of the ETS installation would inevitably be placed at a significant disadvantage regarding the obligation to surrender allowances, even with *identical input, product, and exhaust gas quantities*, due to the mandatory application of the "mass balance methodology" under Article 25 of the MRR.

The proposal would eliminate this type of unequal treatment, which would also economically hinder the optimization of the overall process and thereby the reduction of total CO_2 emissions at the same production capacity, provided that this would require a mixture of partly fossil and partly zero-rated feedstocks.

O:
Any approach other than a proportional one (i.e., "controlled blending") would be a "purely mathematical" model that cannot be communicated to the general public and must therefore be rejected.

C:
Consumers have long since become accustomed to being able to purchase "exclusively renewable electricity" as well as "exclusively renewable gas" (biomethane, eco-gas), and to do so from networks that also transport fossil-fuel-generated electricity and fossil natural gas. Thus, consumers and the general public have long been familiar with models in which, although they are actually supplied from a mixed energy or material flow, their supply is mathematically "fully renewable" due to the feed-in of the corresponding sustainably generated quantity.

By the way: These are, in any case, purely mathematical models—even in the case of "controlled blending"—because, in terms of energy or material composition, there is simply no difference between electricity or gas in the grid, regardless of whether it is generated from fossil fuels or renewable energy sources. The same would apply to CO_2 in a pipeline, whose origin could not be determined by its composition any more than that of the gas supplied for

heating. CO_2 withdrawn from such a CO_2 pipeline could also be classified, purely on a mathematical basis, as "fully zero-rated" CO_2.

O:
For CO_2 originating from biogenic or fossil carbon, the biogenic fraction can be clearly determined based on the carbon's ^{14}C content. This practical and unambiguous method for determining what proportion of a carbon-containing substance is actually biogenic would be called into question by the fictitious designation of sub-quantities as "zero-rated."

C:
Let's set aside the term "practical method" for now and first look at the physical principles underlying such measurement methods:

In the atmosphere, an extremely small but nearly constant fraction of carbon consists of the long-lived radioactive isotope ^{14}C, with the remainder consisting of the stable isotopes ^{12}C (approx. 99%) and ^{13}C (approx. 1%). The nearly constant ^{14}C content of the atmosphere, despite its continuous decay with a half-life of approximately 5,700 years, is explained by the continuous formation of ^{14}C from nitrogen atoms in the atmosphere because of cosmic radiation. Statistically speaking, there is currently approximately one atom of the isotope ^{14}C for every trillion ($=10^{12}$) carbon atoms in the atmosphere.

The carbon in atmospheric carbon dioxide, which was incorporated through plant photosynthesis many millions of years ago and is present today in the form of coal, crude oil, or natural gas, contains virtually no ^{14}C anymore due to the radioactive decay. In newly formed biomass, however, the proportion of ^{14}C relative to total carbon is just as high as in the atmosphere. In principle, this allows for a distinction between new biomass and substances derived from very old biomass.

The "zero-rating" of carbon in the EU ETS is not determined solely by whether the carbon compounds are derived from biomass or fossil sources. Thus, even biomass that does not meet the sustainability criteria and is therefore not zero-rated has the same ^{14}C content as zero-rated biomass. On the other hand, zero-rated renewable fuels (RFNBO, RCF, and sLCF) may contain carbon derived from fossil sources or from geologically formed CO_2 and are therefore ^{14}C-free. In this respect, equating "zero-rated" with "biogenic according to ^{14}C content" would be, at best, an approximation and would result in an incorrect rating for some feedstocks already today.

With increasing material recycling of plastics, whose raw materials are partly fossil-based and partly biogenic, the distinction based on the ^{14}C content is becoming increasingly questionable, too. Furthermore, technical methods for determining the ^{14}C content are currently far from being a widely applicable, cost-effective, and highly accurate measurement method.

In summary, it should be noted that the proposal to grant operators the freedom of attribution would not pose any fundamentally new challenges for the assessment of input materials based on ^{14}C content.

O:
The accurate tracking of carbon and carbon dioxide in ETS installations is highly complex, making the proportional approach ("controlled blending") the only practical simplification option. Otherwise, zero-rated carbon in the ETS installation would have to be physically separated from non-zero-rated carbon during processing.

C:
A similar challenge arises for biomethane in natural gas networks, i.e. in a network that is

vastly larger and more complex than a single ETS installation. The possibility of extracting "100% biogenic gas" from a real gas mixture without any physical separation has already been explained above.

The construction of parallel pipelines and distribution networks—one for natural gas and the other for biomethane—solely on the grounds that physical separation of material flows facilitates accounting would have been completely economically unfeasible.

Similarly, a challenge will arise for the pipeline transport of captured CO_2, some of which originates from zero-rated carbon sources and some from fossil carbon. Here, too, building separate networks solely for the sake of simplified accounting would be economically unfeasible. Thus, the task will be to be able to extract both zero-rated and non-zero-rated CO_2 at the extraction point from such a network, whether for geological storage or as a raw material.

If such a method of "calculatory CO_2 separation" is thus indispensable for transport infrastructure, there is no apparent reason why such accounting should not also be possible in far less complex ETS installations.

It should also be noted that the proposal primarily concerns cases in which the feedstock of the ETS installation is already a mixture of biogenic and fossil carbon. The physical separation of such a mixture would be impossible or could only be achieved with a disproportionate technical effort, which would increase the total amount of greenhouse gases produced and thus run counter to the objectives of the ETS Directive.

O:
When different pure substances have been homogeneously mixed, the "controlled blending" model precisely describes the properties of the mixture and of all sub-quantities from that mixture. To recover the pure substances, they would have to be physically separated from one another, and if that is not possible, then only the "controlled blending" model can be factually accurate.

C:
That is correct, specifically when the pure substances actually differ from one another in such a way, chemically or physically, that they could also be physically separated from one another based on such properties.

The situation is entirely different, however, with the "zero-rating" of carbon, which is based solely on the origin of the carbon-containing materials. Since carbon, regardless of whether it is considered "zero-rated" or not, exhibits no relevant differences in chemical and physical terms, this also applies to the CO_2 formed. No "physical or chemical separation" is required to divide CO_2 originating from partly zero-rated carbon into zero-rated and non-zero-rated subquantities; it is sufficient to perform a simple mathematical operation.

O:
It is generally known that CO_2 from zero-rated biomass is greenhouse gas-neutral, whereas fossil CO_2 harms the climate. Precisely for this reason, emission allowances must be acquired and surrendered for fossil CO_2 released into the atmosphere, whereas zero-rated CO_2 may be released without such pricing.

The proposal, however, would insinuate that it makes no difference whatsoever to the climate impact which type of CO_2 is released into the atmosphere.

C:
When a ton of CO_2 is released into the atmosphere, it *really makes no difference* in terms of climate impact whether the carbon from which the CO_2 originates is called "zero-rated" or

not: Every ton of CO_2 actually released into the atmosphere has exactly the same effect there (after mixing with the other gases in the atmosphere).

The distinction has a different basis, namely the question of whether this release disrupts the *carbon balance* of *the atmosphere* or not. Such a disruption of the balance would occur if, within a short timeframe, a corresponding amount of CO_2 (or carbon) were not removed from the atmosphere elsewhere. In the case of carbon from biomass, it is generally assumed—roughly speaking—that the carbon in question was removed from the atmosphere via photosynthesis only a short time before, so that the balance would be maintained.

In the case of fossil carbon, the removal occurred in the same way but a very long time ago, so that its conversion into released CO_2 would actually disrupt the carbon balance of the atmosphere. It is precisely this disruption that the EU ETS aims to reduce by imposing a price on emitted CO_2.

What matters is not the properties of the specific ton of CO_2 released, but the overall balance expressed by the zero-rating of certain types of carbon. Therefore, from a purely physical standpoint, it is actually irrelevant which "type of CO_2" is released.

The difference arises solely from the accounting principles that keep track of the origin of the carbon.

Let us take the example of an ETS installation where 100 tons of CO_2 are generated, half from zero-rated biomass and half from fossil carbon. If half of the total quantity were to be captured and geologically stored and the other half released into the atmosphere, the overall carbon balance would be neutral. The simplest way to express this in the EU ETS would be to treat the stored amount of 50 t CO_2 as "fossil" and the released amount as "biogenic and zero-rated."

Under the proposal, the plant operator could declare this exactly as described.

Alternatively, the operator could declare the released 50 t of CO_2 as "fossil" and would then have to surrender emission allowances for 50 t of CO_2. The remaining captured CO_2 could be either transferred for further use as "CO_2 from zero-rated carbon" or sent to geological storage, for which negative emission certificates could be issued under the CRCF Regulation, yet probably not for the entire amount of stored CO_2 due to the stringent rules set out in Commission Delegated Regulation (EU) 2026/285.

In any case, the handling of the captured "CO_2 from zero-rated carbon" would fall outside the scope of the ETS, and the declaration in total would be consistent with the ETS.