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Carbon Zero = Climate Neutral = CO_2 Neutral? A Closer Look at the Concept of Climate Neutrality and Beyond

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Executive summary

The world is changing and more and more people and organizations have started to discuss climate goals. These discussions about the climate and the future are based on specific terms and wordings. These words are well-heard by all of us but do we really understand the meanings behind? In this White Paper, we provide some explanations what are the definitions and content behind the word when someone uses a specific phrase.

Introduction

The consequences of growing CO_2 levels and other greenhouse gases and their impacts on the climate have been increasing in the last years with heat waves, droughts, and other extreme weather events. Therefore, it is mandatory to reduce our emissions to diminish the further consequences of climate change. International climate policy has focused for more than 30 years on the goal of climate neutrality with the UN Framework Convention on Climate Change formulated already in 1992 intending to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system [1]. To put this goal into practice, the Kyoto Protocol established a first framework with specific reduction goals for countries, including the Clean Development Mechanism that allowed countries to compensate for their CO_2 emissions through the support of projects that reduced or eliminated them. In 2015, the Paris Agreement set the target of 1.5 °C, which urges countries to reduce their CO_2 emissions drastically for us still to have a chance to stay within or not exceed this limit. Not only politicians are asked to act and to set the guard rails, but also companies, (public) institutions, and every single person have to do their part. To show their support, a lot of companies claim nowadays that they are – or will be – cut down their carbon emissions, consumers can buy climate-friendly products, and we encounter a lot of further terms like carbon zero or zero climate impact. But what are the differences and how is it possible to distinguish between real action and greenwashing? How will countries and companies reach their climate targets and what role does carbon offsetting play?

Getting to NET-ZERO EMISSIONS by 2050

Many words, different meanings – but a common goal

Products are claimed as climate neutral or even climate-positive, the EU wants no net emissions of greenhouse gases by 2050 [2] and the UN-backed race to zero campaign has the goal to achieve net zero greenhouse gas emissions by 2050 at the latest [3]. The overall goal is clear and written down in the Paris Agreement: "…to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels…", "to reach global peaking of greenhouse gas emissions as soon as possible …" and "…to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century." [4]. But what exactly is the difference between climate neutral, carbon zero or no net emissions of greenhouse gases? A closer look at the exact wording reveals that there are differences between the definitions and the context in which they are used.

The scientific definition of climate neutrality is clear: The Intergovernmental Panel on Climate Change (IPCC) defines climate neutrality "as a concept of a state in which human activities result in no net effect on the climate system." [5] It can therefore only be reached on an international level. Furthermore, climate neutrality does not only mean having no emissions of greenhouse gases, but also taking into account other factors which affect the climate. Black carbon, particulate matters, SO_2 or clouds affect the climate: sulfate aerosols, for example, have a cooling effect, whereas black carbon is assumed to have a warming effect. In terms of climate neutrality, such further warming effects would also have to be counterbalanced. Based on Rockstroem at al. [5a] and Wang-Erlandsson et al. [5b], further aspects like human-related changes of land, pollution of water, soil, and air influence climate neutrality and shall be limited to the planetary boundaries perspectively. A real "climate neutrality" in this sense can therefore probably not be reached [6] .

Greenhouse gas neutrality is a balance between all sources of greenhouse gases and sinks that can eliminate them. Greenhouse gases are defined in the Kyoto Protocol [7] and include CO_2, methane, nitrous oxide, halogenated Hydrofluorocarbons (HFC) [halogenated hydrofluorocarbons (HFCs) and perfluorocarbons (PCFs)], sulphur hexafluoride and nitrogen trifluoride. Their greenhouse gas potential is expressed in CO_2-equivalents, which takes into account the fact that every gas has a different impact on climate change. Some greenhouse gases, like CO_2, stay for a very long time in the atmosphere, whereas others, like methane, degrade faster, some absorb more thermal radiation and contribute more, others less [see Table 1]. The IPCC has defined the climate impact of all greenhouse gases as being related to CO_2 and set for 100 years [7]. Greenhouse gas neutrality is equal to the term net zero emissions.

Table 1: Greenhouse gas potential of the greenhouse gases defined in the Kyoto protocol [29, 30, 31]

Greenhouse gas	Greenhouse gas potential [29]
Carbondioxide (CO_2)	1
Methane (CH_4)	28
Nitrous oxide (N_2O)	265
Most abundant halogenated hydrofluorocarbons (H-HFCs) [30]	
HCFC-22 ($CHClF_2$)	1,760
HCFC-141b (CH_3CCl_2F)	782
HCFC-142b (CH_3CClF_2)	1,980
Most abundant hydrofluorocarbons (HFCs) [30]	
HFC-134a (CH_2FCF_3)	1,300
HFC-23 (CHF_3)	12,400
HFC-125 (CHF_2CF_3)	125
HFC-143a (CH_3CF_3)	4,800
HFC-32 (CH_2F_2)	677
HFC-152a (CH_3CHF_2)	138
HFC-227ea (CF_3CHFCF_3)	3,350
HFC-365mfc ($CH_3CF_2CH_2CF_3$)	804
Most abundant perfluorinated hydrocarbons (PFC) [31]	
PFC-14 (CF_4)	6,630
PFC-116 (C_2F_6)	11,100
Nitrogen trifluoride (NF_3)	16,100
Sulfur hexaflouride (SF_6)	23,500

Carbon neutrality, net zero carbon emissions or carbon zero describes the least ambitious goal as it only refers to CO_2 emissions but leaves out other greenhouse gases like methane which has a 25 times higher greenhouse gas potential than CO_2. Carbon neutrality is achieved, ".. when anthropogenic CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period." [8].

Carbon or greenhouse gas neutrality is further divided into "weak" neutrality and "strong" neutrality. **Weak neutrality** refers to the purchase of carbon offsets from emissions-reducing activities that are calculated against a hypothetical reference scenario. This only leads to a reduction in emissions, but not to a full elimination of carbon emissions which should be the goal. Furthermore, due to the calculation against a reference scenario, it is vulnerable to errors and critics [9].

Strong neutrality, in contrast, means to fully compensate for greenhouse gas emissions by the expansion of carbon sinks that remove carbon dioxide permanently. These sinks include natural sinks like forests, moors or soil or human-made sinks like carbon capture and storage technologies.

Finally, **decarbonization** is the way to reach net zero carbon emissions, e.g., by using renewable energies instead of combusting fossil fuels. It is an important step to reaching greenhouse gas neutrality, but only a beginning.
To sum up: one must be aware of these differences and take a closer look behind the terms if somebody speaks of net zero, carbon neutrality, or climate neutrality. Nowadays, there is often a common understanding in public to use climate neutrality synonymously with greenhouse gas neutrality [10] although this is not the same. When focusing on CO_2 as dedicated factor only, climate neutrality can not be reached by the strict original definition.

The goal is clear – but how to reach greenhouse gas neutrality?

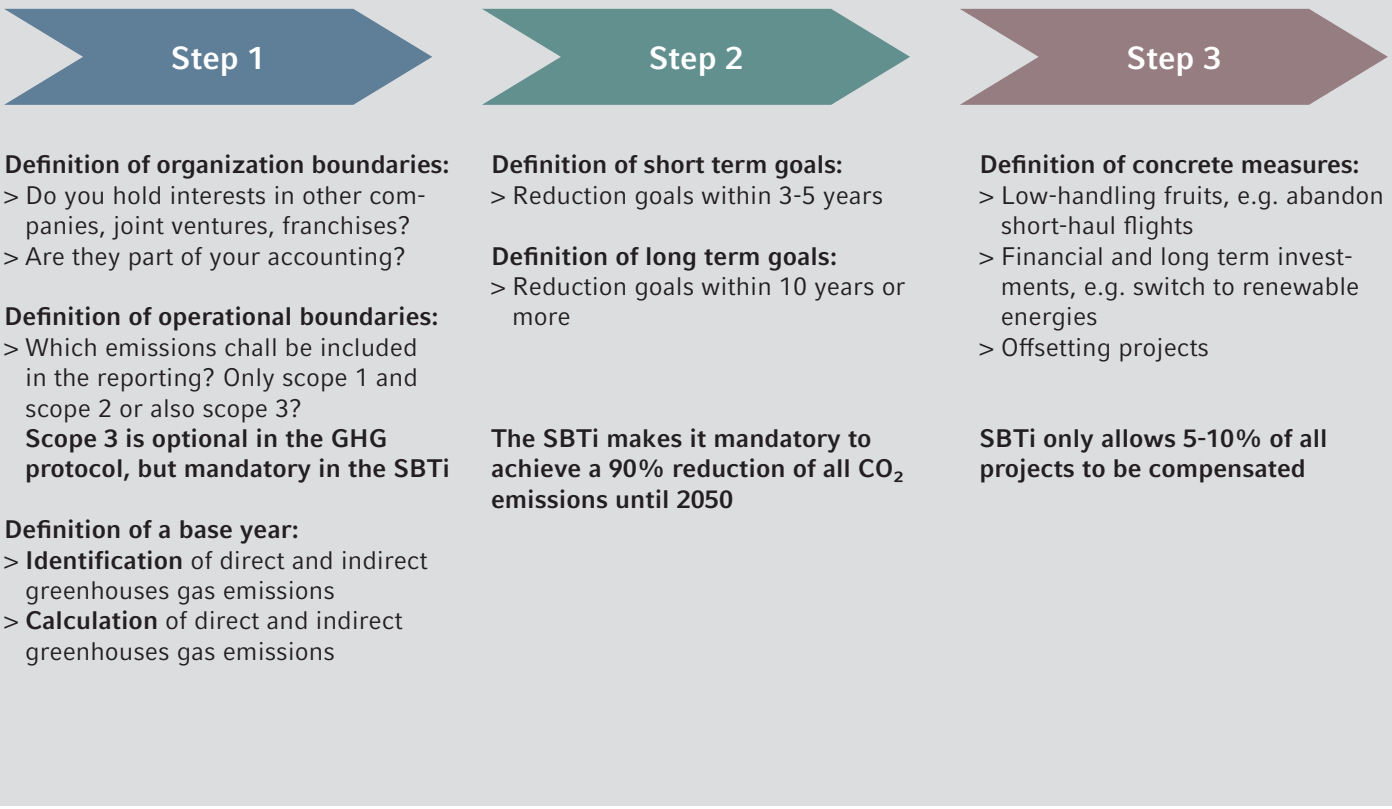
> Greenhouse gas neutrality on a global basis – countries' contribution

Countries estimate their emissions and sinks of greenhouse gases by looking into their energy production and use, industrial processes and product use, waste as well as forestry, agriculture and other land use. International guidelines from the IPCC specify exactly how to measure and how to report national emissions [11]. Initiatives like the Greenhouse Gas Protocol give guidance on how to define and reach a specific mitigation goal [12]. All countries which have signed the Paris Agreement have to define and declare short-term goals for 2025 and 2030 (Nationally Determined Contributions, NDC) as well as long-term strategies on how to reach greenhouse gas neutrality by 2050 (Low Emission Development Strategies, LEDS).

Even though the Paris climate treaty, as a supranational piece of legislation, does not provide for explicit penalties if countries fail to meet their climate targets, it does have significant implications. The publicly visible targets and progress reports [13] are intended to build pressure on governments to meet their targets and to highlight examples and best practices of countries that have managed to reduce their emissions accordingly. At the same time, climate neutrality goals are being incorporated into national or supranational legislations like the European Climate Law that writes into law the guidelines from the Green Deal [14] or the German Climate Protection Act [15].

> How can companies achieve greenhouse gas neutrality?

National emissions are based on private, public, and commercial emissions and these are more or less easy to quantify as they are connected to specific country boundaries.
Companies play an important role here in significantly reducing their emissions within a region or country. But how can companies measure their greenhouse gas emissions exactly? At first glance, this seems easy as you have to measure the energy consumption at your production site. But what about the transportation of raw materials to your production site, the carbon emissions generated through the use of your product or its disposal? These indirect emissions should also be accounted for and guidelines like the GHG Protocol Corporate Standard [16] or the Science Based Target initiative (SBTi) [17] give guidance on how to do this in practice.

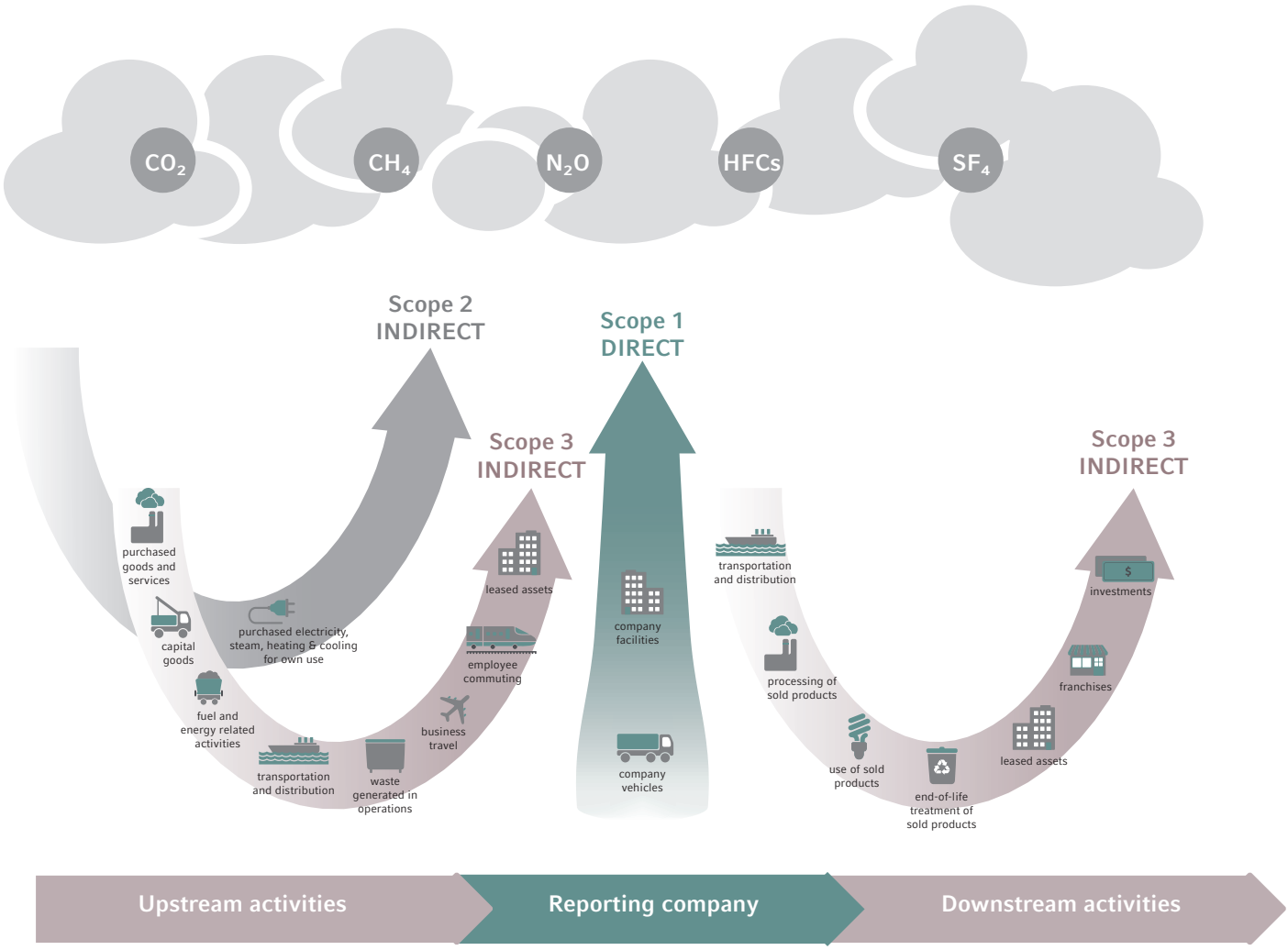


Graph 1: Three steps to reduce a companies`greenhouses gas emissions

The first step is to identify and calculate direct and indirect greenhouse gas emissions within defined organizational and operational boundaries and a defined base year. Organizational boundaries refer to the overall structure of a company and are important if an organization holds interests in other companies, like partnerships, joint ventures or franchises. Operational boundaries refer to direct and indirect emissions. The GHG Protocol divides emissions into three parts:

Scope 1: Direct GHG emissions refer to emissions from sources that are owned or controlled by the company, like the generation of electricity, heat or steam, transportation of materials, products, employees by company owned vehicles and to fugitive emissions.
Scope 2: Indirect emissions refer to purchased electricity.
Scope 3: All other indirect GHG emissions which occur in a company's value chain, like extraction and production of purchased materials, product use, disposal of waste, or employee business travel.

Various calculation tools [18], like the scope 3 evaluator [19] from the GHG Protocol – initiative help companies calculate their CO_2-inventory based on data like fuel combustion, employee travel or their scope 3 emissions. A company must be transparent about which assumptions and methodologies they use to calculate their greenhouse gas inventory ("science based approach"). It is furthermore important to know that measuring scope 3 emissions is optional according to the GHG Protocol Corporate Standard, whereas other standards like the Science Based Target initiative (SBTi) make it mandatory.



Graph 2a: Scope 1, Scope 2 and Scope 3
[32] Adapted based on: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

With all data in hand, the second step follows which includes the setting of goals. These may include short-term as well as long-term goals like reducing GHG emissions by 10% in two years compared to a defined baseline or becoming GHG-neutral within 10 years. The Greenhouse Gas Protocol does not prescribe mandatory targets or reduction measures. The Science Based Target initiative makes it mandatory for a company to reduce scope 1, 2 and 3 emissions and to develop a reduction strategy that is in line with the 1.5 °C target. The overall goal is to establish a business model that is aligned with a net-zero economy. Therefore, companies have to set short-term targets which they would like to reach within five to ten years and long-term targets which they would like to reach by 2050 at the latest. To calculate and set the targets, companies have to take into account 95% of their scope 1 and scope 2 emissions and 67% of their scope 3 emissions for short-term goals and 90% of all scopes for long-term goals. Ultimately, a company shall reduce its overall emissions by 90% by 2050. It is important to know that carbon offsetting will not be counted to reach this final target.

The third step includes concrete measures of how to achieve these goals. These include low-hanging fruits that could easily be implemented, like the abandonment of short-haul flights and switching to trains, but also measures which include greater investments, like buying more energy-efficient machines or switching to renewable energies.

Upstream activities	Downstream activities
1. Purchause goods and services	9. Downstream transportation and distribution
2. Capital goods	10. Processing of sold products
3. Fuel- and energy-related activities (not included in scope 1 or scope 2)	11. Use of sold products
4. Upstream transportation and distribution	12. End-of-life treatment of sold products
5. Waste generated in operations	13. Downstream leased assets
6. Business travel	14. Franchises
7. Employee commuting	15. Investments
8. Upstram leased assets	

Graph 2b: Scope 3 emissions in detail

[32] Original source: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

The SBTi concept is a very challenging approach regarding the scope 3 emissions. Without questioning the need for drastic emission reduction, there is the question if this target is possible to fulfill at all. The usage of products at a customer site is datawise out of reach for a supplier and can normally not be influenced in regards to, e.g., time of usage and selection of power mix. In addition, taking into account the product usage at the user site as scope 3 for the supplier but also as scope 1/ 2 for the user, results in a doubled counted emission in the overall balance. These aspects need to be discussed.
A company will never be completely free of emissions, but it can substantially reduce them. All unavoidable emissions, like the transport of produced goods, can be compensated through carbon offsets with the goal of long-term sequestration of CO_2 emissions as mentioned before. The SBTi allows compensating for 5 – 10% of unavoidable emissions if all other measures have been implemented.
A third standard, ISO 14068, is currently under development [10]. It will define requirements and principles to be followed for greenhouse gas, carbon, or climate neutrality as well as principles for achieving and demonstrating climate neutrality.

Table 2: Comparison of Greenhouse Gas Protocol Corporate Standard and SBTi Corporate Net Zero Standard

	STBi Corporate Net Zero Standard	Greenhouse Gas Protocol Corporate Standard
Mission	Introduce science-based reduction targets into the operational practice of companies	Develop internationally accepted greenhouse gas (GHG) accounting and reporting standards for business and to promote their broad adoption
Goal	Provide a standardized and robust approach for corporates to set net-zero targets aligned with climate science	Help companies prepare a GHG inventory that represents a true and fair account of their emissions, through the use of standardized approaches and principles
Who should use it?	Focused on accelerating companies across the world to halve emissions before 2030 and achieve net-zero emissions before 2050	Focus on companies; applies equally to other types of organizations with operations that give rise to GHG emissions, e.g., NGOs, government agencies, and universities
Who is behind the initiative?	Carbon Disclosure Project, UN Global Compact, WWF , World Resources Institute (WRI)	World Resources Institute (WIR), World Business Council for Sustainable Development (WBCSD)
Which greenhouse gases are included?	Covers all seven GHGs or classes of GHGs covered by the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol	Covers all GHG of the Kyoto Protocol; GHG emissions not covered by the Kyoto Protocol, e.g. CFCs, NOx, etc. shall not be included in scope 1 but may be reported separately
Operational boundaries	It is mandatory to include scope 1, 2 and 3: 95% of scope 1 and 2 emissions and complete scope 3 inventory	Scope 1 and Scope 2 are mandatory; Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions

Table 2: Comparison of Greenhouse Gas Protocol Corporate Standard and SBTi Corporate Net Zero Standard

	STBi Corporate Net Zero Standard	Greenhouse Gas Protocol Corporate Standard
Target definition	**Near term science based targets** are to be reached in 5 – 10 years. Near term science based targets must cover at least 95% of company-wide scope 1 and 2 emissions. When scope 3 emissions make up 40% or more of total emissions (scope 1, 2, and 3 emissions), targets must cover at least two-thirds (67%) of total scope 3. **Long term science based targets** are to be reached until 2050 the latest. **Long-term science based targets** must cover at least 95% of company-wide scope 1 and 2 emissions and 90% of scope 3 emissions.	GHG Protocol Corporate Standard gives guidance on the process of setting and reporting of GHG targets and the different steps involved, but it does not prescribe what a company's target should be.
Offsetting	A maximum of 10% of all emissions of a company can be neutralized (removed from the atmosphere and permanently stored) when the net-zero target has been achieved. Further offsetting beyond the value chain of a company are welcomed but will not be credited for a company's reduction target.	Offsetting can be used to reach a specific GHG reduction target with no limit regarding the share of external offsetting measures. It should be specified whether offsets are used and how much of the target reduction was achieved using them.
Reporting and verification	Company shall report its company-wide GHG emissions inventory and progress against published targets on an annual basis; the report must be publicly available. Validation and approval of the reduction target by SBTi; revalidation and approval every five years; no other external verification.	External verification by a third party or internal verification by personnel that is independent of the GHG accounting and reporting process.

Companies produce and consumers buy products – and with them a specific "carbon burden". This includes the greenhouse gas emissions which are generated not only for its transport or use, but across the whole life cycle from the sourcing of raw materials to its production, transport to the point of sale, usage and disposal. Knowing the carbon footprint brings several benefits: it helps companies to identify levers to reduce emissions, contributes to greater transparency, and provides additional knowledge to buyers. They can include such knowledge in their purchasing decision and especially buyers from the B2B environment can use this data for their scope 3 calculations – including lab managers who would like to reduce the carbon footprint of their lab.

Again, standards give guidelines on how to calculate a product's carbon footprint and define accounting principles. The most important include ISO 14067, GHG Protocol Product Standard and PAS 2050 [20] (see Table 3) for a comparison of all three standards). All three of them require the definition of a functional unit within defined boundaries and compliance with requirements like accuracy, consistency, completeness and relevance of the provided information as well as overall transparency.

Table 3: Comparison of Greenhouse Gas Protocol Product Standard, ISO 14067 and PAS2050

	Greenhouse Gas Protocol Product Standard	ISO 14067	PAS2050
Goal	Provides requirements and guidance for companies and other organizations to quantify and publicly report an inventory of GHG emissions and removal associated with a specific product	Provides a standard method for assessing a product carbon footprint and communication about	PAS provides a standard method for assessing a product carbon footprint (including all GHG emissions)
Who is behind the initiative?	World Resources Institute (WIR), World Business Council for Sustainable Development (WBCSD)	International Standard Organisation (ISO)	British Standards Institution (BSI)
Life Cycle Analysis	Whole production phase Whole life cycle of a product Further aim: identify emission reduction potentials and be able to track product performance	Whole production phase or partial production process Whole life cycle of a product or part of a life cycle Includes mandatory rules to reduce emissions Comparison of different materials from the same category is possible	Whole production phase Whole life cycle of a product Further aim: identify emission reduction potentials
External communication	3rd party verification by independent certification body	3rd party verification by independent certification body Clear communication rules	3rd party verification by independent certification body is highly recommended (other-party verification by non-accredited 3rd party or self-verification is also possible)

Still, there are slight differences. ISO 14067 allows the comparison of products within defined categories with the help of so-called product category rules (PCR) and the external communication of a product's performance. The PAS 2050 and the GHG Protocol Product Standard focus more on one specific product and the latter specifically on monitoring a product's performance over time.

The creation of a carbon footprint is quite complex and it usually takes time to compile and process all the necessary data. If you want to know about the environmental performance of a product, you have to perform a life cycle assessment (LCA). This LCA contains CO_2 but also includes other criteria like biodiversity, change of land use, eutrophication potential, or human toxicity. The product carbon footprint is focusing on CO_2e or CO_2 equivalents only.
Due to this complexity, a LCA as well as product carbon footprints are mostly limited to a few products. Nevertheless, the importance of carbon and environmental footprints will grow in future due to political guidelines in the context of the European Green Deal [21a]; please see also in the literature to change it respectively [21], [21a]. Finally, it is important to emphasize that the carbon footprint of a product provides valuable information regarding the impact on climate change, but it does not necessarily mean that a product with a low carbon footprint is "environmentally friendly" per se.

Climate certificates and compensation for CO_2 emissions

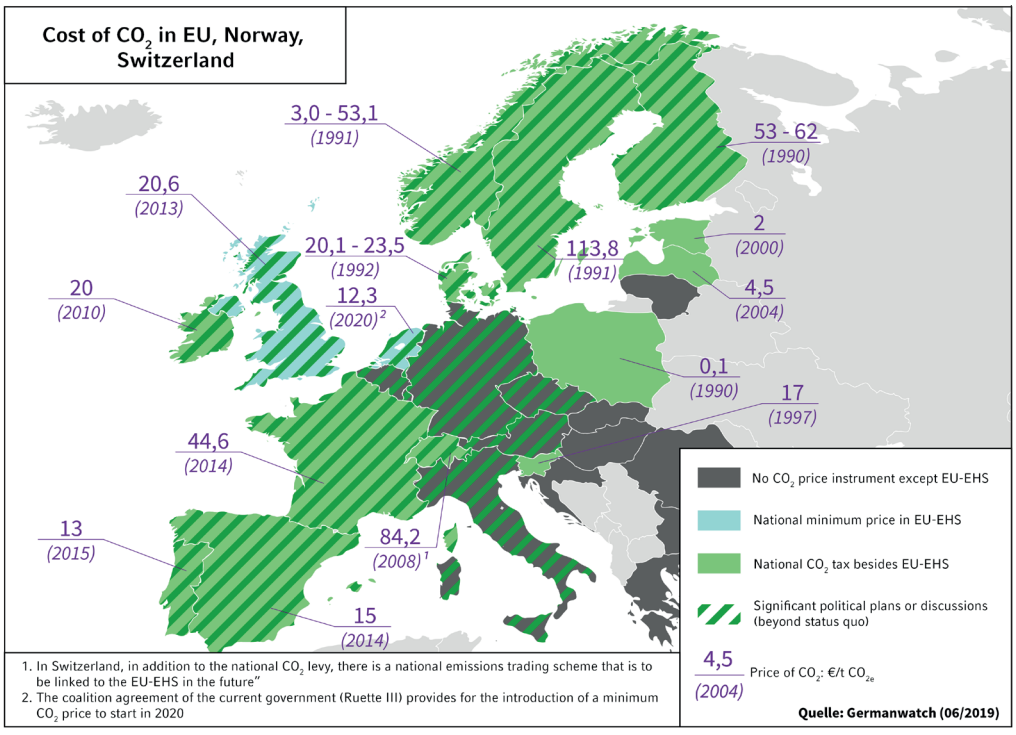
The Kyoto Protocol, enacted in 2005, allowed countries (as addition to the main focus of reducing CO_2 emissions) to compensate for (parts of) their CO_2 emissions by supporting projects which reduced or removed greenhouse gases in or from the atmosphere. Today, companies as well as private persons can also reduce their carbon footprint voluntarily with the help of climate certificates. This carbon offsetting seems to be an acceptable way to reduce carbon emissions as the climate does not care where emissions are avoided. One can choose between different project types, focusing either on the removal or reduction of CO_2 emissions. As mentioned earlier, long-term binding of CO_2 in natural carbon sinks like forests, soils or moors is better than projects supporting local reductions of CO_2 emissions elsewhere, away from the offsetting person or company.

A variety of providers offer different projects and project types – and this is where the difficulties begin. Forest protection or moor protection projects make sense to conserve CO_2 sinks – but how much CO_2 has been bound? And there are a bunch of other project types like the investment in solar energy or clean cookstoves. Every provider has a slightly different calculation methodology. There are standards, but there is no independent regulation or real transparency. What if the reference scenario is calculated far too positively and the real emissions reductions are much lower than the carbon credits claimed? A recent study revealed that most carbon offsetting projects are overrated in terms of CO_2 reduction [9]. Is the respective project really additional and one that would not have been realized without the carbon credits? If yes, then the funding is useful, but if the answer is no and the project would have been initiated anyway, then there is no additional carbon reduction. The European Union is addressing these issues and developing a framework with defined criteria to assess carbon removal projects [22]. Such regulations can help to gain back trust, but other critics remain.

False claims of "climate neutrality" by companies who "just" offset their emissions without changing their actual business model (= reduction of own emissions) led to accusations of greenwashing, generating mistrust among consumers and other stakeholders. Such a strategy contrasts with the original intention of carbon offsetting: compensating for unavoidable emissions as the last step in an overall climate strategy. Again, politics takes the initiative. Currently, the European Union is drafting the Green Claims Directive which will set clear rules against such claims and bring more transparency [23].

Finally, the price per ton of CO_2 depends on the provider and the project location. Since most projects are realized in the global South, the CO_2 price is relatively low – which leads to a smaller steering effect and does not tell the real environmental costs. Researchers in a current study estimate the social cost of carbon dioxide at $185 / ton [24] and the German Environmental Agency calculated the damage of one ton of CO_2 to € 180 already in 2018 [25]. Even the International Monetary Fund calls for a carbon price between $25 and $75, depending on the economic strength [26].

Nevertheless, compensation for (limited) unavoidable emissions does make sense, but a company should wisely choose the compensation project taking into account the aforementioned critics.



A closer look at the pharmaceutical and biotech industry

The life sciences industry is a high CO_2 emitter and healthcare alone accounts for 4.4% of global CO_2 emissions [26]. Of these, 71% is attributable to the supply chain – and hence to biotech and pharmaceutical companies. In numbers, publicly listed biotech and pharmaceutical companies emitted 227 million tons of CO_2 equivalents in 2021 which is more than the emissions of the forestry or paper industry [27]. If the industry wants to achieve the 1.5 °C target, it must reduce its carbon emissions by 9.28% per year. The highest emissions originate in the scope 3 sector where purchased goods and services as well as the use of sold products account for the highest emissions. It is therefore mandatory for the industry, and the individual company, to know the product carbon footprint of its most purchased products to develop reduction strategies in a common approach with the manufacturer. The industry is becoming more and more aware of its climate impact with ever more companies setting targets and reducing emissions. Especially the big companies are leading the way. The top 15 companies have become more efficient and reduced their carbon intensity (= carbon emissions per revenue) by 9.02% per year since 2015. This is a good start, but if the industry grows by 10.8% per year as predicted [28], the savings may be partially offset by the growth. Therefore, there is still a long way to go before the life sciences industry is truly greenhouse gas neutral. Good role models are a few companies that, following the SBTi, have committed to aligning their strategy compatibly with the 1.5 °C target.

In a nutshell

In the context of the fight against the climate crisis, terms like climate neutral, net-zero, or carbon neutral come up and are used in different contexts and meanings. First and foremost, everyone has to be aware of this fact and has to question the context in which a particular term is being used. This is especially important to avoid wrong comparisons but to compare the correct goals resp. terms. Claims like climate neutrality or GHG neutrality have to be backed by transparent goals, measures on how to reach these goals and standards like the GHG Protocol or the Science Based Target initiative that give clear guidance on how to reach greenhouse gas neutrality. Customers should question claims in order to avoid believing misleading statements. For their part, companies should make their strategies and efforts transparent to show that they are serious about climate protection. Because in the end, it is only by working together that we can achieve the goal of climate neutrality as quickly as necessary.

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