



SCIENCE
BASED
TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

FOUNDATIONS FOR SCIENCE-BASED NET-ZERO TARGET SETTING IN THE CORPORATE SECTOR

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DEVELOPED BY



This report was developed by CDP on behalf of the Science Based Targets initiative (SBTi).

The Science Based Targets initiative mobilizes companies to set science-based targets and boost their competitive advantage in the transition to the low-carbon economy. It is a collaboration between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF), and one of the We Mean Business Coalition commitments. The initiative defines and promotes best practice in science-based target setting, offers resources and guidance to reduce barriers to adoption, and independently assesses and approves companies' targets.

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Disclaimer: This research paper explores a selection of technical concepts related to corporate climate action and their relevance for corporate net-zero targets. The paper is not intended to provide a fully formalized framework for corporate net-zero targets, nor to comprehensively address all relevant dimensions of corporate climate targets and strategies. The Science Based Targets initiative will build on the conceptual foundations established in this paper to develop detailed criteria and guidelines to formulate, assess, and implement science-based corporate net-zero targets, following a transparent and inclusive process.

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FOREWORD

By **Gonzalo Muñoz** and **Nigel Topping**,
High-Level Climate Action Champions

A vibrant, prosperous, net-zero emissions world is within our reach and it is our collective responsibility to deliver it. Even in the middle of a global pandemic and the biggest economic crisis of the century, the signals of change from around the world are coming thick and fast: for the first time on record, the size of the global coal power fleet declined during the first half of 2020, with more generation capacity being shut than coming online. Costs of renewable energy technologies continue to plummet, driving exponential growth in solar and wind technology uptake. The Global Wind Energy Council reported that the world's offshore windfarm capacity could grow eightfold by the end of the decade, powered by a clean energy surge led by China. Investment in resilience and zero carbon solutions are increasing, while greater awareness of impact and risk is causing investors to move away from high risk, high carbon assets. The UK's largest pension fund, covering millions of pensions, has said it will ban investments in any companies involved in coal mining, oil from tar sands and arctic drilling. Jurisdictions around the world are setting phase out dates for internal combustion engine vehicles and automakers are making plans for hundreds of new electric vehicle models. Conservation and restoration of nature is increasingly being seen as a source for emissions reductions while simultaneously helping build resilience to climate change.

As we move into this decisive decade of climate action, the stakes could not be higher. The science has warned of the catastrophic impacts of exceeding 1.5°C global temperature rise. There are daily and sobering reminders of the adverse effects of our warming planet on communities, livelihoods and ecosystems. The time to ratchet up our collective global ambition is now. The Special Report on 1.5°C from the Intergovernmental Panel on Climate Change catalyzed a turning point for a large part of society who, acknowledging the depth of the climate crisis, stepped up to align their goals and targets with a net-zero world. Even without having all the answers and systems in place, an ever-growing group of companies, cities, regions, investors and leaders from across civil society are leading the way in the Race to Zero.

These 'real economy' actors, covering nearly 25% global CO2 emissions and over 50% GDP, are united by one thing: they have each committed to achieving net-zero carbon emissions by 2050 at the latest, sending a resounding signal to governments that a net-zero future is not only possible but an urgent priority.

As governments work to recover from the devastating economic impacts of the COVID19 pandemic, we have a unique opportunity to rebuild a healthier, more resilient and zero carbon economy that mitigates future threats, is anchored in a just transition, creates greener and safer jobs, and unlocks inclusive, sustainable growth.

Ambition is growing, and now we must unite behind science to guide our action. That means a robust and science-based understanding of what net-zero means, and what needs to happen in order to get there.

Over the past five years, the Science Based Targets initiative has pioneered using climate science as a guide to inform corporate ambition, with close to 1,000 companies joining its ranks to set emissions reduction targets grounded in science. With the encouraging growth in the number of companies setting net-zero targets, the initiative's work to define a standard, science-based framework for setting corporate net-zero targets and making related claims is critical. As recommended in this paper, we urge businesses to ground their net-zero plans in science - a whole world of opportunity awaits the winners in the race to zero, and nothing less than the future of our planet depends on it.



Gonzalo Muñoz



Nigel Topping

EXECUTIVE SUMMARY

HIGHLIGHTS

- The scientific community has clearly stated the need to reach net-zero global CO₂ emissions by mid-century in order to limit global warming to 1.5°C and to reduce the destructive impacts of climate change on human society and nature.
- As public awareness of the need to reach net-zero emissions at the global level has grown, the number of companies committing to reach net-zero emissions has increased rapidly in recent years.
- The growing interest in net-zero targets represents an unparalleled opportunity to drive climate ambition from companies. However, it also creates the pressing need for a common understanding on what net-zero means for companies and how they can get there, so that the growing momentum behind net-zero targets translates into action that is consistent with achieving a net-zero world by no later than 2050.
- For the past five years, the SBTi has pioneered translating climate science into a framework that allows companies to set ambitious climate targets, and that allows for independent assessment of these targets based on a set of robust criteria and transparent validation protocols. As of August 2020, close to 1,000 companies are setting science-based GHG emission reduction targets through the Science Based Targets initiative.
- Acknowledging the growth in net-zero target setting, the SBTi is developing a science-based framework for the formulation and assessment of net-zero targets in the corporate sector.
- This paper provides the initial conceptual foundations for science-based net-zero target setting. These foundations will be translated into specific criteria and guidance following a transparent and balanced multi-stakeholder process.

CONTEXT

In 2018, the Intergovernmental Panel on Climate Change (IPCC) confirmed that in order to limit global warming to 1.5°C, the world needs to halve CO₂ emissions by around 2030 and reach net-zero CO₂ emissions by mid-century. In addition, the IPCC stresses the need for deep reductions in non-CO₂ emissions across the economy to achieve this limit.

The IPCC defines net-zero as that point when “anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period”. The Paris Agreement sets out the need to achieve this balance by the second half of this century.

The concept of net-zero has risen in prominence ever since, as countries, cities, companies and others are increasingly committing to reaching this ambitious goal. As of July 2020, a quarter of global CO₂ emissions and more than half of the global economy were covered by net-zero commitments, according to the [Race to Zero](#) campaign led by the High-Level Climate Action Champions in the run up to COP 26.

Corporate net-zero targets are being approached inconsistently, making it difficult to assess these targets’ contribution to the global net-zero goal. A close examination shows that corporate net-zero targets to date differ across three important dimensions: (1) the range of emission sources and activities included; (2) the timeline, and most importantly; (3) how companies are planning to achieve their target. The three most common tactics in corporate net-zero strategies are: eliminating sources of emissions within the value chain of the company (i.e. a company’s scope 1, 2, and 3 emissions); removing CO₂ from the atmosphere; and compensating for value chain emissions by helping to reduce emissions outside of the value chain (e.g. through the provision of finance). Without a common understanding, today’s varied net-zero target setting landscape makes it difficult for stakeholders to compare goals and to assess consistency with the action needed to meet our global climate and sustainability goals.

ABOUT THIS PAPER

This paper provides a conceptual foundation for setting and assessing corporate net-zero targets based on robust climate science. The paper explores the scientific literature that informs how the global economy can reach a state of net-zero emissions within the biophysical limits of the planet and in line with societal climate and sustainability goals.

This paper intends to provide clarity on key concepts, rather than a definitive set of criteria or detailed guidance. Some of the key questions explored in this paper include: What does it mean to reach net-zero emissions at the global level? What can be inferred from mitigation scenarios that are consistent with limiting warming to 1.5°C? What does it mean to reach net-zero emissions at the corporate level? What is the role of decarbonisation and offsetting in science-based corporate net-zero strategies?

Translating planetary climate science into actionable criteria at the level of an individual company requires some normative decisions that do not directly emerge from the science. Recognising this, the SBTi will build on this paper with a transparent and inclusive multi-stakeholder process to develop actionable criteria, detailed guidance and technical resources to support companies with the formulation and implementation of science-based net-zero targets.

The recommendations shared in this paper should be implemented in consideration of broader social and environmental goals, in addition to climate mitigation. While the analyses in this paper have been designed primarily to ensure that corporate net-zero targets are consistent with climate science, we acknowledge that this is only one of the dimensions that need to be considered by corporates when developing their climate and sustainability strategies.

KEY FINDINGS

What is the underlying science behind science-based net-zero targets?

Researchers have explored a wide range of scenarios that limit warming to 1.5°C. Generally speaking, the lower the level of near-term emissions abatement in a pathway, the higher the need to remove carbon from the atmosphere at a later time to stabilise temperatures at a certain level.

While some level of atmospheric carbon removal is necessary and can be achieved in synergy with other social and environmental goals, the deployment of negative emission technologies at a large scale is subject to a number of uncertainties and constraints, including potential adverse effects on the environment and trade-offs with other Sustainable Development Goals. Acknowledging these risks and trade-offs, the analysis presented in this paper is based on mitigation pathways that limit warming to 1.5°C with limited reliance on the deployment of carbon dioxide removals at scale.

These pathways achieve rapid and profound reductions in CO₂ and non-CO₂ emissions in the first half of the century while scaling up measures to remove carbon from the atmosphere to neutralise the impact of emission sources that remain unavoidable.

What does it mean to reach net-zero emissions at the corporate level?

To reach a state of net-zero emissions for companies consistent with achieving net-zero emissions at the global level in line with societal climate and sustainability goals implies two conditions:

1. To achieve a scale of value-chain emission reductions consistent with the depth of abatement achieved in pathways that limit warming to 1.5°C with no or limited overshoot and;
2. To neutralise the impact of any source of residual emissions that remains unfeasible to be eliminated by permanently removing an equivalent amount of atmospheric carbon dioxide.

Companies may reach a balance between emissions and removals before they reach the depth of decarbonisation required to limit warming to 1.5°C. While this represents a transient state of net-zero emissions, it is expected that companies will continue their decarbonisation journey until reaching a level of abatement that is consistent with 1.5°C pathways.

What is the level of abatement expected in science-based net-zero targets?

Mitigation pathways that limit warming to 1.5°C without relying on unsustainable levels of carbon sequestration require a profound and far-reaching abatement of GHG emissions across the economy. Scenarios with a 66% probability of limiting warming to 1.5°C reach a level of abatement of about 90% of all GHG emissions by mid-century. The level of emissions abatement for different activities and emission sources in these scenarios depends on the technical and economic feasibility to abate them. While some emission sources are fully eliminated before mid-century (e.g. deforestation, power generation), other activities are decarbonised at a slower pace (e.g. industrial process CO₂ emissions) or have some remaining, unavoidable emissions (e.g. some non-CO₂ emissions from agriculture).

Companies setting science-based net-zero targets are expected to attain a level of reduction in value-chain emissions consistent with the depth of abatement achieved in scenarios that limit warming to 1.5°C with no or limited overshoot. How this is translated into specific criteria to define the scope of net-zero targets and expectations for different sources of emissions in the value-chain, will be defined in the next phase of this process.

How are residual emissions defined?

According to scenarios that limit warming to 1.5°C with no or limited overshoot, most of the emissions that our economy generates today will have to be eliminated by mid-century. However, there are some *residual emissions* that remain unabated by the time net zero is reached. Some of these emissions continue to be reduced throughout the second half of the century, after net-zero is reached, while others remain unabated throughout the 21st century due to technical or economic constraints.

1.5°C-aligned mitigation pathways should be the basis for determining the level of residual emissions for different activities and sectors of the economy at different points in time.

What is the role of offsetting in science-based net-zero targets?

This paper differentiates between actions that companies take to help society avoid or *reduce emissions outside of their value chain* (compensation measures) and measures that companies take to *remove carbon from the atmosphere within or beyond the value chain (neutralisation measures)*. Both, neutralisation and compensation measures are being used by companies to *offset* emissions. Generally speaking, offsetting can play two roles in science-based net-zero strategies:

1. **In the transition to net-zero:** Companies may opt to compensate or to neutralise emissions that are still being released into the atmosphere while they transition towards a state of net-zero emissions;
2. **At net-zero:** Companies with residual emissions within their value chain are expected to neutralise those emissions with an equivalent amount of carbon dioxide removals;

Both compensation and neutralisation measures by companies can play a critical role in accelerating the transition to net-zero emissions at the global level. However, they do not replace the need to reduce value-chain emissions in line with science.

What is the role of nature-based climate solutions in science-based net-zero strategies?

The accumulation of carbon and other GHGs in the atmosphere is driven not only by energy, industrial and agricultural processes, but also by the loss of carbon contained in soils and in terrestrial ecosystems. The IPCC has determined that up to 13% of anthropogenic emissions are due to deforestation and land-use change. From a climate mitigation perspective, the loss of nature is not only causing further accumulation of carbon in the atmosphere, but also decreasing the ability of our natural systems to reduce atmospheric carbon concentrations.

With this dual role, nature can and must play a critical role in climate mitigation strategies. It is an undeniable priority that ambitious action must be taken to eliminate deforestation and to halt nature loss. In addition, protecting, restoring and enhancing ecosystems can improve our ability to withdraw carbon from the atmosphere. Mitigation pathways that limit warming to 1.5°C with no or limited

overshoot reduce net carbon emissions from land-use change to zero by 2030. After that, the land system becomes a net carbon sink.

In line with this, nature-based climate solutions can play the following key roles in corporate science-based net-zero strategies:

1. **As part of a company's emissions abatement plan:** Companies with land-use intensive business models (e.g. due to consumption or production of agricultural commodities) must aim to eliminate deforestation from their supply chains by no later than 2030.
2. **As a compensation measure:** Companies in all sectors can catalyse action that preserves or enhances existing carbon stocks as part of an effort to compensate emissions as they transition toward a state of net zero emissions. It is strongly recommended that companies prioritise interventions with strong co-benefits and that contribute to achieving other social and environmental goals.
3. **As a neutralisation measure:** Companies with emissions that are not feasible for society to abate can resort to nature-based carbon sequestration measures to counterbalance the impact of unabated emissions. Interventions that contribute to restoring natural ecosystems are preferred, and companies should avoid interventions with the potential to create additional land-use pressure.

In all cases, land-based mitigation strategies should follow a robust mitigation hierarchy and should adhere to strict social and environmental safeguards. As stated above, nature-based climate solutions used as compensation and neutralisation measures do not replace the need to reduce value-chain emissions in line with science.

What is the difference between net zero targets and GHG emission reduction targets, if both are science-based?

Science-based GHG emission reduction targets ensure that companies reduce their emissions at a rate that is consistent with the level of decarbonisation required to limit warming to 1.5°C or well-below 2°C.

Science-based net-zero targets go beyond this. Building on science-based GHG emission reduction targets, they ensure that companies also take responsibility for emissions that have yet to be reduced, or that remain unfeasible to be eliminated.



Initial recommendations for corporate net-zero target setting

On the basis of the analysis conducted in this paper, the following initial recommendations are provided for companies seeking to set and implement robust net-zero targets. These recommendations will be followed by development of more detailed guidance and criteria that the SBTi will develop using an inclusive and transparent multi-stakeholder process:

- 1. Boundary:** A company's net-zero target should cover all material sources of GHG emissions within its value chain.
- 2. Transparency:** Companies should be transparent about the sources of emissions included and excluded from the target boundary, the timeframe for achieving net-zero emissions, the amount of abatement and neutralization planned in reaching net-zero emissions, and any interim targets or milestones.
- 3. Abatement:** Companies must aim to eliminate sources of emissions within its value-chain at a pace and scale consistent with mitigation pathways that limit warming to 1.5°C with no or limited overshoot. During a company's transition to net zero, compensation and neutralization measures may supplement, but not substitute, reducing value chain emissions in line with science. At the time that net zero is reached, emissions that are not feasible for society to abate may be neutralized with equivalent measure of CO₂ removals.
- 4. Timeframe:** Companies should reach net-zero GHG emissions by no later than 2050. While earlier target years are encouraged, a more ambitious timeframe should not come at the expense of the level of abatement in the target.
- 5. Accountability:** Long-term net-zero targets should be supported by interim science-based emission reduction targets to drive action within timeframes that are aligned with corporate planning and investment cycles and to ensure emission reductions that are consistent with Paris-aligned mitigation pathways.
- 6. Neutralization:** Reaching net-zero emissions requires neutralizing a company's residual GHG emissions with an equivalent amount of carbon removals. An effective neutralization strategy involves removing carbon from the atmosphere and storing it for a long-enough period to fully neutralize the impact of any GHG that continues to be released into the atmosphere.
- 7. Compensation:** While reaching a balance between emissions and removals is the end goal of a net-zero journey, companies should consider undertaking efforts to compensate unabated emissions in the transition to net-zero as a way to contribute to the global transition to net-zero.
- 8. Mitigation hierarchy:** Companies should follow a mitigation hierarchy that prioritizes eliminating sources of emissions within the value chain of the company over compensation or neutralization measures. Land-based climate strategies should prioritize interventions that help preserve and enhance existing terrestrial carbon stocks, within and beyond the value chain of the company.
- 9. Environmental and social safeguards:** Mitigation strategies should adhere to robust social and environmental principles, ensuring amongst others, protection and/or restoration of naturally occurring ecosystems, robust social safeguards, and protection of biodiversity, amongst others.
- 10. Robustness:** Compensation and neutralization measures should: (a) ensure additionality, (b) have measures to assure permanence of the mitigation outcomes, (c) address leakage and (d) avoid double-counting.

Areas for further development

Following publication of this paper, the SBTi intends to develop the following outputs following a robust and transparent process:

- **Criteria** for the formulation of science-based net-zero targets in the corporate sector;
- A **validation protocol** to assess net-zero targets against the set of criteria to be developed as part of this process;
- **Detailed guidance** for science-based net-zero target setting in the corporate sector, including guidance for **credible claims**.

To support the next phase of this process, further research and consultation is planned to address some of the key technical questions, including:

- **Understanding suitable residual emissions for different sectors of the economy:** At the sector or activity level, how much emissions abatement is needed, and which emissions sources are infeasible to abate in scenarios that limit warming to 1.5°C?
- **Interim targets:** What are credible transition pathways that are consistent with limiting warming to 1.5°C, and how should the use of transition pathways differ by emissions scope for each company?
- **Neutralization mechanisms:** What factors need to be considered to effectively counterbalance the impact of a source of emissions that remains unabated?
- **Compensation mechanisms:** What are effective mechanisms through which companies can accelerate the transition to net-zero beyond their value chain? What factors should be considered in deploying compensation tactics?
- **Claims:** What are the conditions that a company needs to meet to claim that they have reached net-zero emissions?

1

INTRODUCTION

Why do we need to reach net-zero emissions?

Every year, the amount of greenhouse gas (GHG) emissions released into the atmosphere as a result of human activity and the volume of greenhouse gas emissions that re-integrate into the biosphere through naturally occurring biogeochemical cycles result in an imbalance that causes a net accumulation of GHGs into the atmosphere. Since 2010, human activity has caused more than 300 billion tons of greenhouse gas (GHG) emissions to be released into the atmosphere. Natural processes remove some of this gas from circulation, but most of it will accumulate for centuries.

The scientific community has consistently warned that the accumulation of anthropogenic GHG in the atmosphere is the main cause of observed and projected increases in global mean surface temperature. In 2014, the Intergovernmental Panel on Climate Change (IPCC) established in its Fifth Assessment Report that human-induced global warming has a near-linear relationship with cumulative CO₂ emissions that result from human activity

To reach a state in which human activity no longer contributes to global warming means achieving a state in which anthropogenic GHG emissions no longer accumulate in the atmosphere: a state known as **net-zero emissions**. According to the IPCC, net-zero emissions are reached when "anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period." (Figure 1).

Reaching net-zero emissions at the global level means that, in aggregate, all sources of anthropogenic GHG emissions that currently total up to 55 GT of tCO₂e per year, will have to be eliminated, and those emissions that cannot be eliminated due to technical or economic reasons, will have to be counterbalanced with an equivalent amount of anthropogenic carbon dioxide removals (CDR). Achieving a state of net-zero GHG emissions is one of the primary goals of climate change mitigation at the global level and is explicitly recognized in the Paris Agreement, which calls for achieving "*a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century*".

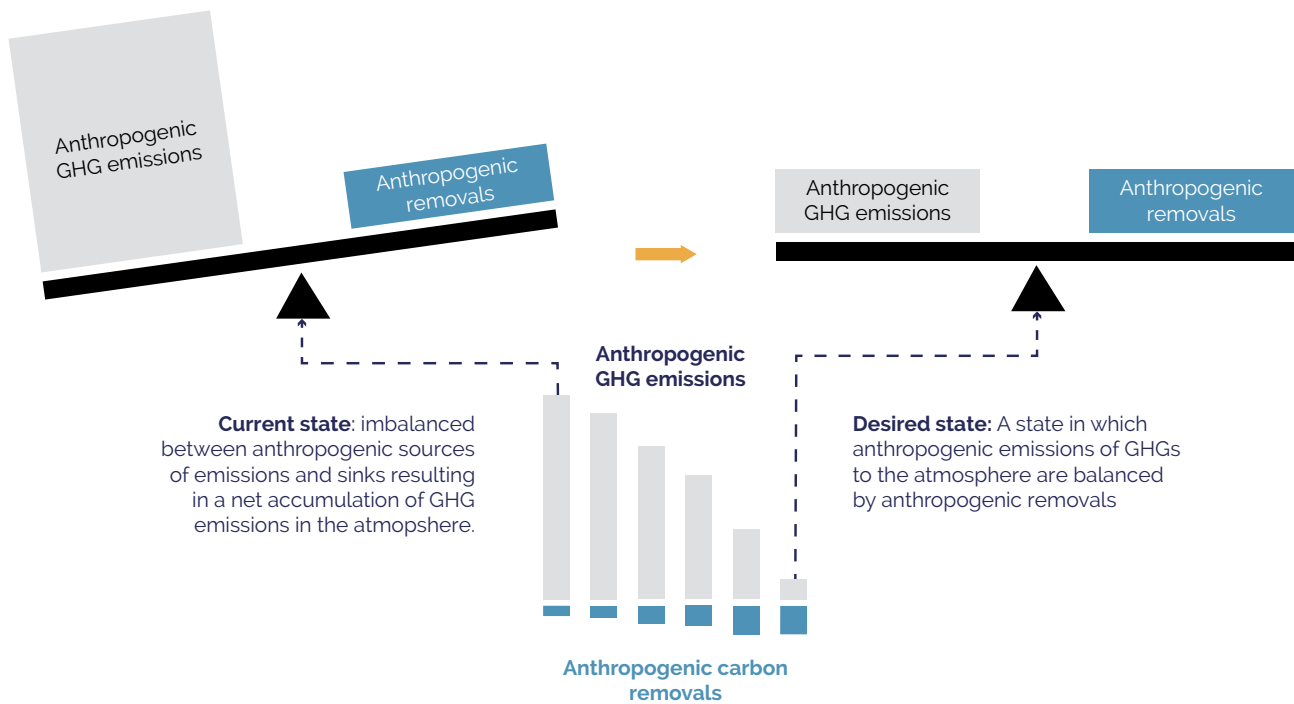


Figure 1. Net-zero emissions at the global level

Why do we need a common understanding about net-zero in the corporate sector?

With the growing recognition of the need to reach net-zero emissions at the global level, there has been a rapid growth in the number of countries and non-state actors committing to reach net-zero emissions. According to the [UNFCCC](#), by June 2020, the number of state and non-state actors committed to reaching net-zero carbon emissions by mid-century, already represented a quarter of global CO₂ emissions, and almost half of global GDP.

The growth in corporate net-zero targets is an important signal of growing ambition to fight climate change in the economy. However, it is important that they also drive the transformation that is needed to achieve net-zero emissions at the planetary level and to meet our global climate and sustainability goals.

While many companies have set targets to reach net-zero emissions, they have interpreted the goal in a variety of ways. Some companies have set targets that require deep emission reductions across the value chain and

shifting to a business model that is compatible with a net-zero economy. Others have set targets that entail modest emission reductions and heavier reliance on offsetting practices. With this heterogeneous landscape of net-zero targets, it is difficult for stakeholders to assess or to compare net-zero targets and to understand the implications of such targets.

About this paper

This paper intends to provide an understanding of today's net-zero target setting landscape and provides some conceptual foundations for informing the formulation and assessment of net-zero targets informed by science. This paper intends to provide clarity on key concepts, rather than a definitive set of criteria or detailed guidance. Translating planetary climate science into actionable criteria at the level of an individual company requires some normative decisions that do not directly emerge from the science. Recognising this, the SBTi will build on this paper with a transparent and inclusive multi-stakeholder process to develop actionable criteria, detailed guidance and technical resources to support companies with the formulation and implementation of science-based net-zero targets.

2

DECONSTRUCTING CORPORATE NET-ZERO TARGETS

While corporate net-zero targets are often treated as equivalent, and assumed to have comparable ambition, when examining them in detail significant differences can be found amongst them. This section dissects net-zero targets in the corporate sector and proposes a taxonomy to facilitate the understanding of net-zero targets in the corporate sector.

Broadly speaking, corporate net-zero targets differ across three key dimensions: (1) the boundary of the target; (2) the mitigation strategy that the company will follow to attain the target; and (3) the timeframe to achieve the target (Figure 2). Each of these dimensions is explored in the following subsections.

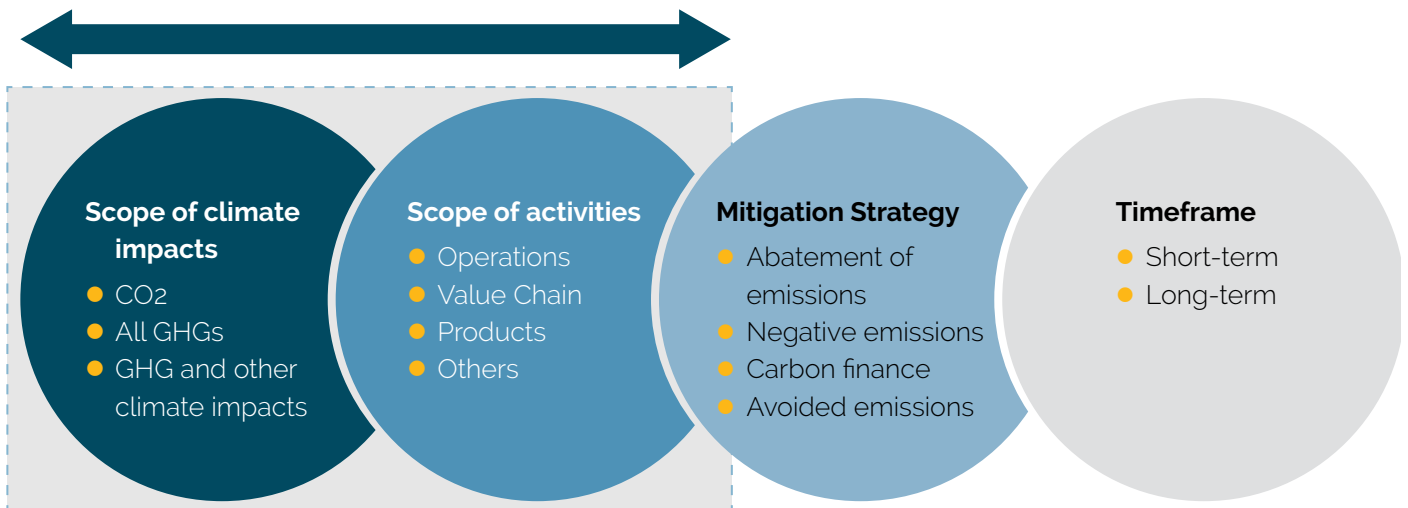


Figure 2. Key dimensions in corporate net-zero targets

2.1 TARGET BOUNDARY

One of the most important aspects of corporate net-zero targets is the range of emission sources covered within the boundary of the target. The target boundary determines whether a company is committing to address the most material sources of emissions in its value chain and, in many cases, the most material climate-related transition risks to which the company is exposed.

In today's net-zero target setting landscape, the scope of emission sources covered within net-zero target sources is inconsistent. In some cases, companies are setting targets covering only their operational emissions (emissions referred to as Scope 1 and Scope 2 in the GHG Protocol Corporate Standard) or activities in certain geographical areas. In others, companies are setting targets only for certain products or for certain activities within their value chain. An illustration of the diversity in net-zero target boundaries, with specific examples, is included as Supplementary Table 2.

Beyond the range of activities covered within a net-zero target, target boundaries also differ in the climate forcers included within the target. In some cases, companies are including all relevant sources of GHGs within the boundary of the target while in others, targets are covering CO₂ emissions only.

2.2 CARBON NEUTRALITY, CLIMATE NEUTRALITY OR NET-ZERO

The different climate forcers included in a target has also led to a confusing use of terms. In some cases, companies refer distinctly to the terms carbon neutrality, net-zero GHG emissions or climate neutrality, to reflect the scope of climate forcers included in a target, in the same way

that these terms are used in the scientific context (see Supplementary Table 1). However, more commonly, companies have used the terms carbon neutrality and climate neutrality not with the intention of describing a distinct set of climate forcers included within the boundary of a target, but rather to describe the practice of balancing a company's emissions with an equivalent amount of carbon credits.

2.3 TARGET TIMEFRAME

Another key dimension that defines the ambition and implications of a corporate net-zero target is its timeframe. Unlike GHG emissions reduction targets, which are usually formulated expressing the expected change in emissions between a base year and target year, corporate net-zero targets usually define a target year by which the company is expected to operate in a state of net-zero emissions.

In the understanding that global CO₂ emissions need to reach net-zero by mid-century in order to limit warming to 1.5°C, corporate net-zero targets are often formulated as long-term targets aiming to reach a state of net-zero emissions by no later than 2050.

In today's net-zero target setting landscape, long-term net-zero targets often imply deep abatement of emissions and measures to compensate or to neutralize unabated emissions. However, it is also common that companies set shorter term net-zero targets involving more modest reduction in emissions and a more significant deployment of compensation or neutralization measures.

With increased pressure from a growing set of stakeholders to take more ambitious climate action, this distinction between longer and shorter term targets seems to be disappearing, and a growing number of companies are aiming to achieve a state of net-zero emissions, involving deep abatement of emissions, within shorter timeframes.

2.4 MITIGATION STRATEGIES AND TACTICS

Perhaps the most important aspect that differentiates corporate climate targets is the strategy used by companies to achieve their targets, to mitigate their impacts on the climate, and to contribute to society's transition to net-zero. The combination of measures deployed to attain their targets will determine whether a company is effectively eliminating their impact on the climate, the effectiveness with which a company is addressing the transition risks to which they are exposed, and ultimately, will have an impact on our collective ability to reach net-zero emissions at the global level.

Most corporate climate change mitigation strategies involve a portfolio of mitigation tactics that may change

over time and that result in different mitigation outcomes (See discussion on mitigation outcomes in [Supplementary Discussion 1](#)). Some of these tactics help reduce the impact of a company on the climate, while others may contribute to society's transition to net-zero without reducing the climate impact of a company's value chain.

Acknowledging this subtle but important difference, the following taxonomy (Figure 3) is presented to better understand corporate mitigation tactics, the effect that they have on the climate (i.e. mitigation outcomes) and whether they contribute to reducing the climate impact of a company's value chain or whether they contribute to the net-zero in other parts of the economy. Each of these tactics is described below.

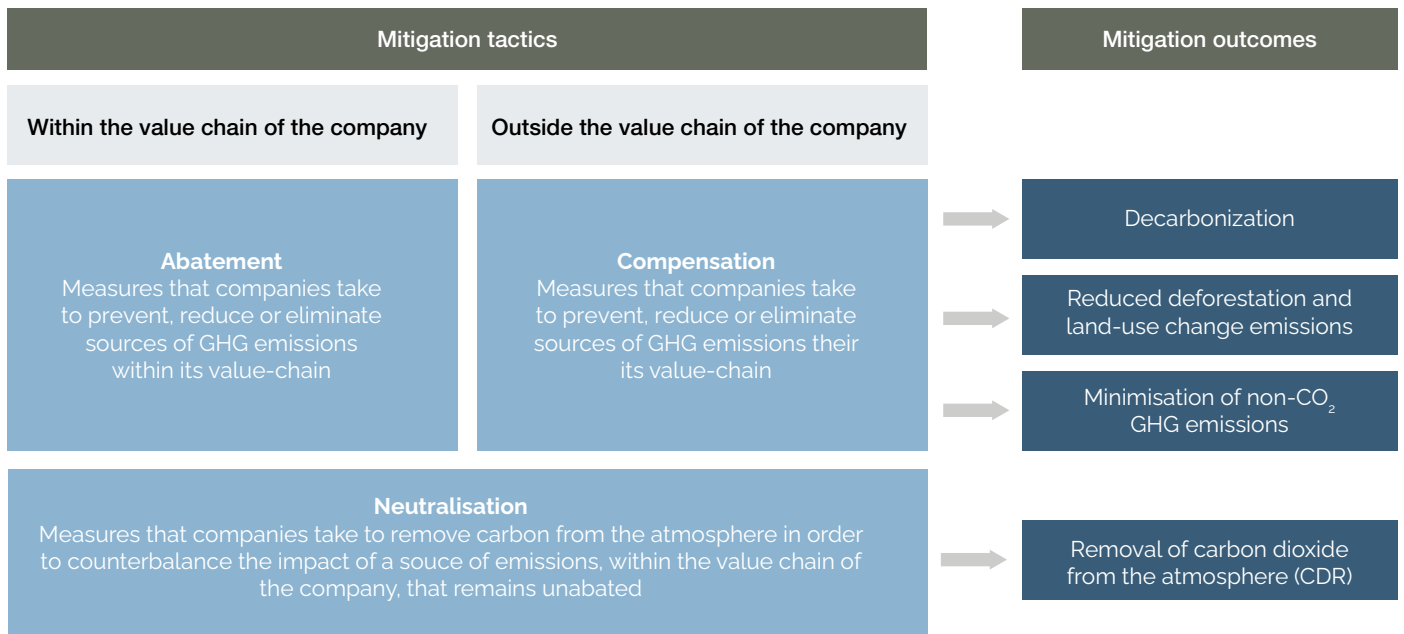


Figure 3. Taxonomy of climate mitigation tactics and outcomes

Abatement

Emissions abatement corresponds to measures that prevent the release of GHGs into the atmosphere by reducing or eliminating sources of emissions associated with the operations of a company and its value chain. Reducing or eliminating sources of emissions within a company's value chain mitigates the impact of the company on the climate, and the climate-related risks to which the company is exposed.

The accounting, reporting and abatement of energy and industry-related emissions in the corporate sector is a well established practice and has been the primary focus of corporate climate mitigation programs, such as the Science Based Targets initiative. In contrast, the monitoring, accounting, reporting and abatement of emissions from deforestation and land-use change is an area that is not yet sufficiently addressed in corporate climate mitigation plans, as discussed in Supplementary Text 2.

Neutralization

To neutralize is to "render something ineffective or harmless by applying an opposite force or effect." Accordingly, the removal and permanent storage of atmospheric carbon is a measure that, theoretically, can neutralize or counterbalance the effect of releasing CO₂ and other GHGs into the atmosphere.

The removal of carbon from the atmosphere, as a result of human activities, is a lever that is present, to a greater or to

a lesser extent, in virtually all scenarios that limit warming to 1.5°C. Increasingly, neutralization measures are also becoming more common in corporate climate plans, and in particular, in net-zero targets.

Carbon dioxide removal activities (CDR) may occur within the value-chain of the company or outside of it. A process to standardize GHG accounting of carbon removals by corporates is being conducted by the [GHG Protocol](#), with final guidance expected for release in early 2022.

The use of CDR in net-zero strategies is discussed in detail in Section 3 of this paper. Additionally, some of the risks and challenges of relying on the large scale deployment of negative emission measures to meet the Paris goals are discussed in the Supplementary Discussion 4.

Compensation

Building upon long-established mitigation hierarchies, compensation is defined in this paper as "measurable GHG emission reductions, resulting from actions outside of the value-chain of a company that compensate for emissions that remain unabated within the value-chain of a company".

Compensation measures commonly used by companies include direct investment in emission reduction activities, purchase of carbon credits, and avoided emissions through the use of sold products, amongst others. A more detailed discussion on compensation measures is included in Supplementary Text 3.

3

DEFINING NET-ZERO: GUIDING PRINCIPLES FOR SCIENCE-BASED NET-ZERO TARGETS

In the previous section, corporate net-zero targets have been examined in detail, identifying the main differences in the way net-zero target setting is currently being approached in the corporate sector. Acknowledging the current diversity in net-zero target setting, this section proposes a set of principles to guide the formulation and assessment of net-zero targets in a way that ensures that these targets drive the action needed to meet societal climate and sustainability goals.

3.1 ACHIEVING A STATE THAT IS COMPATIBLE WITH REACHING NET-ZERO EMISSIONS AT THE PLANETARY LEVEL

To stabilise the increase in global temperature, we need to reach net-zero CO₂ emissions at a global level and significantly reduce the rate of accumulation of other long-lived GHGs. Achieving a state of net-zero CO₂ emissions at the global level implies achieving a balance between the amount of carbon released into and removed from the atmosphere, as a result of human activity.

Reaching this state should serve as a North Star for climate mitigation efforts across the entire economy. While the transition to net-zero will be different for each individual actor, depending on their individual and unique circumstances, it is desirable that all actors converge towards a state that is compatible with reaching net-zero emissions at the planetary level.

Acknowledging this, the following principle is proposed to ensure that corporate net-zero targets lead to a state that is compatible with reaching net-zero emissions at the global level:

▾ Guiding principle 1:

Reaching net-zero emissions for a company involves achieving a state in which its value chain results in no net accumulation of carbon dioxide in the atmosphere and in no net-impact from other greenhouse gas emissions.

3.2 TRANSITIONING TO NET-ZERO IN LINE WITH GLOBAL CLIMATE AND SUSTAINABILITY GOALS

The first guiding principle introduced in this section provides clarity on the destination that the global economy needs to reach (i.e. reaching a balance between emission sources and carbon removals), and how this translates from the global level to the corporate level. However, there are multiple transition pathways, each with different implications for our climate, for nature, and for society. The second principle introduced here intends to guide the transition to ensure that a state of net-zero is reached in a way that is consistent with societal climate and sustainability goals and within the biophysical limits of the planet.

Through the Paris Agreement, parties and signatories committed to "*holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.*" Signatories to the Agreement also committed to "*reach global peaking of greenhouse gas emissions as soon as possible*" and to "*undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century*".

In the years since the Paris Agreement was signed, the imperative to limit warming to 1.5°C has become even stronger. Against the backdrop of increasingly frequent and destructive climate-related disasters, the IPCC Special Report on 1.5°C delivered a harrowing scientific consensus: while impacts to human health, society, and nature associated with 1.5°C of warming are worse than previously acknowledged, the risks associated with exceeding 1.5°C are far higher - often approaching the impacts we expected to see at 2C.

To minimise these risks, the IPCC SR15 highlights pathways that limit warming to 1.5°C with no or limited overshoot (overshoot <0.1°C). Accordingly, it is recommended that companies inform their climate mitigation strategies by using mitigation pathways that limit warming to 1.5°C with no or limited overshoot.

As described in the IPCC SR15, pathways that limit warming to 1.5°C, with no or limited overshoot, require reaching approximately net-zero CO₂ emissions by no later than 2050, accompanied by rapid declines in non-CO₂ emissions. This would be accomplished through rapid and profound transitions in the global energy, industry, urban, and land systems that involve:

- ▶ Full or near-full decarbonisation for energy and industrial CO₂ emissions achieving a zero-emission energy supply system by mid-century;
- ▶ Eliminating CO₂ emissions associated with agriculture, forestry and land-use by 2030;
- ▶ Deep reductions in non-CO₂ emissions from all sectors; and
- ▶ Removing CO₂ from the atmosphere to neutralize residual emissions and, potentially, to sustain net negative emissions that reduce cumulative CO₂ in the atmosphere over time.

It is important to emphasize that the different system transformations in 1.5°C mitigation pathways occur concurrently and all of them are needed for society to reach net-zero emissions and limit warming to 1.5°C. An understanding of the synergies and trade-offs between different climate change mitigation pathways and sustainable development should also guide climate action.

Many such interactions exist. For example, research indicates that exceeding around 100 EJ of bioenergy per year would put unsustainable pressure on available land, food production and prices, preservation of ecosystems and potential water and nutrient constraints.

Similarly, different approaches to CO₂ removal are associated with sustainability trade-offs and in some cases opposition from civil society. Social and political issues

aside, the sustainable CO₂ removal potentials of bioenergy with carbon capture and storage (BECCS) and afforestation and reforestation in 2050 are estimated to be 0-5 GT CO₂/yr and 0-3.6 GT CO₂/yr, respectively (Fuss et al. 2018, IPCC SR15 SPM). By comparison, global GHG emissions reached around 55 GT CO₂e in 2018 (UNEP). These figures suggest that reaching net-zero emissions without incurring undesirable consequences to sustainable development requires a substantial decrease in GHG emissions matched with CO₂ removal interventions with strong social and environmental safeguards.

To minimize these trade offs, it is expected that, in transitioning towards net-zero, companies achieve a level of abatement that is consistent with the level of abatement reached in pathways that limit warming to 1.5°C with no or limited overshoot. Accordingly, the following principle is proposed:

▼ Guiding Principle 2:

In accordance with the best available science, the Paris Agreement and Sustainable Development Goals, companies should transition towards net-zero in line with mitigation pathways that are consistent with limiting warming to 1.5°C with no or limited overshoot.



3.3 ENSURING THE VIABILITY OF THE BUSINESS MODEL IN A NET-ZERO ECONOMY

Reaching net-zero emissions at a global level requires profound transformations across all sectors of the economy. Achieving the goal relies, in part, on cascading policy, legal, technology, and market changes that will occur as a result of societal efforts to mitigate and adapt to the climate crisis.

It is crucial – both for the success of the climate action movement and to limit business risks – for companies to ensure that their business models align with a net-zero economy. In other words, companies need to transition to business models that create value to shareholders and stakeholders without causing accumulation of GHGs in the atmosphere. This understanding is also foundational to principles that were developed by the Oxford Martin Net Zero Carbon Investment Initiative, which are being put into practice by the Net Zero Asset Owners Alliance representing over US\$4.6 trillion under management (Millar et al., 2018).

Moreover, changes to society and the economy pose unprecedented risks, as well as opportunities, to companies. Examples of these risks include more stringent policy frameworks, increases in litigation, changes in consumer behaviour, stigmatisation of sectors, and changes in shareholder expectations.

According to the Task Force on Climate-Related Financial Disclosures (TCFD), "Emissions are a prime driver of rising global temperatures and, as such, are a key focal point of policy, regulatory, market, and technology responses to limit climate change. As a result, organizations with significant emissions are likely to be impacted more significantly by transition risk than other organizations. In addition, current or future constraints on emissions, either directly by emission restrictions or indirectly through carbon budgets, may impact organizations financially."

Acknowledging the need to mitigate transition risks and to create business models that are viable in a net-zero economy, a third guiding principle is proposed. This principle supplements the first two guiding principles that define what it means for companies to reach net-zero emissions and net-zero transition pathways compatible with societal climate and sustainability goals.

▾ Guiding Principle 3:

The mitigation strategy followed by the company should inform long-term strategies and investments that mitigate exposure to climate-related transition risks, ensuring that the business model of the company will continue to be viable in a net-zero economy.

4

ASSESSING THE EFFECTIVENESS OF CORPORATE MITIGATION STRATEGIES TO REACH NET-ZERO

As described in Section 2, corporate net-zero strategies usually consist of a combination of tactics that mitigate the impact of the company on the climate and accelerate society's transition to net-zero. The multiple combinations of mitigation tactics lead to different outcomes for companies, but also for society, for nature and for the climate.

This section illustrates five hypothetical mitigation strategies that mirror common approaches in today's corporate target-setting landscape. The strategies presented in this section do not represent recommendations from the Science Based Targets initiative, but rather, possible configuration of mitigation tactics in corporate net-zero strategies. Each strategy is assessed against the principles defined in Section 3. Based on this analysis presented in this paper, its authors draw high-level recommendations for the formulation of science-based corporate net zero targets in Section 5.

4.1 STRATEGY 1: REPLACING VALUE-CHAIN EMISSION REDUCTIONS WITH CARBON CREDITS

With this strategy, emissions within a company's value chain are reduced at a rate that is not aligned with Paris-aligned emissions trajectory and carbon credits are

purchased in an amount equal to the company's unabated value chain emissions. (Although carbon credits may be issued for activities that result in any mitigation outcome, this hypothetical strategy is focused on carbon credits representing emission reductions. Considerations relevant to carbon credits representing CO₂ removal are discussed in Strategy 3.) This strategy represents a common approach used by companies to make carbon neutrality claims.

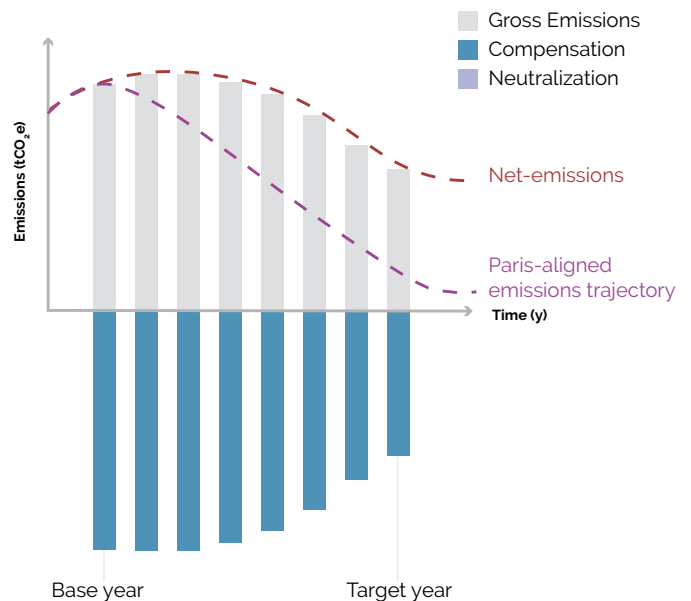


Figure 4. Replacing abatement with carbon credits representing emission reductions

Strategy 1: Illustrative example

In the base year of its climate target, a manufacturing company generates electricity for on-site consumption through the combustion of fossil fuels. In its transition to net-zero, the amount of emissions the company plans to abate falls short of what can be considered Paris-aligned, but the company plans to compensate for unabated emissions by purchasing an equivalent amount of carbon credits.

Carbon credits are issued from a greenfield renewable energy project that results in the avoidance of emissions from a higher carbon alternative. In its net-zero target year, the company may have enabled the avoidance of emissions elsewhere, but emissions equivalent to the purchased carbon credits continue to accumulate in the atmosphere as a result of the company's activity.



How effective is this strategy at neutralizing the impacts of a company's value chain GHG emissions on the climate (Principle 1)?

In a best-case scenario (i.e., assuming full additionality), the volume of emissions avoided through the purchase of carbon credits corresponds to an equivalent volume of GHG emissions that is not being reduced within the value chain of the company and that will continue to accumulate in the atmosphere. In other words, for every ton of CO₂ that is offset with a carbon credit, another ton of CO₂ remains unabated within that company's value chain. Understanding that reaching net-zero emissions globally requires all sources of emissions to be eliminated or neutralized with an equivalent amount of negative emissions, this strategy is not consistent with reaching a state that is consistent with reaching net-zero emissions at the planetary level.

This strategy is also weakened by GHG accounting incompatibility. The emissions reductions outside of the value chain are accounted for via consequential accounting, whereas corporate emissions inventories follow an attributional accounting approach. Although both accounting approaches share a common unit (tCO₂e), mixing them is generally not appropriate (Brander 2016).

If adopted at scale, would this strategy be consistent with the attainment of the Paris Agreement and the Sustainable Development Goals (Principle 2)?

Limiting warming to 1.5°C requires achieving a state by mid-century in which anthropogenic activity does not contribute to the accumulation of GHGs in the atmosphere. In many scenarios, it is even assumed that anthropogenic activity should result in a net removal of CO₂ from the atmosphere. Achieving this goal requires eliminating nearly all sources of anthropogenic GHG emissions and neutralizing hard-to-abate emissions with an appropriate amount of CO₂ removals.

The widespread adoption of a practice that leaves a ton of emissions unabated for every ton of emissions abated somewhere else would not be consistent with phasing out nearly all sources of anthropogenic GHG emissions. By contrast, when financing emission reductions outside the value chain of a company occurs in addition to emissions abatement inside the value chain, as illustrated in Strategy 5, Principles 1 and 2 can be met.

How effective is this strategy at mitigating climate-related transition risks and securing business models that are resilient in a net-zero economy (Principle 3)?

A strategy that focuses on mitigation outcomes outside the value chain of a company does not lead to a decarbonized business model or mitigate a company's climate-related transitions risks.

4.2 STRATEGY 2: REPLACING ABATEMENT WITH AVOIDED EMISSIONS FROM PRODUCTS AND SERVICES

With this strategy, emissions in a company's value chain are reduced at a rate that is not aligned with Paris-aligned emissions trajectory, but the company claims that the products or services it sells result in a reduction or avoidance of emissions outside of the company's value chain at an amount equivalent to the company's unabated value chain emissions.

This is generally done by comparing emissions of a higher-carbon reference product or service with a lower-carbon, or carbon neutral alternative that a company brings to the market. For instance, displacing coal-based electricity with gas-based or renewable electricity.

How effective is this strategy at neutralizing the impacts of a company's value chain GHG emissions on the climate (Principle 1)?

Identically to Strategy 1, if the volume of emissions avoided through the use of a company's sold products is used to justify continued GHG emissions in the value chain of a company, GHG emissions continue to accumulate in the atmosphere due to the activities of the company.

If adopted at scale, would this strategy be consistent with the attainment of the Paris Agreement and the Sustainable Development Goals (Principle 2)?

Identically to Strategy 1, the widespread adoption of a net-zero model that leaves a source of emissions unabated for every volume of emissions avoided, would not be compatible with the global goal of reaching net-zero emissions at the global level.

How effective is this strategy to mitigate climate-related transition risks and to help create business models that are resilient in a net-zero economy (Principle 3)?

The development and commercialisation of products and services that help society reduce emissions can contribute to building a climate-resilient business model; however, if the emissions associated with the value chain of a company remain unabated, the company's transition risk remains unmitigated.

4.3 STRATEGY 3: REPLACING ABATEMENT WITH NEGATIVE EMISSIONS

In this strategy, value chain emissions are reduced at a scale that falls short of what can be considered Paris-aligned and unabated emissions are balanced by CO₂ removal and sequestration. This means heavy reliance on CO₂ removal is used to enable gross value chain emissions that exceed levels consistent with scenarios that meet the ambition of the Paris Agreement.

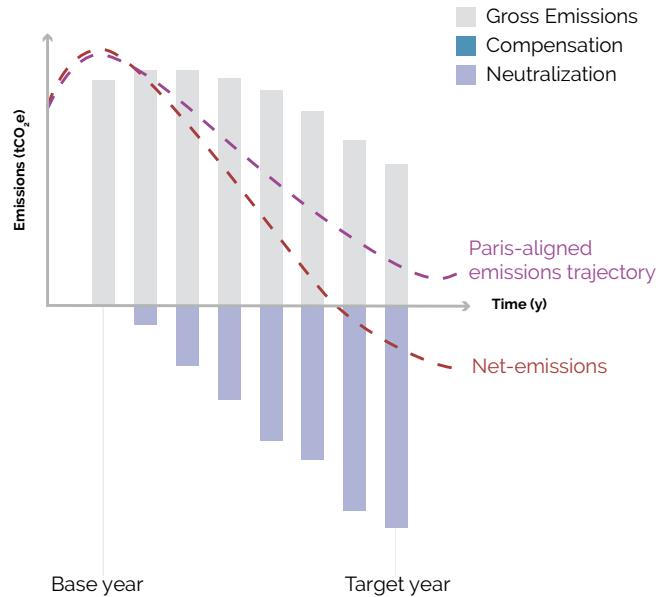


Figure 5. Replacing abatement with neutralization

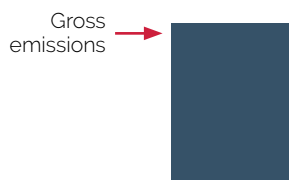
Strategy 3: Illustrative example

In the base year of its climate target, a utility generates electricity through the combustion of fossil fuels. In its transition to net zero, the utility transitions some of its generation capacity towards renewable electricity but retains a significant proportion of fossil power generation. To neutralize its unabated emissions, the utility captures and stores atmospheric CO₂ through a combination of afforestation and DAC with geologic sequestration.

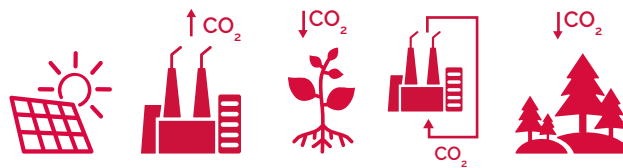
Base year scenario



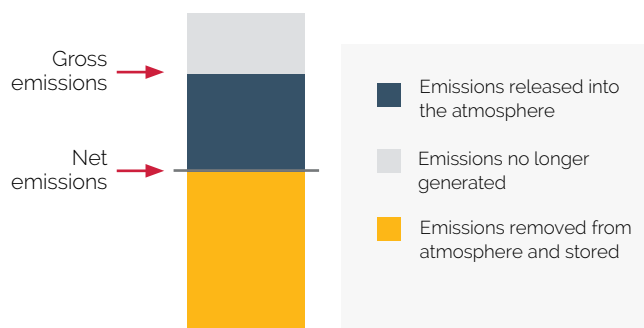
Electric utility with an asset base consisting mainly of unabated fossil generation



Net-zero scenario



Electric utility reaches net-zero emissions through a combination of renewable assets and carbon removal measures



How effective is this strategy at neutralizing the impacts of a company's value chain GHG emissions on the climate (Principle 1)?

In theory, a company can achieve a state of no net accumulation of CO₂ in the atmosphere through negative emissions. However, the robustness of a net-zero strategy that relies heavily on negative emissions depends on the effectiveness of the underlying CO₂ removal and, especially, on the permanence of the stored carbon.

Generally speaking, CO₂ removal is considered to involve higher risks than reducing GHG emissions for a number of reasons including technical feasibility, social and environmental trade-offs, earth system feedbacks, and risk of ineffective sequestration (Dooley, Kartha, 2017; Lade et al., 2020). A detailed discussion on negative emissions is included in [Supplementary Discussion 4](#).

If adopted at scale, would this strategy be consistent with the attainment of the Paris Agreement and the Sustainable Development Goals (Principle 2)?

CO₂ removal plays an important role in most pathways that limit warming to 1.5°C with no or limited overshoot. However, their role comes alongside a far greater role played by emissions reductions, including an almost full decarbonization of the economy, permanent suspension of deforestation, and substantial decrease in non-CO₂ emissions.

While terrestrial carbon sequestration can make a significant contribution to climate mitigation, its large-scale deployment also has the potential to trigger excessive levels of land conversion, thereby resulting in adverse social and environmental impacts (IPCC SRCCL). These negative impacts may include desertification, land degradation, food insecurity, displacement of local communities, worsened livelihoods, loss of natural ecosystems, loss of biodiversity, and pollution (Dooley and Kartha, 2018).

To minimise these trade-offs and to maximise synergies with the broader sustainable development agenda, it is important to avoid the widespread adoption of net-zero strategies that rely on unsustainable levels of land-use conversion at the expense of emissions abatement. It is also critical to ensure that the deployment of nature-based climate solutions follows a mitigation [hierarchy](#) and robust sustainability principles, including, among others, incorporation of diverse native species, protecting biodiverse ecosystems and respecting social safeguards (Seddon et al., 2020).

How effective is this strategy at mitigating climate-related transition risks and securing business models that are resilient in a net-zero economy (Principle 3)?

Some CO₂ removal options can mitigate transition risks and enhance the resilience of business models in certain sectors. For instance, the incorporation of harvested wood products as a structural material in buildings can meet or drive evolving market expectations for innovative solutions to the climate crisis, in addition to reducing the sector's impact on the climate.

Alternatively, reliance on negative emissions to maintain high-carbon business models would not mitigate transition risks and can create strategic and financial lock-in to unsustainable business models (Dahlmann, et al., 2019). For instance, a car manufacturer could invest in CO₂ removal to neutralize the impact of internal combustion engine vehicles it plans to continue producing. In a net zero economy, however, consumer preferences, air quality regulations, climate policy and transportation infrastructure will continue to evolve in favour of electric and zero-emission vehicles, making this mitigation strategy inadequate and locking the company into an unviable business model.

4.4 STRATEGY 4: EMISSIONS ABATEMENT IN LINE WITH SCIENCE

In this strategy, value chain emissions are abated at a rate consistent with emissions pathways that meet the ambition of the Paris Agreement. Reducing emissions in line with science will bring emissions to zero, for some emission sources, or close to zero, for other activities where some emission sources remain unavoidable.

In scenarios that limit warming to 1.5°C with no or limited overshoot, the gross emissions of many economic activities reach zero by the time net zero is achieved globally. However, some activities are expected to retain a level of residual emissions even when global emissions reach net zero. In a science-based net zero strategy, any residual emissions are expected to be neutralized by the time global emissions reach net-zero.

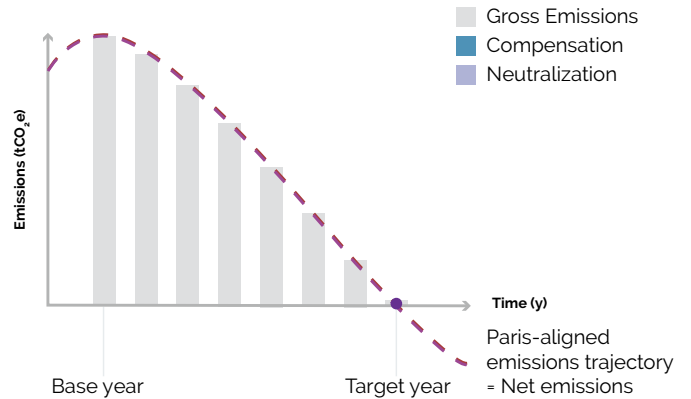
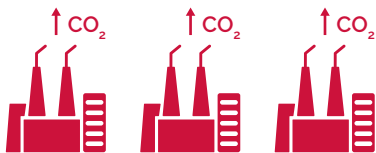


Figure 6. Approach based on eliminating emissions in line with science

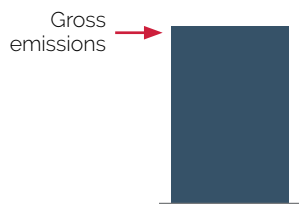
Strategy 4: Illustrative example

In the base year of its climate target, a utility generates electricity through the combustion of fossil fuels. In its transition to net-zero, the utility switches to mainly non-emitting power generation (e.g. renewable technologies) and retrofits remaining generation sites with CCS, which prevents the release of CO₂ emissions into the atmosphere.

Base year scenario



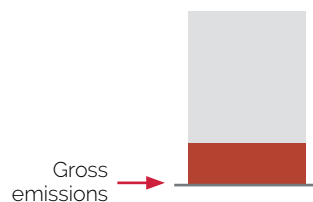
Electric utility with an asset base consisting mainly of unabated fossil generation



Net-zero scenario



Electric utility with an emissions-free asset base



- Emissions released into the atmosphere
- Emissions no longer generated
- Emissions captured and stored before being released into the atmosphere

How effective is this strategy at neutralizing the impacts of a company's value chain GHG emissions on the climate (Principle 1)?

By avoiding the generation or preventing the release of GHG emissions, a company can effectively neutralize its impact on the climate, as its activities will no longer contribute to the accumulation of GHGs in the atmosphere.

If adopted at scale, would this strategy be consistent with the attainment of the Paris Agreement and the Sustainable Development Goals (Principle 2)?

Virtually all scenarios that limit warming to 1.5°C with no or limited overshoot require an almost complete phase-out of all anthropogenic CO₂ emissions and a significant decrease in non-CO₂ emissions. In most of these scenarios, net land-use change CO₂ emissions are phased out by 2030, while net CO₂ emissions from energy and industry are eliminated by 2050. The widespread adoption of corporate net-zero strategies with emissions abatement consistent with this level of ambition would be consistent with the climate goals of the Paris Agreement.

Furthermore, the broad adoption of net-zero strategies that embrace deep decarbonisation, eliminate land-use change emissions and minimise non-CO₂ emissions would reduce the need for CO₂ removal, avoiding negative impacts to sustainable development.

How effective is this strategy at mitigating climate-related transition risks and securing business models that are resilient in a net-zero economy (Principle 3)?

Reducing GHG emissions can limit exposure to current and future climate-related transition risks. Although reducing GHG emissions within the organizational boundary of a company can limit risk to assets owned or controlled by a company, effective risk abatement strategies also need to consider the most relevant sources of emissions across the entire value chain of a company, as these emissions may be orders of magnitude larger. Accordingly, robust net zero strategies should also discourage companies from allocating capital to assets, technologies, and business models that are not viable in a world where the Paris goals are met. Conversely, investing in assets and/or business models that are consistent with deep decarbonization can expose companies to sizable business opportunities in the transition to a net-zero economy.

4.5 STRATEGY 5: CLIMATE POSITIVE APPROACH

In this strategy, value chain emissions are abated at a rate consistent with emissions pathways that meet the ambition of the Paris Agreement and residual emissions are neutralized with CO₂ removal by the time net-zero is reached. In addition, the company contributes to accelerating society's net zero transition beyond its value chain e.g. by compensating all emissions released into the atmosphere while the company transitions towards a state of net-zero emissions.

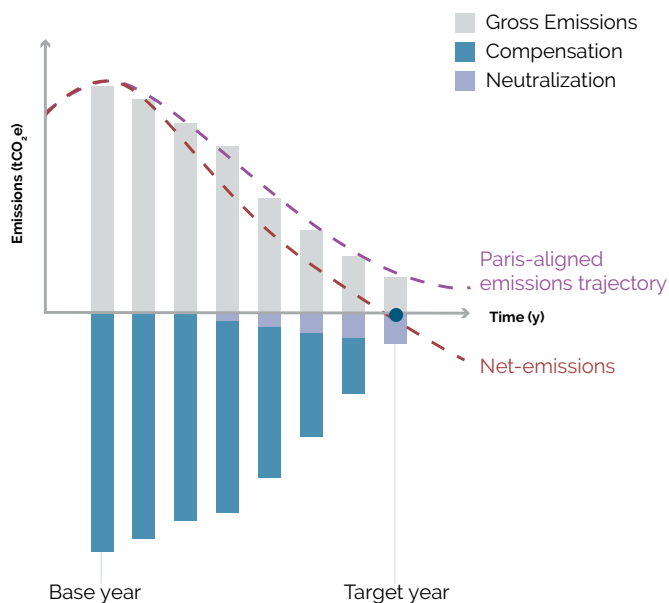


Figure 7. Climate positive approach

Given that Strategy 5 has the same foundations as Strategy 4, its assessment against all three principles is unchanged. Recognizing a climate positive approach to corporate climate action can help bridge the practice of compensating with carbon credits representing emission reductions that has prevailed for decades with a science-based approach to mitigating climate impact consistent with reaching net zero globally. While this approach is labelled 'climate positive', it should be noted that there are ongoing efforts to provide a more comprehensive definition of what being 'Climate Positive' means for a business.

Rationale for a climate positive approach

A climate positive approach to net-zero provides an opportunity for companies to contribute to the broader social and environmental agenda while ensuring the integrity of their own climate strategy. For instance, a company may be interested in financing climate protection activities that help improve the health of local communities where they operate or that help conserve critical ecosystems in areas of interest for the company. Companies may also contribute to global decarbonization and act as climate stewards by helping to close the climate finance gap or engaging constructively and responsibly in climate policy.

The purpose of including Strategy 5 is not to dictate the specific implementation of a climate positive approach, but rather to illustrate how it can guide a corporate net-zero strategy. The approach requires companies to transition to net-zero at a rate consistent with appropriate mitigation scenario, while compensating for all unabated emissions before net-zero is reached. Compensation measures drive mitigation outcomes beyond the value chain, helping other parts of the economy and world transition to net zero. Neutralization could also be deployed earlier and at greater volumes in a climate positive approach.

Compensating for unabated emissions, or undertaking additional neutralization on the journey to net zero should not be used as a vehicle to claim that net-zero has been reached. However, a climate positive strategy provides an opportunity for companies to contribute not only to closing the emissions gap, but also to closing the climate finance gap; and it is an avenue to evolve from an approach that "does no harm" to one that does good.

4.6 SUMMARISED ASSESSMENT OF CORPORATE NET-ZERO STRATEGIES

The following table presents a summarised assessment of the five hypothetical mitigation strategies described above.

Table 1. Summarised assessment of corporate net-zero strategies

Strategy	Value chain emissions abatement	Measures to balance unabated value chain emissions	Principle 1: consistent with no net accumulation of GHGs in the atmosphere?	Principle 2: consistent with the attainment of the Paris Agreement and SDGs?	Principle 3: business model resilient in a net zero economy?
Strategy 1 Replacing abatement with carbon credits representing emission reductions	Value chain emissions are abated by an arbitrary amount	Unabated emissions are balanced by carbon credits representing emission reductions	No	No. The Paris Agreement cannot be attained without halting accumulating of GHGs in the atmosphere	No. Retaining a relatively high-emissions business model is unlikely to meet stakeholder expectations
Strategy 2 Replacing abatement with avoided emissions		Unabated emissions are balanced by avoided emissions due to sold products or services			
Strategy 3 Replacing abatement with negative emissions		Unabated emissions are balanced by an appropriate amount of CO ₂ removal			
Strategy 4 Abatement of emissions in line with science	Value chain emissions are abated at a rate consistent with Paris-aligned climate change mitigation scenarios	Unabated emissions are balanced by an appropriate amount of CO ₂ removal	Yes, if CO ₂ sequestration is permanent	No. Overreliance on CO ₂ removal generates trade-offs with other social and environmental goals	Uncertain. Overreliance on negative emissions may not address stakeholder expectations
Strategy 5 Climate positive approach		During the transition to net zero, unabated emissions are compensated. When net zero is achieved, emissions are balanced with an appropriate amount of CO ₂ removal			

5

DISCUSSION AND RECOMMENDATIONS

5.1 DISCUSSION

The importance of corporate net-zero targets

Corporate net-zero targets represent an important tool for companies to signal their commitment to evolve towards a business model that is compatible with a net-zero economy and to inform short- and longer-term strategies and investments. By defining net-zero targets with respect to atmospheric science, the scale of the challenge faced by the global economy is made clear and the conditions that need to be met across an entire system of actors are set.

Defining net-zero at the corporate level

This paper has introduced two guiding principles that help ensure that net-zero targets are consistent with the action needed to reach net-zero emissions at the planetary level in line with societal climate and sustainability goals. These two principles together help define what it means for companies to reach a state of net-zero emissions consistent with limit warming to 1.5°C. Additionally, a third principle has been proposed to ensure that companies transition towards a business model that continues to be viable in a net-zero economy.

Based on the guiding principles introduced in this paper, it can be concluded that reaching a state of net-zero emissions consistent with limit warming to 1.5°C involves two conditions:

1. To achieve a scale of value-chain emission reductions consistent with the depth of abatement achieved in pathways that limit warming to 1.5°C with no or limited overshoot; and
2. To neutralize the impact of any source of residual emissions that remains unfeasible to be eliminated by permanently removing an equivalent amount of atmospheric carbon dioxide.

Companies may reach a balance between emissions and removals before they reach the depth of decarbonization required to limit warming to 1.5°C. While this represents a transient state of net-zero emissions, it is expected that companies will continue their decarbonization journey until reaching a level of abatement that is consistent with 1.5°C pathways.

The importance of reducing emissions in line with science

Mitigation pathways that limit warming to 1.5°C without relying on unsustainable levels of carbon sequestration require a profound and far-reaching abatement of GHG emissions across the economy. The analysis presented in this paper reaffirms that emissions abatement constitutes the most effective tool available to companies to mitigate their impact on the climate, to address climate-related transition risks and, ultimately, to reach a state of net-zero emissions.

Therefore, credible net-zero targets need to be backed-up with plans to reduce value-chain emissions in line with mitigation pathways that limit warming to 1.5°C.

The role of negative emissions in science-based net-zero strategies

According to scenarios that limit warming to 1.5°C with no or limited overshoot, most of the emissions that our economy generates today will have to be eliminated by mid-century. However, even in these scenarios, there are some residual emissions that remain unabated by the time net zero is reached. Some of these emissions will continue to be reduced throughout the second half of the century, after net-zero is reached, while others will remain unabated throughout the 21st century due to technical or economic constraints.

Companies with residual emissions within their value chain are expected to neutralize those emissions with an equivalent amount of permanent carbon dioxide removals. While removing carbon plays an important role in most pathways that limit warming to 1.5°C with no or limited overshoot, the scale-up of carbon sequestration measures comes alongside rapid and profound abatement of GHG emissions across the economy.

Furthermore, the deployment of negative emission technologies at a large scale is subject to a number of uncertainties and constraints, including potential adverse effects on the environment and trade-offs with other Sustainable Development Goals. For these reasons, companies should not see negative emissions as a substitute for reducing value-chain emissions in line with science.

The role of emissions compensation in science-based net-zero strategies

Avoided emissions, the purchase of carbon credits, and other interventions enable companies to contribute positively to climate action beyond their value chains and can actively contribute to other goals of the Paris agreement - namely climate adaptation, climate finance, and the sustainable development agenda. These activities may be highly impactful, despite the fact that they may not counterbalance a company's unmitigated emissions and should be considered as options that enable companies to contribute to society reaching net-zero. That is a valuable goal in itself and helping others to reduce emissions and adapt to climate change, will also help make it possible for all companies to reach net-zero more efficiently.

Companies should continue to pursue a wide range of options for contributing to climate change mitigation, which includes helping society reduce emissions through carbon finance or through products and services. Doing so will be critical to society achieving net-zero and should indeed constitute part of a company's net-zero strategy - but without being used as a substitute for reducing value chain emissions.

In some cases, the avoided emissions associated with a company's sold products or services or the carbon finance provided by a company may, in fact, also lead to emissions reductions in the company's value chain making it easier for the company to reach net-zero. There are also cases where carbon credits may accelerate decarbonization in a way with no traceable impact on the company's own emissions inventory. These activities, too, should be encouraged -- particularly if they are associated with co-benefits - but they should also not be understood as a substitute to reduce or emissions or as an alternative to neutralize a company's unabated value chain emissions.

The role of nature-based climate solutions in science-based net-zero strategies

With its dual role as a source of emissions and as a natural carbon sink, nature can and must play a critical role in climate mitigation strategies. It is an undeniable priority that ambitious action must be taken to eliminate deforestation and to halt nature loss. In addition, protecting, restoring and enhancing ecosystems can improve our ability to withdraw carbon from the atmosphere.

In line with this, nature-based climate solutions can play the following key roles in corporate science-based net-zero strategies:

- **As part of a company's emissions abatement plan:** Companies with land-use intensive business models (e.g. due to consumption or production of agricultural commodities) must aim to eliminate deforestation from their supply chains by no later than 2030.
- **As a compensation measure:** Companies in all sectors can catalyse action that preserves or enhances existing carbon stocks as part of an effort to compensate emissions as they transition toward a state of net zero emissions. It is strongly recommended that companies prioritise interventions with strong co-benefits and that contribute to achieving other social and environmental goals.
- **As a neutralization measure:** Companies with emissions that are not feasible for society to abate can resort to nature-based carbon sequestration measures to counterbalance the impact of unabated emissions. Interventions that contribute to restoring natural ecosystems are preferred, and companies should avoid interventions with the potential to create additional land-use pressure.

In all cases, land-based mitigation strategies should follow a robust mitigation hierarchy and should adhere to strict social and environmental safeguards. As stated above, nature-based climate solutions used as compensation and neutralization measures do not replace the need to reduce value-chain emissions in line with science.

Recommendations for science-based corporate net-zero targets

On the basis of the analysis conducted in this paper, the following initial recommendations are provided for companies seeking to set and implement robust net-zero targets. These recommendations will be followed by development of more detailed guidance and criteria that the SBTi will develop using an inclusive and transparent multi-stakeholder process:

1. **Boundary:** A company's net-zero target should cover all material sources of GHG emissions within its value chain.
2. **Transparency:** Companies should be transparent about the sources of emissions included and excluded from the target boundary, the timeframe for achieving net-zero emissions, the amount of abatement and neutralization planned in reaching net-zero emissions, and any interim targets or milestones.
3. **Abatement:** Companies must aim to eliminate sources of emissions within its value-chain at a pace and scale consistent with mitigation pathways that limit warming to 1.5°C with no or limited overshoot. During a company's transition to net zero, compensation and neutralization measures may supplement, but not substitute, reducing value chain emissions in line with science. At the time that net zero is reached, emissions that are not feasible for society to abate may be neutralized with equivalent measure of CO₂ removals.
4. **Timeframe:** Companies should reach net-zero GHG emissions by no later than 2050. While earlier target years are encouraged, a more ambitious timeframe should not come at the expense of the level of abatement in the target.
5. **Accountability:** Long-term net-zero targets should be supported by interim science-based emission reduction targets to drive action within timeframes that are aligned with corporate planning and investment cycles and to ensure emission reductions that are consistent with Paris-aligned mitigation pathways.
6. **Neutralization:** Reaching net-zero emissions requires neutralizing a company's residual GHG emissions with an equivalent amount of carbon removals. An effective neutralization strategy involves removing carbon from the atmosphere and storing it for a long-enough period to fully neutralize the impact of any GHG that continues to be released into the atmosphere.
7. **Compensation:** While reaching a balance between emissions and removals is the end goal of a net-zero journey, companies should consider undertaking efforts to compensate unabated emissions in the transition to net-zero as a way to contribute to the global transition to net-zero.
8. **Mitigation hierarchy:** Companies should follow a mitigation hierarchy that prioritizes eliminating sources of emissions within the value chain of the company over compensation or neutralization measures. Land-based climate strategies should prioritize interventions that help preserve and enhance existing terrestrial carbon stocks, within and beyond the value chain of the company.
9. **Environmental and social safeguards:** Mitigation strategies should adhere to robust social and environmental principles, ensuring amongst others, protection and/or restoration of naturally occurring ecosystems, robust social safeguards, and protection of biodiversity, amongst others.
10. **Robustness:** Compensation and neutralization measures should: (a) ensure additionality, (b) have measures to assure permanence of the mitigation outcomes, (c) address leakage and (d) avoid double-counting.

5.2 AREAS FOR FUTURE DEVELOPMENT

Following publication of this paper, the SBTi intends to develop the following outputs following a robust and transparent process:

- **Criteria** for the formulation of science-based net-zero targets in the corporate sector;
- **A validation protocol** to assess net-zero targets against the set of criteria to be developed as part of this process;
- **Detailed guidance** for science-based net-zero target setting in the corporate sector, including guidance for **credible claims**.

To support the next phase of this process, further research and consultation is planned to address some of the key technical questions, including:

- **Understanding suitable residual emissions for different sectors of the economy:** At the sector or activity level, how much emissions abatement is needed, and which emissions sources are infeasible to abate in scenarios that limit warming to 1.5°C?
- **Interim targets:** What are credible transition pathways that are consistent with limiting warming to 1.5°C, and how should the use of transition pathways differ by emissions scope for each company?
- **Neutralization mechanisms:** What factors need to be considered to effectively counterbalance the impact of a source of emissions that remains unabated?
- **Compensation mechanisms:** What are effective mechanisms through which companies can accelerate the transition to net-zero beyond their value chain? What factors should be considered in deploying compensation tactics?
- **Claims:** What are the conditions that a company needs to meet to claim that they have reached net-zero emissions?

GLOSSARY

Afforestation/reforestation (AR): Planting of forests on lands that have not historically contained forests or that have previously contained forests. AR is commonly depicted as the largest contributor to land-use related carbon sequestration;

Bioenergy: Energy produced by biomass. In many cases, bioenergy is considered "carbon neutral" because combustion-related CO₂ emissions are ideally balanced by CO₂ that is sequestered by biomass feedstock;

Bio-geophysical effects: Effects which influence climate as a result of biological changes to the physical properties of Earth (i.e. land use change) (Betts et al. 2007)

Carbon credit: An emissions unit that is issued by a carbon crediting program and represents an emission reduction or removal of greenhouse gases. Carbon credits are uniquely serialized, issued, tracked, and cancelled by means of an electronic registry. (Schneider et al. 2020)

Climate forcers: atmospheric compounds (e.g. GHG such as CO₂, CH₄, etc) or bio-geophysical attributes (e.g. albedo) that impact climate, primarily by affecting Earth's energy balance

Carbon dioxide removal (CDR): The IPCC defines CDR as "anthropogenic activities removing CO₂ from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products."

Climate-related transition risk: Risks related to the transition to a lower-carbon economy. These may entail extensive policy, legal, technology, and market changes to mitigate or to adapt to climate change

Compensate: "measurable climate mitigation outcomes, resulting from actions outside of the value-chain of a company that compensate for emissions that remain unabated within the value-chain of a company" (Ekstrom et al. 2015)

Corporate climate targets: goals set by a corporation to reduce the corporation's impact on the climate. Targets may include a variety of climate forcers across different corporate activities (i.e. operations, value chain, or products) and may use emissions abatement, compensation, or neutralization.

Decarbonization: measures that prevent the release of CO₂ emissions associated with electricity, industry and transport

Fifth Assessment Report (AR5): The fifth report from the United Nations Intergovernmental Panel on Climate Change (IPCC) on the state of the science of climate change. AR5 includes three working group reports: The Physical Science Basis; Impacts, Adaptation, and Vulnerability; Mitigation of Climate Change (IPCC, 2014).

Global emissions budget: a threshold set by scientists for total accumulated emissions to avoid a particular level of temperature increase such as 1.5°C.

Global mean temperature change: the change in global average surface temperatures due to anthropogenic emissions

Global warming potential: how much heat a greenhouse gas traps over a specified period of time measured relative to carbon dioxide

Greenhouse gases (GHGs): a gas which absorbs and re-emits infrared radiation, thereby trapping it in Earth's atmosphere. Includes carbon dioxide, methane, water vapor, nitrous oxide, and ozone.

GHG emissions reduction targets: goals set by an organization or political actor, which aim to reduce the organization or political actor's direct or indirect emissions by a specified amount.

Insetting: when a company offsets the emissions or other environmental/social impact of a company within its own supply chain (Smedley, 2015)

Intergovernmental Panel on Climate Change (IPCC): United Nations body for assessing the science related to climate change;

IPCC Special Report on 1.5°C (SR15): A Special Report requested by the United Nations on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. The report includes over 6,000 scientific references and was prepared by 91 authors from 40 countries;

Mitigation outcomes: the tangible results of climate mitigation efforts such as decarbonization, conservation of biogenic carbon stocks, carbon finance, or avoided emissions.

Mitigation strategy: corporate strategies for reducing their impact on climate

Mitigation tactics: the mechanism by which a corporation reduces its impact on the climate or contributes to societal transition to net-zero. These include: abatement, neutralization, and compensation

Nationally Determined Contributions (NDCs): climate mitigation and adaptation targets set by countries as part of the Paris Agreement developed at COP21 in 2015. NDCs constitute a commitment by each country to outline their climate plan post-2020 (UNFCCC, 2020).

Nature-based solutions: defined by the Nature-based Solutions Initiative as "actions that work with and enhance nature to help address societal challenges" (Nature-based Solutions Initiative, 2020).

Negative emissions: see carbon dioxide removals

Neutralise: defined by the Oxford English Dictionary as "making (something) ineffective by applying an opposite force or effect." With respect to halting the accumulation of emissions in the atmosphere, neutralisation of unabated emissions can only occur through negative emissions.

Carbon offset: see carbon credit

Residual emissions: GHG emissions that remain unabated in scenarios that limit warming to 1.5°C with low/no overshoot.

Science Based Targets: Targets that are in line with what the latest climate science says is necessary to meet the goals of the Paris Agreement – to limit global warming to well-below 2°C above pre-industrial levels and pursue efforts to limit warming to 1.5°C

Sustainable Development Goals (SDGs): "The 17 global goals for development for all countries established by the United Nations through a participatory process and elaborated in the 2030 Agenda for Sustainable Development, including ending poverty and hunger; ensuring health and well-being, education, gender equality, clean water and energy, and decent work; building and ensuring resilient and sustainable infrastructure, cities and consumption; reducing inequalities; protecting land and water ecosystems; promoting peace, justice and partnerships; and taking urgent action on climate change (Masson-Delmotte, et al., 2018);"

Value chain emissions: A company's scope 1, 2, and 3 emissions as defined by the GHG Protocol accounting standard.

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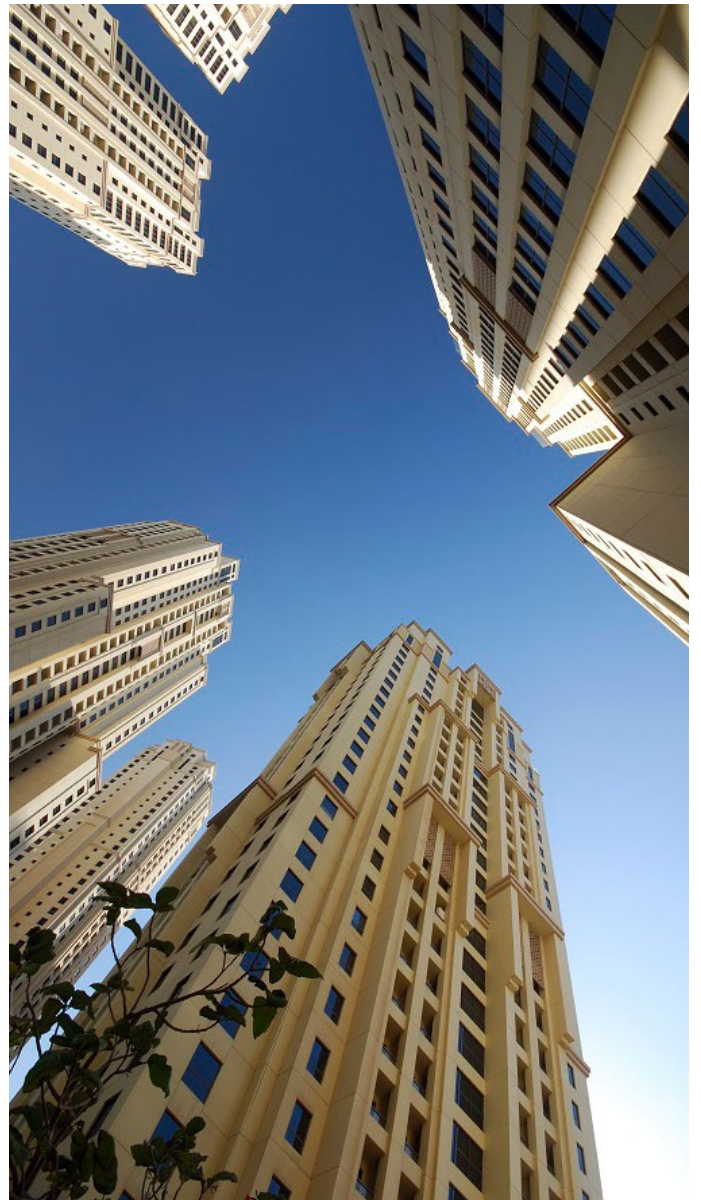
ANNEX 1: SUMMARY OF PUBLIC STAKEHOLDER CONSULTATION

Introduction

In early November 2019, the SBTi shared the working paper "Towards a Science-Based Approach to Climate Neutrality in the Corporate Sector" and hosted two public webinars introducing the SBTi's principles to inform corporate net-zero targets. More than 500 participants attended and were invited to share feedback on the following topics in a follow-up survey:

1. Principles to guide climate neutrality in the corporate sector
2. Working definition of net-zero for corporations
3. The value of a net-zero target-setting framework and ability to make claims
4. The role of CO₂ removals
5. CO₂ removals outside the corporate value chain
6. Ambition of interim GHG emissions reduction targets

The SBTi received more than 80 written responses and recorded a variety of perspectives obtained via follow-up meetings with representatives from companies, NGOs, and accreditors. The results are summarized here, and key points of feedback that have improved the outcome of our work are identified.

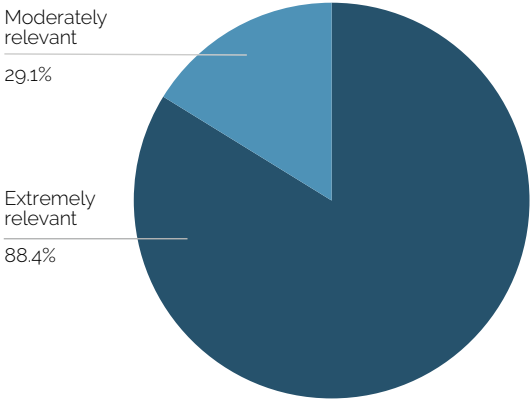


Summary of feedback

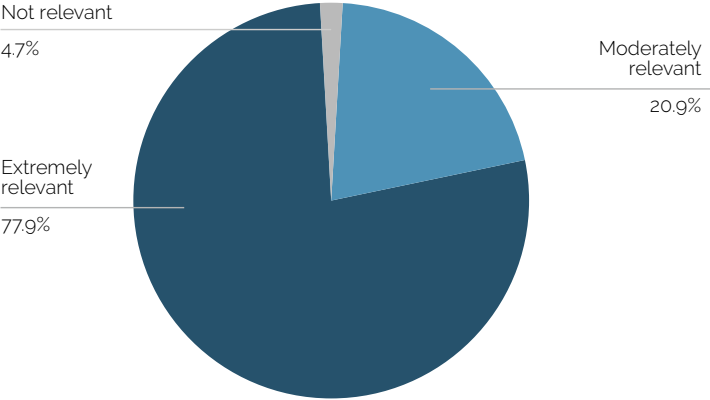
1. Respondents overwhelmingly agreed with Principles 1 and 2, but there was mixed agreement on Principles 3 and 4. A large number of respondents suggested clarifying the implicit boundary of Principle 1: "business model of a company" was considered to be too vague. Additionally, some respondents could not clearly understand the difference between principles, and some respondents suggested that the climate-related transition risks faced by a company (Principle 3) might be dependent on

factors outside the company's control. In the open-ended response, a number of respondents urged the SBTi to specify maximizing the "social benefits," "co-benefits," and "SDG alignment" of climate action; and others suggested that the principles should more clearly indicate optimizing the overall impact of corporate climate mitigation strategies (e.g., more carefully consider mitigation hierarchy and how companies may contribute to system transformation including demand side engagement and/or avoided emissions, which are in some cases more urgent than investment in removals).

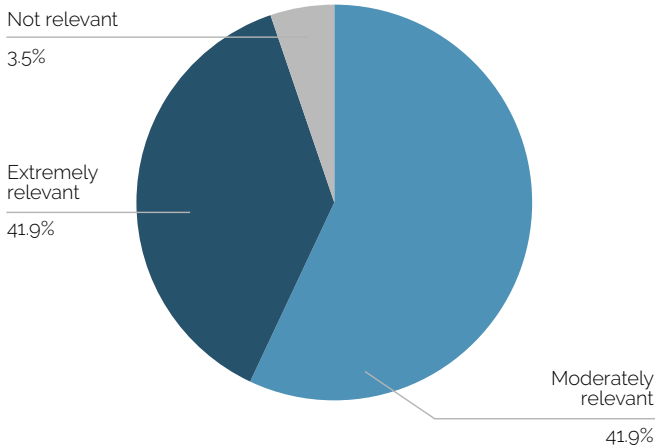
Principle 1: no net impact on climate (physical dimension)



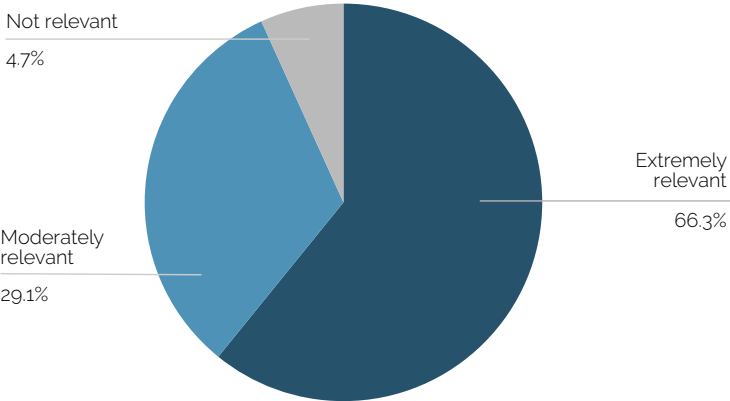
Principle 2: in-line with 1.5C mitigation pathways (societal risk dimensions)



Principle 3: mitigation climate-related transition risks to company (transformation)

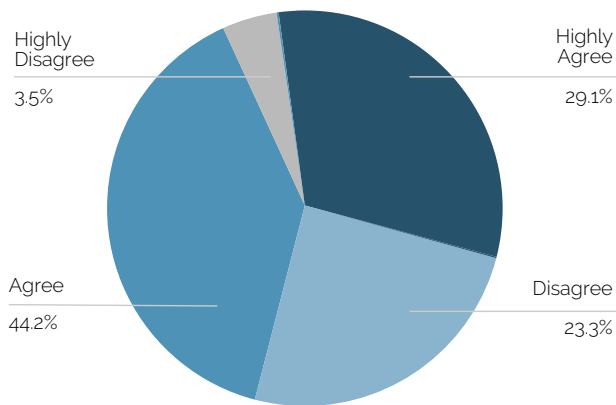


Principle 4: should inform strategies & investment for company (transformation)



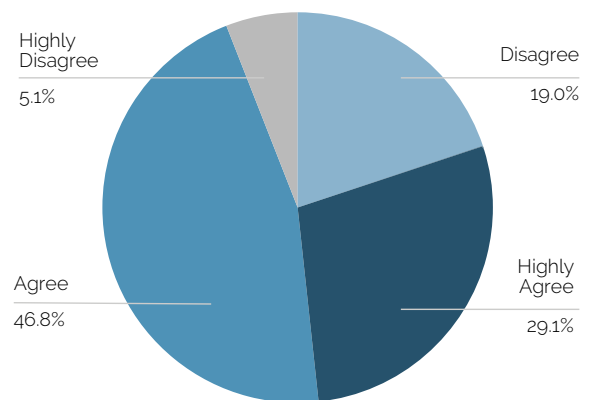
2. About three-quarters of respondents indicated high agreement or agreement with the working definition. The respondents that indicated disagreement urged the SBTi to produce a definition that includes verified emissions reductions (VERs), or avoided emissions, outside the value chain of the company;

Do you agree with this working definition?



Three-quarters of respondents indicated that interim targets on Scopes 1+2 should be 1.5C-aligned and 40-50% of respondents indicated the same for targets on Scope 3. The other 50-60% of respondents suggested that the ambition of Scope 3 targets should be more flexible.

The role of removals



3. Most attendees see value in having a net-zero framework that is compatible with SBTs. There was relatively widespread support for allowing companies that have balanced unmitigated emissions with removals to make some claim to incentivize an immediate scale-up of removals; however, others stressed that neutrality claims should only be recognized in targets that fully satisfy emissions abatement criteria.
4. Three-quarters of respondents highly agreed or agreed with the proposed "role of removals." Respondents in agreement with the proposal voiced support for a continued emphasis on near-term reductions that minimize delayed action, as well as issues and unknowns associated with CDR.

5. Three-quarters of respondents preferred not limiting the source of removals, while one-quarter preferred limiting removals to the company's value chain. A few respondents suggested that removals outside the value chain should only be allowed if removals inside the value chain are not viable, which could be determined based on sector-specific guidance. Some respondents prefer for VERs to be interchangeable with CO2 removals.
6. Respondents in disagreement suggested that a tiered approach to decarbonization and removals threatens to under-develop critical markets and opportunities to scale CDR or increase flexibility for companies to pursue any cost-effective option.

Summary of associated revisions

1. All of the principles have been clarified to address feedback. Principles 3 and 4 were combined to simplify the SBTi's assessment of mitigation strategies and avoid redundancy. The emissions boundary associated with Principle 1 was changed from the "business model of a company" to a company's "value chain." Principle 2 expresses a clear preference for transition pathways that support achieving the Sustainable Development Goals.
2. The SBTi has retained its stance that value chain emissions abatement is central to a credible net zero strategy, but has made changes to its assessment of mitigation strategies that better recognize the importance of VERs, carbon credits, and activities that accelerate climate change mitigation outside a company's value chain.
3. The relationship between science based targets (SBTs) and net zero targets, as well as the SBTi's intended scope of work, has been clarified.
4. The addition of a "climate positive" mitigation strategy, which couples emissions abatement with neutralization and compensation before companies reach net zero, demonstrates that scaling up CO₂ removal is possible without weakening the ambition of value chain emissions abatement.
5. CO₂ removals are considered valid inside or outside the value chain, and the revised paper addresses neutralization and compensation, in particular avoided deforestation, with increased clarity and urgency. Future work will examine measures in each category and provide guidance to help companies decide on neutralization and compensation activities in the transition to net zero.
6. The preferred approach in the Net Zero Foundations report is a climate positive approach, where emissions abatement measures are coupled with neutralization and compensation measures. Such an approach serves as a continued commitment to the development of carbon removal technologies while maintaining that rapid abatement is the best mitigation tactic to ensure alignment with 1.5°C pathways.
7. Future work will address how net zero criteria intersect with GHG accounting practices such as differentiated emissions reporting across scopes, as well as sector and activity-specific considerations.

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ANNEX 2: SUPPLEMENTARY DISCUSSION

Supplementary Discussion 1: Mitigation outcomes in global mitigation pathways

There is a large number of possible pathways to reach net-zero emissions at the global level and to deliver on the goals of the Paris Agreement. For its [Special Report on 1.5°C](#), the IPCC assessed over 220 pathways that keep warming below 2°C throughout the 21st century, including 90 scenarios that are consistent with limiting warming to 1.5°C at the end of the century.

While each of these pathways have different underlying assumptions and different implications for the climate, for society, and for nature, generally speaking, reaching net-zero emissions in all pathways involve measures that lead to the following outcomes:

Decarbonisation

CO₂ emissions are the largest anthropogenic climate forcer, accounting for over three quarters of anthropogenic GHG emissions in the period between 2007 and 2016 (IPCC SRCCL). 86% of anthropogenic CO₂ emissions result from the combustion of fossil fuels and other industrial processes (e.g. production of cement, steel and chemicals). Accordingly, decarbonisation refers to measures that prevent the release of CO₂ emissions associated with electricity, industry and transport. Decarbonisation is accomplished by either avoiding processes or activities that release CO₂ into the atmosphere (e.g. fossil fuel combustion and certain chemical reactions) or by capturing and safely storing CO₂ before it is released (e.g. carbon capture and storage).

Reduced deforestation and land-use change emissions

According to the IPCC 5th Assessment Report, land-use and land-use change emissions contributed about 14% of annual CO₂ emissions between 2002 and 2012. It has been determined with very high confidence that net CO₂ emissions from land-use and land-use change are mostly due to deforestation (Friedlingstein et al. 2019).

The drivers of deforestation are well understood, and halting forest loss is associated with plentiful co-benefits to biodiversity, water, and improved livelihoods. Moreover, transforming the land sector could contribute significantly to global mitigation needed by 2050 to limit warming to 1.5°C and reduce the need for costlier geologic CO₂ removal in the future.

Minimization of non-CO₂ emissions

For many sectors and companies, CO₂ emissions are the dominant climate forcer and therefore the focus of emissions abatement measures. However, for some sectors, non-CO₂ GHG emissions (e.g., methane associated with landfills, refrigeration gases and agriculture) are a significant source of climate impacts.

Considering the differences in global warming potential, atmospheric lifetime, and mitigation costs of CO₂ versus non-CO₂ GHG emissions, opportunities to minimize non-CO₂ emissions should not be ignored during the transition to net zero.

Permanent or short-lived CO₂ sequestration

Reaching net-zero globally can only occur if unabated emissions are balanced by CO₂ removal (CDR), halting the accumulation of GHGs in the atmosphere. As defined in the IPCC SR15, CDR consists of "anthropogenic activities removing CO₂ from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. [...]"

Afforestation, reforestation and forest restoration are some of the most common methods of removing CO₂ from the atmosphere. Among these options, restoring natural forests is by far the most effective way to do so (Lewis, 2019). Bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC) have also been identified as potential CDR options, which by contrast rely more on the development of emerging technologies and changes to the energy system. All neutralization options are associated with potential concerns related to permanence

of storage, which will need to be addressed by accounting frameworks, safeguards offered by providers of carbon removal solutions, and, in some instances, legal frameworks (Lin 2019).

While not the focus of this paper, it is important to note that some CDR options are opposed by communities most harmfully impacted by climate change and extractive industries. More than 110 civil society organizations – many of them representing indigenous peoples – support banning all forms of CCS and placing limits on land-intensive CDR proposals. Their statement cites potentially adverse effects on water and food availability, land rights, and Self Determination as primary concerns (Indigenous Environmental Network, Friends of the Earth International, La Via Campesina, Climate Justice Alliance, ETC Group, and Biofuelwatch 2018). Some of these concerns are shared by scientific researchers and political scholars (Lin 2019, Cox 2018).

Supplementary Discussion 2: Deforestation and land-use change emissions in company value chains

Over a quarter of permanent forest loss is due to land conversion for the production of agricultural commodities, such as beef, soy, palm oil, and wood fiber (Curtis et al., 2018). For many companies sourcing agricultural commodities, the majority of land use-related emissions lie outside their direct operations, as Scope 3 emissions. While Forest Trends (2020) has identified over 480 companies that have made commitments to address commodity-driven deforestation, much still remains to be done.

In an analysis conducted by CDP (2020), nearly 70% of high-impact forest-risk companies have failed to disclose critical information requested by shareholders or purchasing organizations, which has hindered performance and transparency. Furthermore, out of the companies that have made deforestation-free commitments, about a quarter

have reported no or limited progress on their commitments. Although tools have been available to support companies in achieving these commitments, a lack of standardized reporting methodologies and guidance has inhibited companies from accounting for land-use and land-use change emissions within their GHG inventories. Because such emissions are not commonly included within GHG inventories, they are also not commonly addressed sufficiently by corporate mitigation strategies.

Consequently, both the SBTi and the GHG Protocol are developing work that will enable companies to draw clear links between zero deforestation commitments, other land-based actions, and emissions reductions. Accordingly, companies are expected to improve their accounting of land-use and land-use change emissions and implementation of land-based mitigation response options. Strong synergies should be expected between reducing these emissions, achieving deforestation commitments, supporting biodiversity, and delivering other socioeconomic benefits



Supplementary Discussion 3: Common compensation measures in corporate climate change mitigation strategies

The following represents a discussion on compensation measures commonly used by companies in carbon neutrality or net-zero targets. The measures hereby describe current practice, rather than recommendations from the Science Based Targets initiative.

Avoided emissions through the use of sold products

The GHG protocol defines avoided emissions as emission reductions that occur outside of a product's life cycle or value chain, but as a result of the use of that product. Avoided emissions is a relative metric estimated by comparing the climate impacts of a given product, activity or service against the climate impacts of a reference product, activity or service.

It is a relatively common practice for companies to set targets, or to make claims, that involve balancing the emissions generated by the company with an equivalent amount of emissions that the company is avoiding through the use of the products or services that the company is commercialising.

Carbon finance

Climate mitigation activities, financed directly or through the purchase of carbon credits, can result in any of the physical mitigation outcomes represented in Figure 4. As per the taxonomy introduced earlier in this section,

financing of activities that remove carbon from the atmosphere would be classified as neutralization tactics, while financing of activities that avoid or reduce emissions would be classified as compensation. In some cases, activities can result in more than one mitigation outcome. When finance of climate mitigation activities adhere to robust quality criteria, they can contribute to the society's transition towards net-zero, either by reducing the volume of GHGs released into the atmosphere, or by helping remove carbon from the atmosphere. For instance, by financing measures that support countries in achieving Nationally Determined Contributions (NDCs), especially in the context of Reducing Emissions from Deforestation and Forest Degradation (REDD+), companies are effectively contributing to society's transition to net-zero and to meeting the Sustainable Development Goals.

In some cases, companies use carbon finance as a vehicle to abate emissions within their own value chain (e.g. a practice sometimes referred to as insetting). In these cases, the mitigation outcome occurs within the value chain of the company and therefore, should be captured as part of abatement efforts following adequate GHG accounting methods.

Carbon finance decisions need to be carefully assessed on an individual basis as they can produce both co-benefits and collateral impacts that can affect other sustainable development goals. Among the many markers of quality for carbon credits, additionality (i.e. that the mitigation activity would not have taken place in the absence of the added incentive created by the carbon credits) has historically been a unique quality criterion for this type of climate finance.

Supplementary Discussion 4: Challenges that negative emission measures face to effectively mitigate climate impacts

Some of the challenges associated with relying on the large-scale deployment of negative emission technologies as a substitute for reducing emissions include:

A. Timescale mismatch

When neutralizing unabated greenhouse gases, two factors are important to consider: the warming effect of the GHGs that remain unabated and the atmospheric lifetime of these gases. From a lifetime perspective, GHGs are usually classified into two main categories: long-lived climate pollutants (e.g. CO₂, N₂O, SF₆) and short-term climate pollutants (e.g. CH₄, HFC-134a, etc.). At the scale at which carbon dioxide is released into the atmosphere, it is estimated that the impact of CO₂ can persist for many millennia (Eby et al., 2009). Likewise the IPCC reports an atmospheric lifetime of over 100 years for nitrous oxide, and of thousands of years for some fluorinated compounds (e.g. SF₆, CF₄, etc.).

Similarly, carbon storage options can be classified into options that store carbon for short periods and others that explore carbon for longer periods. For instance, carbon stored in biomass used for energy purposes is generally considered a short-term storage option (although there are some exceptions), as carbon is released into the atmosphere as soon as the biomass is combusted.

Likewise, carbon stored in biomass used for paper and packaging production is estimated to be released into the atmosphere within less than 10 years. Carbon stored in bio-materials (e.g. furniture) is estimated to last a few decades and some harvested wood products (e.g., building materials) can store carbon for over 100 years.

Geological storage is generally considered a more permanent carbon storage option than terrestrial or ocean sequestration. The IPCC SR15 states that under certain conditions, upwards of 70% of carbon stored in geological sites can be retained for over 10,000 years. Yet, the IPCC also reports that permanence is subject to a number of "socio-economic and political factors, and there are parallels to questions of fossil-fuel reservoirs remaining in the ground".

B. Risk of reversal

Even if a carbon storage strategy is intended to store carbon for long periods, all carbon storage measures are subject to risks that could release the stored carbon back into the atmosphere. For instance, carbon sequestered in land is vulnerable to release either through human action (e.g. land clearing) or natural forces (e.g. drought, fire and pests). Leakage of CO₂ stored in oceans is also considered a significant risk, unless carbon is transformed into a stable chemical product. As described above, even geological carbon storage can be exposed to a number of physical conditions that could cause some of the carbon to be leaked back into the atmosphere (Herzog, 2011).

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ANNEX 3: SUPPLEMENTARY TABLES

Supplementary Table 1: IPCC definitions of climate neutrality-related terms

Term	Scope of climate forcers	Definition from IPCC SR15
Carbon neutrality (or net-zero CO ₂ emissions)	CO ₂ emissions	Net-zero CO ₂ emissions are achieved when anthropogenic CO ₂ emissions are balanced globally by anthropogenic CO ₂ removals over a specified period.
Net-zero emissions	All GHG emissions	Net-zero emissions are achieved when anthropogenic emissions of GHGs to the atmosphere are balanced by anthropogenic removals over a specified period. Where multiple GHGs are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, chosen time horizon, and others).
Climate neutrality	All GHG emissions, regional or local bio-geophysical effects of human activities, and, arguably, other radiative forcers.	The concept of climate neutrality refers to a state where human activities result in no net effect on the climate system. To achieve such a state, relevant bio-geophysical changes due to human activities (e.g., changes to earth's surface reflectivity or a regional water system) would need to be avoided and net-zero emissions would need to be achieved.

While the chosen examples are relatively clear about the scope of activities and scope of climate forcers covered, some other corporate climate targets are phrased such that the boundary is ambiguous or hard to understand.

Supplementary Table 2: Examples of different target boundaries for corporate neutrality targets

Scope of activities covered	Definition	Example
Geographical boundary	In this case, companies set a neutrality target for the activities undertaken in specific geographies.	Arcelormittal, the world's largest steel producer, has <u>committed</u> to achieve carbon neutrality in Europe by 2050.
Operations	It is common for companies to set a neutrality target covering all of their direct operations (usually including scope 1 and scope 2 emissions).	Industrial company Bosch, has <u>committed</u> to achieve carbon neutrality by 2020 for their global operations, including over 400 manufacturing, research and administrative facilities across the globe.
Others	Companies can also set neutrality targets for a specific site, product, product portfolio or other boundaries.	Daimler AG <u>aims</u> to reach carbon neutrality by 2039 for its car division (Mercedes-Benz Cars), including a new carbon neutral passenger car fleet.
Value-chain	Companies can also set neutrality targets for a specific site, product, product portfolio or other boundaries.	Volkswagen has <u>committed</u> to be a CO ₂ neutral company by 2050, including all production and vehicles.

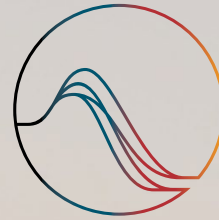
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