SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

SCIENCE BASED TARGETS IN THE CHEMICALS SECTOR: STATUS REPORT

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DISCLAIMER

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This report presents a summary of intended work to be completed but we cannot guarantee that all outcomes will be achieved as proposed, pending data availability and project funding. The data presented herein does not represent official criteria of the SBTi.

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OBJECTIVE

This report outlines the key research questions and objectives for the Science Based Targets initiative's (SBTi's) project to develop sector-specific guidance and target-setting criteria for the global chemicals sector. The report also summarizes the work performed by the SBTi to date, presents the opportunities and challenges facing chemical companies in setting emissions reduction targets, and provides background on the SBTi's general target-setting methods. Following this report, the SBTi will continue our stakeholder inclusive process to develop the sector-specific guidance, pathways and target-setting criteria described below. The SBTi will communicate key milestones publicly, and our sectoral webpage will be kept up to date on the project's status.

INTRODUCTION

SBTi Background

The SBTi mobilizes private sector companies to set science-based greenhouse gas (GHG) emissions reduction 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 corporate and financial institution science-based target (SBT) setting, offers resources and guidance to reduce barriers to adoption, and independently assesses and validates companies' targets. Setting a science-based target benefits companies by future-proofing growth, saving money, providing resilience against regulation, boosting investor confidence, and spurring innovation and competitiveness – while also demonstrating a concrete commitment to goals aligned with the Paris Agreement. Since its inception in 2015, the SBTi has shown tremendous growth. As of the end of 2022, companies representing over one-third of global market capitalization had approved science-based targets (SBTs) or commitments to set targets with the SBTi (SBTi, 2022a).

SBTi Target Setting Methods

The SBTi's target setting criteria requires companies to develop a comprehensive greenhouse gas (GHG) emissions inventory, and to set SBTs on their scope 1 and 2, and in some cases, scope 3 emissions (SBTi, 2021c). Companies have several options to set scope 1 and 2 targets: 1) the cross-sectoral method known as the absolute contraction approach (ACA), and 2) the sectoral decarbonization approach (SDA):

- The ACA is based on the expectation that all companies, regardless of their sector, reduce their absolute emissions by the same amount to align with the remaining global carbon budget associated with 1.5°C-aligned emissions scenarios. Companies that set targets using the ACA method must reduce absolute emissions linearly between the base year and target year, at a rate that meets or exceeds the minimum ambition level defined in SBTi's criteria.

- The SDA method is based on the concept that all companies within a homogeneous sector or subsector reduce their carbon emissions *intensity* (relative to a unit of activity, such as tons produced) towards a target convergence value by no later than 2050.

The SBTi develops guidance and/or criteria for sectors that it identifies as warranting specific resources. Once guidance is published, all companies within that sector must follow the sector-specific criteria when setting targets. With some exceptions[1], these companies are allowed to set targets using either the ACA or SDA methods but must also adhere to any applicable sector-specific criteria around GHG accounting, GHG inventory boundaries, and scope 3 target requirements.

In 2022 the SBTi published guidance and criteria for the forestry, land, and agriculture (FLAG) sector (SBTi, 2022b).[2] Companies operating within this sector must evaluate their eligibility under the criteria and set targets as outlined in the guidance. In some cases, companies may be impacted by more than one set of criteria depending on the reach of their value chains. For example, companies that produce synthetic fertilizers will be covered by the chemicals sector guidance from this project; however, they may also be subject to the FLAG guidance due to the scope 3 use-phase emissions of their product in the agricultural sector.

In October 2021, the SBTi published its first Net-Zero Standard to provide a standardized and robust approach for corporates to set net-zero targets that are aligned with climate science (SBTi, 2021b). All guidance, pathways, and criteria produced as part of the Chemicals Sector Development Project will be consistent with the Net-Zero Standard. More specifically, all SDA pathways published for the chemicals industry will be consistent with the SBTi's Pathways to Net-Zero paper that the SBTi developed to inform the Net-Zero Standard (SBTi, 2021a). The Pathways to Net-Zero paper established the sector-specific carbon budgets needed to maintain consistency and alignment with the global carbon budget across the SBTi's various sector SDA pathways.

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[1] For certain sectors, such as the Power sector, the sector-specific pathway is more ambitious than the ACA pathway (i.e., the sector is expected to decarbonize faster than the economy as a whole). In these circumstances, the SBTi requires companies in these sectors to set targets using the sector pathway.

[2] The FLAG sector addresses emissions/removals due to sources associated with land use change (e.g., deforestation and conversion of natural lands to agriculture) and land management (e.g., enteric CH_4 emissions, emissions from farm machinery, emissions from fertilizer use, etc.).

Chemicals Sector Development Project

The global chemicals sector has a critical role to play in the global transition towards net-zero carbon emissions. The sector's complex and heterogeneous product value chains involve nearly every segment of the economy, such as energy, transportation, the built environment, consumer goods, and agriculture. In addition, the production of chemicals is one of the leading industrial sources of carbon dioxide (CO_2) emissions, ranking third in total emissions in the industrial sector behind cement and iron and steel manufacturing (IEA 2021b). What's more, the chemicals industry is the largest industrial consumer of energy products worldwide, due its reliance on energy (i.e., hydrocarbon) products as the feedstock to many processes in addition to its use of these products to produce energy directly (IEA, 2020). For these reasons, the rapid decarbonization of the chemicals sector, and its far-reaching value chains, is crucial if the world is to achieve the goals of the Paris Agreement. Annex 1 gives an overview of the global chemical industry's current estimated scope 1, scope 2 and scope 3 emissions.

The SBTi requires companies to establish ambitious near-term SBTs (target periods of 5-10 years) because emissions pathways aligned with a 1.5°C level of ambition require deep and immediate reductions in emissions across all sectors (IPCC, 2018. Section C1). Therefore, the time is now for companies in the chemicals sector to set SBTs and to take actions to reduce emissions from their operations. These efforts will not come without significant challenges. The sector's key base products are produced using energy intensive processes with fossil-based feedstocks, and many of the technologies required to eliminate carbon emissions from these processes are not in widespread commercial use. Further, the demand for products produced by the sector is expected to increase in the coming decades, in part to support new technologies and decarbonization efforts in other industries. The sector's expected growth presents challenges, but also opportunities to implement low-carbon processes and products to meet the new demand. It is critical that new investments be made in line with clear goals towards carbon emissions reductions over all three scopes, to avoid the risk of stranding assets early in their operational lives. Since the lead time to bring new plants or technologies online can often be many years, it is more crucial than ever that companies immediately establish their strategies for reducing carbon emissions across their value chains.

At this time, it is important to address the full chemicals sector concurrently, rather than developing tools for certain products individually. As described above, the SBTi target-setting methods rely on established sectoral carbon budgets and rely on publicly available emissions scenarios which typically consider the chemicals sector as whole. There will be inherent trade-offs between products within the industry when considering future technology and emissions scenarios. By evaluating the entire sector together, we can contemplate the interactions between major chemical value chains in future scenarios and ensure consistency with the sectoral carbon budget.

Through the Chemicals Sector Development Project, the SBTi will develop sector-specific guidance and SBT-setting tools for the chemicals industry, including sectoral decarbonization approach (SDA) pathways and criteria for setting scope 3 targets. The SBTi has convened an expert advisory group (EAG) consisting of subject matter experts from industry, academia, and civil society to help inform and advise on the work. The initial scoping phase of the project was completed in 2020 (SBTi, 2020), during which the SBTi analysed key barriers to chemical companies setting SBTs and identified areas in which the SBTi may mitigate these barriers.

The basic goals of the project have not changed since the SBTi Chemicals Scoping Report was published. In this report, the SBTi will revisit the conclusions from the initial scoping phase in the context of advances in climate science and technology over the past 2 years. This report will also confirm the goals for the Chemicals Sector Development Project and lay the foundation for the work to come.

Chemical Companies in the SBTi

While the SBTi is developing guidance for the industry, chemical companies may set SBTs using the ACA and SBTi's general target-setting criteria. In fact, over 100 chemical companies have either set a target or committed to setting a target with the SBTi as of October 2022.

Once guidance for the chemicals sector has been finalized, it will become applicable to chemical companies following a grace period. It is not expected that companies with validated targets and companies with targets in the validation pipeline when the guidance is published would be required to resubmit their targets to align with the new guidance. However, the guidance will become applicable should the company revise their target, or when the target becomes due for review and revision per SBTi's criteria.

STATUS OF THE CHEMICALS SECTOR

Chemical Sector Introduction

The chemicals sector has one of the most complex and diverse value chains of all sectors in the global economy. Products from the chemicals sector are critical to nearly every aspect of modern life. These products vary from bulk industrial chemicals such as ammonia, to highly specialized pharmaceuticals and laboratory reagents. The health care, agriculture, construction, manufacturing, and transport industries all rely heavily on chemical products. In 2017, direct contributions from the chemicals sector were estimated to be $1.1 trillion in gross value added (GVA), which represented more than 1% of global gross domestic product (GDP) (Oxford Economics, 2019). What's more, demand for chemicals is expected to continue to grow in the decades to come (IEA, 2020).

Defining the boundaries of the chemicals sector is critical to this project and is discussed more in the next section. In general, the chemicals value chain begins with feedstocks that provide the key elements in chemicals' production: carbon, hydrogen, and oxygen. Other critical elements such as nitrogen, sulphur, chlorine, and phosphorus are also introduced at various production points depending on the chemical being produced. Today, most of the sector's carbon and hydrogen come from fossil-based feedstocks, in the form of direct fossil fuels (e.g., coal, natural gas, natural gas liquids) or as products of crude oil refineries (e.g., naphtha). For this reason, the chemicals industry is the largest industrial consumer of energy in the world when both feedstocks and fuel consumption are considered (IEA, 2020). Alternative feedstocks, such as bio-based materials, recycled materials and captured CO_2 can also be used to replace fossil-based sources. These options are discussed more below as well.

Much of the chemicals value chain starts with the production of ammonia, methanol, ethylene, propylene, benzene, toluene, and mixed xylenes (the latter five known as high value chemicals, or HVCs)[3]. This is visualized below in the "Chemical Sector Boundary" section. These seven building blocks will be referred to as "primary chemicals" for the purposes of this report, consistent with the International Energy Agency's (IEA's) modelling of individual chemicals (IEA, 2022c). Production of primary chemicals involve energy-intensive processes, requiring large amounts of heat currently produced primarily through the combustion of fossil fuels. Next to the emissions related to the combustion of fuels, process emissions are also generated when there is a difference in carbon content between feedstocks and products (with the excess carbon often combusted as a fuel or emitted directly as CO_2)[4]. Primary chemical production accounted for approximately two-thirds of all direct (scope 1) CO_2 emissions from the industry as a whole (IEA, 2021a). Primary chemicals are further utilized to generate hundreds of intermediate products, which are themselves used to produce thousands of additional products. The chemicals value chain is not linear in nature, with many overlapping and intersecting material paths. An interconnected intermediate product trade between geographic regions and with other industry sectors further complicates matters. This interconnectivity and interdependence between major products imply that we must consider the chemicals sector as whole, even if individual guidance and target setting methods are established for different products and for scope 3 emissions hot spots.

Efforts to reduce GHG emissions in the sector must emphasize the reduction of direct CO_2 emissions from primary chemical production, but also:

- **Indirect impacts in the form of scope 2 emissions from the generation of purchased electricity or heat**. These emissions will become more significant as new technologies are implemented to allow the electrification of energy-intensive processes. Additionally, certain processes, such as the chlor-alkali process, require large amounts of electricity even with

[3] Ethylene and propylene are part of a broader group of organic chemicals called "olefins". Benzene, toluene, and xylenes (commonly known as BTX) are part of a group call "aromatics".
[4] Non-CO_2 GHG emissions (like for example N_2O) are also generated as process emissions.

current technologies. Scope 2 emissions must be considered alongside scope 1 emissions when setting SBTs.

- **Indirect value chain (scope 3) emissions**. Scope 3 emissions in the chemicals industry are as important as they are complex. Downstream producers of intermediate and final products must consider the scope 1 and 2 emissions from primary chemical suppliers within their scope 3 boundary. Additionally, the carbon embedded in most chemical products is typically emitted further down the chain, either during the use phase (e.g., CO_2 emissions from urea-based fertilizer application) or at the end-of-life via incineration or decomposition. The upstream emissions associated with the extraction and production of the fossil-based feedstocks and fuels, and their alternatives are just as critical.
- **Emissions of non-CO_2 GHGs.** CO_2 is not the only GHG emitted within the chemicals value chain. Fugitive emissions of methane occur during the production and transport of feedstocks and fuels (coal, naphtha, natural gas and natural gas liquids) and can also occur within the operational boundary of chemical companies. Nitrous oxide (N_2O) is emitted during the production, and after the application of N-fertilizers in agriculture. Additionally, chemical companies also produce non-CO_2 GHG gases as products, such as hydrofluorocarbons (HFCs) for use in refrigeration/air-conditioning applications, which can be emitted during the production and use phases.

The following sections discuss the key questions that the SBTi will address as part of this project, considering the chemicals sector's inherent complexity, major sources of emissions both within and external to the value chain, and priorities to ensure companies have the proper guidance to commit to 1.5°C-aligned emissions reduction targets.

Sectoral Challenges and Barriers in Setting SBTs

The SBTi Chemicals Scoping Report summarized the ongoing sector challenges as:

1) Where are the boundaries of the chemicals sector?
2) Given its heterogeneity, how can the sector be disaggregated meaningfully and effectively?
3) How should companies address scope 1 and 2 emissions linked with energy use, externally produced heat, self-generation of electricity, combined heat, and power (CHP), process emissions, and fugitive emissions?
4) How should companies measure and address their scope 3 emissions linked with data availability and end-of-life (EOL) treatment of sold products emissions?
5) How should companies deal with (differences in) value chain integration (e.g., some companies owning crackers and polymer plants, and other companies only operating one of the two)?

6) How should companies deal with non-CO_2 greenhouse gas emissions?

These six questions are addressed in greater detail below. Where appropriate, these are linked with relevant decarbonization levers presented in the text boxes.

Note on decarbonization levers in text boxes in this section
To reach net-zero, the chemicals industry must adopt numerous, fundamental technological and operational changes. In this section we briefly summarize some of the current low-carbon opportunities within the sector. **These technologies are presented for context only and do not represent an endorsement or expectation from the SBTi of adopting a specific technology roadmap.**

Q1: Where are the boundaries of the chemicals sector?

In principle the scope of the chemicals sector was identified in the SBTi Chemicals Scoping Report. Since its publication, the IEA has published its Net-Zero Emissions by 2050 (NZE) Scenario, which has been a key input in the determination of the SBTi sector pathways. The scoping report however further indicates that there is still work to do to:

- Establish the dividing line between “oil and gas” and the “chemicals” sectors.
- Understand the implications for pharmaceutical companies of including the pharmaceuticals sector in the chemical sector.
- Due to the increased importance of the circular economy development, the boundary between chemical industry and waste industry in chemical and mechanical recycling technologies needs to be decided.
- Consider development of intensity pathways for the production of chemicals sector feedstocks including naphtha, ethane, and methane to inform scope 3, category 1 targets for companies in the chemicals sector.

Q2: Given its heterogeneity, how can the sector be disaggregated meaningfully and effectively?

The chemical industry is heterogeneous by nature. The SBTi Chemicals Scoping Report recommended subdividing the chemicals sector into several products, at a minimum HVCs, ammonia, methanol, and potentially merchant hydrogen, and to provide physical intensity pathways for these if the available data allows. This choice of products covers:

- The majority of scope 1 emissions, and the start of most chemical value chains.
- A significant share of the sector's process emissions.

Low and zero-carbon hydrogen
The production of hydrogen as an input for ammonia and methanol is currently a major source of CO_2 emissions in the industry. The most common production route for hydrogen is steam methane reforming, which primarily generates hydrogen and CO_2. The hydrogen is separated and in most cases the CO_2 is emitted to the atmosphere.[5] It is possible to capture and sequester/reuse the CO_2 that is emitted from this process (so called "blue hydrogen"); however, this does not address upstream emissions from, for example, natural gas extraction and products, and CO_2 capture rates achieved are not always 100%. What's more, permanent sequestration of captured CO_2 requires significant infrastructure and viable options for permanent storage. Hydrogen can also be produced via electrolysis of water. When renewable electricity is used to power electrolysis, this is known as "green hydrogen" production. Green hydrogen has the potential to produce hydrogen with no direct CO_2 emissions; however, it requires very large quantities of reliable renewable electricity. Other (innovative) production routes to hydrogen, such as production of hydrogen based on biomass, are under development as well.

Q3: How should companies address scope 1 and 2 emissions linked with energy use, externally produced heat, self-generation of electricity, combined heat, and power (CHP), process emissions, and fugitive emissions?

Scope 1 and 2 emissions are often seen in conjunction, with scope 1 emissions (currently) being largest for the chemical sector.

A survey presented in the SBTi Chemicals Scoping Report raised a few chemicals-specific topics on scope 1:

- On **process emissions:** The majority of the respondents of the 2020 survey felt there could be reasons to treat process emissions differently in target setting.

[5] This process is commonly referred to as "grey hydrogen".

- On **fugitive emissions**[6]**:** Less than 50% of the respondents knew the fugitive emissions from their installations fully – currently their relevance for the overall scope 1 emissions is not clear.

Carbon capture and utilization/sequestration (CCU/S)

As described above, CO_2 can be captured from emissions sources and permanently stored via geologic sequestration. In addition to capturing CO_2 from hydrogen production, combustion emissions, such as those from heat generation or from end-of-life incineration of waste products, are also candidates for CCS. CCS is a major decarbonization lever in other industries as well.

Another route for the captured carbon is for reuse as a raw material and carbon source in (primary) chemical production (CCU). This may include carbon captured within the chemicals value chain, or from other emissions-intensive industries (e.g., cement production).

CO_2 sourced via direct air capture (DAC) from the atmosphere may also be used as a carbon source to the chemicals value chain. Carbon from DAC has the advantage of avoiding any upstream emissions associated with captured industrial or energy sourced fossil CO_2.

The SBTi Chemicals Scoping Report noted the expected increase of the sector's electricity use (from electrification) needs to be integrated in the overall scope 1 and 2 target setting. Further, many chemical companies generate (part of) their electricity themselves, often in a CHP installation, complicating interpretation of the sector's energy use and emission data. Some chemical companies also import, or export, electricity and/or heat.

Electrification

Replacing any heat energy currently supplied through fossil fuel combustion with renewable electricity would eliminate the associated direct energy-related GHG emissions however, some of the process emissions would remain. For example, projects are underway to prove the viability of electrified steam cracker furnaces in the production of olefins. Electric boilers for providing plant steam and hot water are possible, and electric heat pumps can do the same (up to certain temperatures) while increasing the energy efficiency. Such measures should be coupled with efforts to increase energy efficiency and must also be powered by renewable electricity so the emissions are not simply shifted to the power sector.

[6] Fugitive emissions are those that occur from sources other than stacks or direct process sources. Examples of fugitive emissions are leaks from equipment and piping, or emissions that occur due to cleaning or repair operations that cannot be reasonably captured. Process emissions have been defined in the "Chemical Sector Introduction" section above.

Q4: How should companies measure and address their scope 3 emissions linked with data availability and end-of-life (EOL) treatment of sold products emissions?

The diversity and wide use of products across numerous sectors' supply chains makes scope 3 data gathering an intensive and complex task. Data availability and quality thus vary across scope 3 categories and are especially limited in categories without expenditure information, such as end-of-life-related emissions. According to the SBTi Chemicals Scoping Report, many chemical companies don't fully know what happens to their products at the end of their life. Our current EAG has confirmed that the available data on scope 3 emissions from the chemicals sector continues to be limited, although efforts are underway in certain regions to improve data availability. Scope 3 emissions are typically calculated based on several types of sources, like:

- Primary sources come directly from suppliers or customers and are, when relating to the specific product, generally considered the most accurate.
- Life cycle assessment (LCA) databases, and similar sources, provide emission factors per unit of purchased or sold goods based on averaged or extrapolated data on a mass or volume basis.
- Lastly, input-output based approaches rely on estimates of emissions based on total spend (per $ or per € for example).

There is a need for guidance on where primary vs average data can be used, in relation to the materiality of the emissions and the desire of the company to measure improvements (hybrid approach, improving data quality over time). Making relevant data available in a centralized and automated manner, for example, by building on LCA and benchmarking information could help as well. More information of key scope 3 categories can be found in Annex 3.

Specifically, it would help to clarify:

- Increased requirements on downstream emissions reporting and targets, and consistent treatment of end-of-life and purchased goods and services emissions for recycled, bio-based and captured carbon-based materials.
- Whether (and in which cases) to make inclusion of end-of-life emissions in the target boundaries and/or a circular/renewable feedstock targets mandatory. If so, whether this target could be met with an end-of-life approach and/or with a circular materials or end-of-life target approach.
- When to classify products as "durable," or which typical plastic/chemical products/product groups are "durable" (as this impacts the scope 3, category 12 emissions).

- How the guidance should be applied (and how to properly account for emissions) for cases of bio-based chemicals, recycling (mechanical and various forms of chemical recycling), CCU, and electrification, especially for scope 3, category 12 emissions.
- The guidance for (chemical) recycling should consider an adequate comparison of value chains, for example comparing:
    - Crude oil → naphtha → HVC[7],
    - Waste → pyrolysis oil → HVC, and
    - Biomass → syngas → synthetic naphtha or methanol → HVC

Material circularity (reuse and recycling)
Reducing product demand, reusing products, and recycling material back into the value chain can help reduce GHG emissions by reducing the demand for virgin, fossil-based raw materials. Material circularity that occurs downstream in the value chain can also reduce the demand for primary chemicals altogether. A challenge around reuse and recycling is the indirect influence chemical companies have on the downstream fate of their products. Recycling can occur in several areas in the value chain, via several routes. The first is the recycling of waste materials that are generated during intermediate and final product production (pre-consumer recycling). These materials can typically be recycled back as raw materials to the process that created them. Post-consumer recycling occurs at the end-of-life stage of a product, most commonly for plastic products. Plastics can be recycled via **mechanical recycling**, in which the polymeric materials are not chemically altered, but are returned to a physical state in which they can be used in new products. However, mechanical recycling can currently lead to "downcycling" to products that require a lower grade of plastic, due to degradation of the material during the recycling process. Plastics can also be **chemically recycled**, in which they are returned to a monomeric state, or to even more basic raw materials. These recycled materials can be used as feedstocks further upstream in the value chain. Chemical recycling can result in materials that are indistinguishable from their virgin counterparts; however, the recycling processes are not yet in widespread use, and they can be energy intensive and GHG emissions associated with the recycling process may offset part of the reductions from replacing virgin material.

[7] For these comparisons, "HVC" should be read as "HVC and downstream products".

Bio-based materials

Bio-based feedstocks can replace virgin fossil-based feedstocks. Some bio-based routes to produce the key primary chemicals are[8]:

- Hydrogen / Methanol / Ammonia:
  - Gasification of biomass.
  - Use of biomethane in steam methane reforming (SMR).
- Ethylene:
  - Conversion of biomass to ethanol → dehydrate towards ethylene.
- High Value Chemicals.
  - Bio-methanol (see above) to Olefins / Aromatics.
  - Replacing virgin naphtha by bio-naphtha.

Alternatively, many intermediate or end products can be replaced by new molecules with a different structure but the same functionality that can be more easily produced from biomass.

While bio-based products have the advantage of replacing fossil-based carbon in the chemicals value chain, there are still GHG emissions impacts that must be considered. There may be land use change impacts and impacts from fertilizer use from the growing of the raw materials for bio-feedstocks, and the conversion of such raw materials into usable bio-based products requires energy input as well. Lastly, potential impacts to biodiversity are possible arising from the associated land use change.

Q5: How should companies deal with (differences in) value chain integration (e.g., some companies owning crackers and polymer plants, and other companies only operating one of the two)?

The value chains in the chemical sector often cover several intermediate steps. Sometimes one company operates all these steps, but regularly each step is executed by a different company. Sometimes companies sell part of their plants – for example the (energy intensive) upstream part of the value chain or outsource the production of, for example, hydrogen. Especially when considering scope 1 emissions not covered by a product specific SDA, or when considering scope 3 emissions, methodologies to be developed should keep this in mind to prevent undesirable effects from such differences in value chain coverage (i.e., "emissions leakage").

[8] List is not intended to be complete.

Q6: How should companies deal with non-CO2 greenhouse gas emissions?

Emissions scenarios for the chemical sector's non-CO_2 greenhouse gases emissions are not as well described as its CO_2 emissions. The SBTi Chemicals Scoping Report suggests prioritizing on scope 1 and downstream scope 3 for the sector's non-CO_2 emissions, and potentially focusing on N_2O – relevant for the production and use of fertilizer. Upstream emissions of CH_4 from purchased fossil fuels are also relevant for the industry and must be considered as part of scope 3 target setting.

Chemical Sector Boundary

The SBTi Chemicals Scoping Report proposed a boundary of the chemicals sector for the purposes of SBTi guidance. The SBTi sector definition is based on the IEA's Energy Technology Perspectives scenarios and adopts the same boundary used in this model, which means manufacture of pharmaceuticals is included[9].

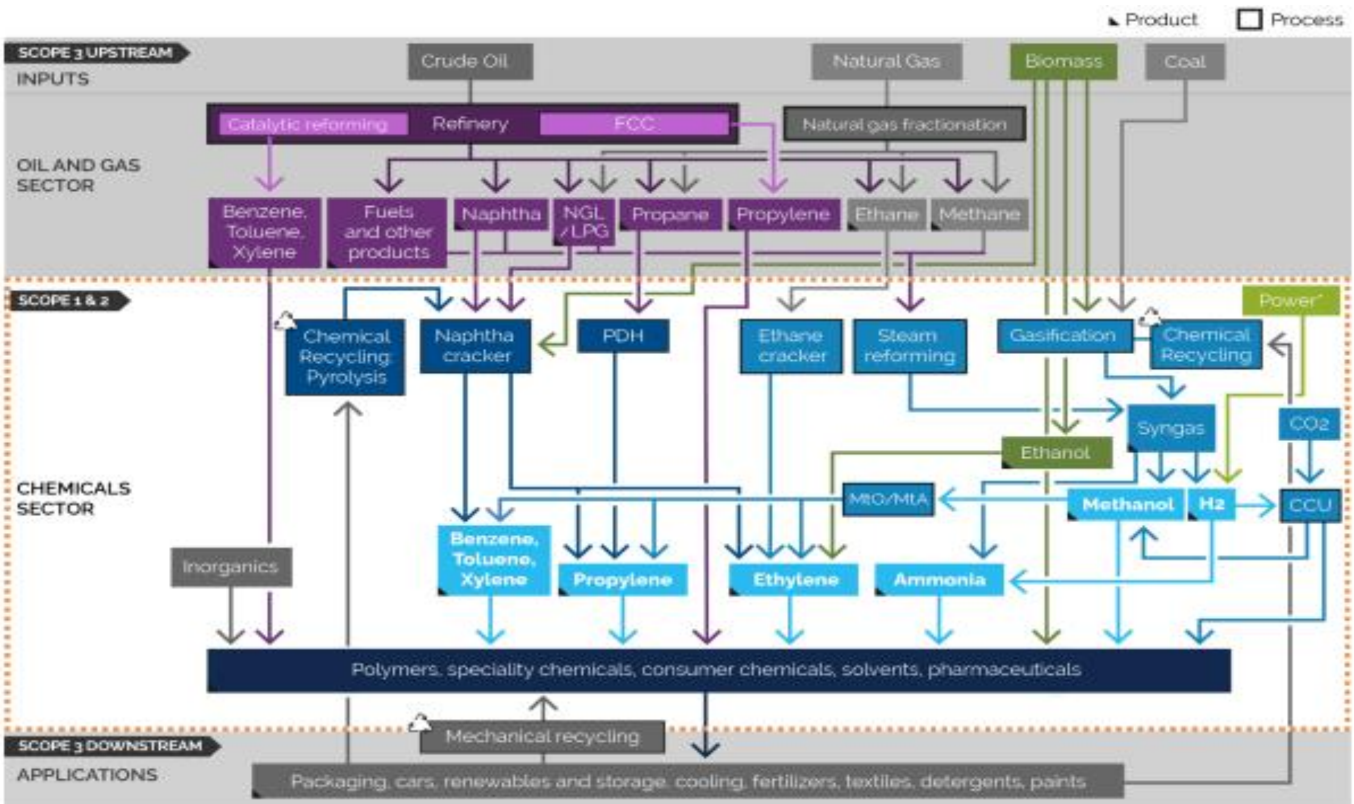
The chemicals sector as included in IEA's modelling includes the following:

- High-value chemical production (IEA's ETP defines these as ethylene, propylene, benzene, toluene, and (mixed) xylene; primary production routes currently include steam cracking, bioethanol dehydration, naphtha catalytic cracking, propane dehydrogenation, methanol-to-olefins, and methanol-to-aromatics) (IEA, 2020).
- Methanol and ammonia production (fossil fuel-based, biomass-based and electrolysis-based).

The other parts of the chemicals sector are covered in a more crosscutting manner, e.g., emissions from fuel combustion and emissions associated with any electricity generation in the sector are accounted for in the power sector.

The visual representing the sector boundaries from the SBTi Chemicals Scoping Report is repeated below.

[9] (IEA, 2020b) confirms the inclusion of the pharmaceutical sector in the chemical sector.



Notes: CCU = Carbon capture and utilization; FCC = Fluidized catalytic cracking; H_2 = Hydrogen; NGL = Natural gas liquids; LPG = Liquified Petroleum Gas; MtO = Methanol to olefins; MtA = Methanol to aromatics; PDH = Propane dehydrogenation. *Power denotes selected electricity use. Note discussion below on classification of chemical recycling.
Source: SBTi.

Figure 1: Visualization of Chemicals Sector Components and Boundaries (SBTi, 2020).

The SBTi Chemicals Scoping Report discusses whether the following activities should or should not fall within the boundaries of the chemical sector:

1) Pharmaceuticals,
2) Production of Propylene and BTX in refineries,
3) Chemical recycling,
4) Mechanical recycling and
5) Production of Biofuels.

Based on recent discussions with the project's current EAG, we add the following activities to this list:

6) Final plastic products (e.g., packaging),
7) Production of ammonia for use as energy carrier,
8) Production of hydrogen for use (as energy carrier or reducing agent) outside the chemical industry.

The section below summarizes the SBTi's current proposed treatment of these subsectors as we enter the next phase of our project. As discussed below, the starting point is that SBTi's overall carbon budget for the chemical sector is based on the IEA's NZE scenario. We will thus only deviate from their sector boundaries if data availability allows doing so transparently.

As the SBTi aims to develop target-setting criteria and guidance for the chemicals sector, rather than produce novel emissions scenarios, it is important to understand what inclusion within the sector for the SBTi means:

- Exclusion of certain areas from the chemicals sector guidance does not imply those areas cannot set SBTs. Such sectors would be subject to the SBTi's cross-sector criteria, or other sector criteria as applicable.
- Inclusion would typically require companies to follow the chemicals sector-specific guidance, and therefore may impose criteria that are above and beyond SBTi's cross-sector criteria, such as the inclusion of certain mandatory scope 3 emission source types.
- Inclusion may also allow companies to use target-setting methods that are only available to the sector, for example sector-specific SDA methods.
- Inclusion does not imply that an SDA pathway covering scope 1 and 2 emissions would be available for all emissions sources. Scope 1 and 2 emissions from areas not covered by an SDA pathway could be covered using SBTi's cross sector methodology (ACA method).
- Companies should still use the organizational boundary setting and GHG emissions consolidation procedures in the GHG Protocol. This might mean that an organization has scope 1 emissions from multiple sectors.

Table 1: SBTi's current proposed treatment of subsectors and rationale.

Subsector		Status
1	**Pharmaceuticals**	In sector. To explore whether inclusion may be optional.

Rationale:
The SBTi Chemicals Scoping Report states that impacts for the pharmaceutical sector should be explored. Having pharmaceuticals as part of the chemical sector is in line with IEA's modelling scope (SBTi 2020), and many characteristics of the pharmaceutical sector are the same as for specialty chemicals.

Having the pharmaceuticals in the chemical sector has the following consequences:

- Scope 1 and 2 emissions are relatively low in comparison with the chemical sector's overall scope 1 and 2 emissions, therefore an SDA pathway covering these emissions is unlikely.
- The guidance developed will apply to the pharmaceutical sector, such as:
    - Scope 2 guidance on electricity / CHPs;
    - Scope 3 guidance provided on category 1, 3 and bio-based feedstocks.

Subsector		Status
2	**Chemical products produced within refineries**	To be determined

Rationale:
Production of naphtha and propane (feedstocks for the chemical industry) in refineries are considered outside the scope of the chemicals industry, since they are produced alongside, and often using the same processes, as energy products. These feedstocks will be considered in future work for the SBTi's oil & gas sector guidance. As shown in Figure 1, production of propylene (via FCC) and BTX (via aromatics extraction) in refineries is not currently considered part of the chemicals sector[10].

Rationale of including in the chemical sector:

[10] In line with Figure 3.2 in (IEA, 2022c).

Subsector		Status
2	**Chemical products produced within refineries**	To be determined

- Propylene and BTX are primarily used by the chemical sector[11] (first platform chemical in often long value chains), therefore inclusion in the sector puts would consider all propylene and BTX production together.
- May incentivize emission reductions in continued propylene and BTX production in view of the projected steep decline of global refinery production.
- May be appropriate for so-called "crude to chemical" production routes where chemicals are produced from crude oil feedstock in a single plant.

Rationale of not including in the chemical sector:

- Available emission scenarios may account for chemicals produced in refineries under the oil & gas sector, or not at all.
- Propylene and BTX are produced concurrently with energy products, making comparison of emissions profiles to traditional production routes difficult.
- Emissions and production allocation/accounting become very complex when chemicals are produced simultaneously with energy products.

The consequences of increased production of chemicals in bio-refineries and decreased production of chemicals in fossil-based refineries will also be considered.

We do not propose to move the refineries' production of naphtha to the chemical sector. Naphtha is a feedstock for the chemical sector, and the chemical industry doesn't produce its own virgin fossil naphtha.

The feasibility of establishing a carbon budget to produce propylene and BTX in refineries, and the methodology that refineries would need to apply, needs to be explored.

For the sake of clarity: Propane Dehydrogenation (PDH) to produce propylene is included within the chemical sector (SBTi, 2020).

We will consider whether specific guidance is needed for companies that may need to set targets in both the chemicals and the oil & gas sector, considering that targets should not become too complex.

[11] Very different than, for example, hydrogen – which is for example used in the steel sector as well.

Subsector		Status
3	**Chemical recycling**	(At least partially) in sector

Rationale:
The chemical recycling value chain starts with waste disposal and collection, often followed by sorting / separation, after which a variety of chemical recycling options exist. Some of the chemical recycling options (like gasification to produce syngas for conversion to for example methanol) could logically fall under the chemicals sector. Including other parts of the value chain (like the collection of waste) in the chemicals sector depends on potential methodological needs.

Subsector		Status
4	**Mechanical recycling**	To be determined

Rationale:
Scope 1 and 2 emissions from mechanical recycling are relatively small.
IEA "currently models the small amount of energy required for mechanical recycling today as part of the 'Other chemicals' segment of the chemicals sector." (IEA, 2022b)[12].

Subsector		Status
5	**Production of biofuels or biofeedstocks**	To be determined

Rationale:
IEA does not group the production of biofuels (SBTi, 2020) in the chemicals sector, despite the similarities in production processes.

We will aim to clarify the boundary between biofeedstock production and the chemicals sector.

[12] IEA doesn't model sorting and collection of plastic waste within the chemical sector.

Subsector		Status
6	**Final plastics products like production of packaging**	To be determined, likely outside the chemical sector.

Rationale:
Emissions from the conversion of chemicals to consumer-products have different characteristics than emissions for the chemical sector.

We aim to provide brief guidance where there is a logical overlap with the chemicals industry, such as accounting for scope 3 category 12 emissions from sold plastic products, and accounting for recycling emissions.

Subsector		Status
7	**Production of ammonia and methanol as energy carriers**	To be determined

Rationale:
Ammonia production currently causes significant CO_2 emissions (450 Mton/year as shown in Annex 2). Production of ammonia for industrial use (including conversion to / application as fertilizer) falls under the chemical sector.

This project will consider where to account for ammonia generated for use in other sectors (e.g., transport and electricity generation[13]) specifically when used as a fuel or as an energy carrier. Ammonia produced for non-industrial purposes are not included in the IEA's chemicals sector definition (SBTi, 2020). Ammonia for industrial purposes can be produced using the same production processes as for the production as an energy carrier. Including non-industrial ammonia as part of this chemicals sector guidance precludes the development of potentially different pathways for the production of the same chemical. Similar considerations apply to methanol production for use in industrial applications vs its use in other sectors.

Rationale of excluding non-industrial ammonia from the chemicals sector include:

- In line with IEA's sector demarcation[14].
- Production of ammonia / methanol for use as fuel could, in the immediate term, rely on different production processes, to achieve a GHG emission saving relative to fossil fuels.
- Prevents a potential need to shift carbon budget from other sectors (e.g., energy sector) to the chemical industry.

[13] (IEA, 2021c) pages 72-73.
[14] (IEA, 2021c) page 79.

Subsector		Status
8	**Production of hydrogen for use outside the chemical industry (as energy carrier or reducing agent)**	To be determined

Rationale:
Hydrogen is currently produced for many uses, both within and outside the chemicals sector. For example, hydrogen production is a key step in producing ammonia, hydrogen is produced for use as a reducing agent in the steel sector, and oil refineries generate hydrogen as part of the production of fuels.

The SBTi currently considers hydrogen produced by other industrial sectors, such as steel, as being within the emissions boundary of those sectors for target-setting purposes. We will consider in this project how to consider hydrogen that is produced and sold as a product itself (merchant hydrogen).

Note that ultimately many industrial gases are used in other sectors. These industrial gases remain in the chemical sector – as their associated energy consumption is relatively limited. Exceptions may be made for hydrogen, ammonia and methanol as these are not only used as chemicals, but also as energy carriers.

GUIDANCE DEVELOPMENT

The next phase of this project will focus on developing SDA pathways and target setting guidance for the chemicals sector. The chemicals sector is unique among major industrial industries due to the large variety of products produced. As noted above, the heterogeneous nature of the sector makes it impractical to develop a single SDA pathway that would cover the entire industry. Therefore, our goal is to develop SDA pathways to cover the production of individual primary chemicals (ammonia, methanol, merchant hydrogen, and high value chemicals [ethylene, propylene, BTX]), which contribute the majority of direct emissions from the industry. Annex 2 presents the rationale for focusing on these products.

The chemicals sector SDA pathways will be based on one or more existing emissions scenarios for the industry. A viable emissions scenario must include future projections for emissions and demand for the industry, and it must be consistent with the chemicals sector's remaining carbon budget and the SBTi's criteria, described further below. One such potential scenario is the IEA NZE scenario, which the SBTi has used for SDA pathway development in other sectors and to establish the overall carbon budget per sector (SBTi, 2021a). The NZE scenario, as presented, provides a summary of the scope 1 CO_2

emissions within the chemicals sector, a trajectory of the emissions and demand of the sector until 2050, and some similar granular data for primary chemicals. Figure 2.1 in the IEA's Ammonia Technology Roadmap report (IEA 2021c) provides an overview of the direct CO_2 emissions associated with ammonia production, and the production of chemicals and petrochemicals, in the NZE scenario until 2050. Other emissions scenarios have been evaluated as well and are listed in Annex 4. These include the One Earth Climate model (ISF, 2022) and the paper "Electrification of the Chemical sector (Eryazici, Ramesh & Villa, 2021)". The SBTi will review all this available data to inform the chemicals SDA pathways and may utilize multiple sources to fill data gaps.

Our approach to developing SDA pathways will:

- Build on credible, accessible, and transparent data sources only. The SBTi's criteria for viable emissions scenarios include (SBTi 2019):
  - **Plausibility:** A plausible scenario is based on a credible narrative. A scenario with high plausibility may be considered relatively likely to occur.
  - **Consistency:** A scenario is consistent if it has strong internal logic and is not built on assumptions or parameters that completely overturn the evidence of current trends and positions without logical explanation.
  - **Responsibility:** A responsible scenario is predicated on minimizing the risk of not achieving the Paris Agreement.
  - **Objectivity:** Responsible scenarios are also objective, in that they are agnostic of what is preferable to the organization.
- Have a global scope: In line with the current approach taken by the SBTi, we do not expect to develop separate pathways for individual regions. Relevant regional studies may be used to inform global pathway development.
- Involve interpolation for individual years where needed, assuming data availability will likely be based on ~10 year intervals.
- Be explicit and consistent in which products and which emissions sources will be included in SDA pathways. This will be done to ensure consistency between different emissions scenarios, as well as consistency between the underlying emissions scenarios and companies' targets. For example, HVCs may be defined differently between different data sources. The SBTi will ensure that any data used to inform SDA pathways are consistent with the chosen convention to the extent possible.

The SBTi will use the procedures outlined below to develop target-setting guidance and resources for the chemicals sector. We have described the current assumptions formed from our development work to-date; however, these assumptions may change in future phases of the project. The process described below provides a general overview of the steps required to establish target-setting guidance. A detailed description of final assumptions and justifications will be provided with the final published guidance. Note that for readability purposes the remainder of this chapter has been written in the form of “SBTi will”; however, meeting these goals depends amongst others on data availability and sufficient funding, and is not guaranteed.

Scope 1 and 2 Emissions Target Setting

Step 1: Determine primary chemicals for which an individual SDA pathway will be developed, considering the general criteria above for developing an SDA pathway, and the following results of our initial research.

- IEA’s NZE scenario, and IEA’s complementary reports for the chemical sector, provide some emissions and production data granularity for HVCs, ammonia, methanol and hydrogen.
- We have found no other sources with comparable starting points as IEA’s NZE, or with comparable pathways at a more granular level. Similar scenarios address the same primary chemicals, or a subset of them, as the NZE IEA model.
- Together, HVC, ammonia, methanol and hydrogen consume about two thirds of the chemical sector’s energy (refer to Annex 2).
- Developing SDA pathways for these four subproducts (HVCs, ammonia, methanol and merchant hydrogen) will still require some allocation of emissions scenario data among the product pathways.
- The SBTi will evaluate whether it is feasible and/or advantageous to develop SDA pathways at a more granular level, such as at the individual HVC level (e.g., ethylene, propylene, xylenes, etc.). We will consider the different production pathways for each individual chemical in the present and those assumed in emissions scenarios to determine whether it is possible and appropriate to define SDA pathways at this more granular level.
- The SBTi will evaluate how to cover scope 1 emissions from the chemicals sector that do not arise from the production of primary chemicals. We will consider whether an SDA pathway for “other products" is feasible, or whether such emissions are best covered using SBTi’s cross-sector methodology (i.e., the ACA).

Step 2: Establish demand projections for chemicals in chosen SDA pathways. Production rates in future years are a necessary input to the intensity-based SDA pathways.

- Use data source such as IEA NZE (IEA, 2021b – page 200, table A5) to determine production projections for primary chemicals.

- Allocate production to individual SDA pathways.
  - If necessary, supplement and/or adjust growth projections for each of the primary chemicals, and for "the rest", based on checks with other literature.
  - Avoid double counting of hydrogen used for the production of ammonia and methanol.

Step 3: In case data would allow doing so, divide the sector carbon budget amongst the SDA pathway chemicals and products not covered by an SDA pathway.

- Using the IEA NZE as a starting point, establish CO_2 emissions projections, by year, through 2050 for primary chemicals.
  - In case chemical sector boundaries would be chosen that would not be in line with IEA's NZE scenario's sector boundaries, the SBTi will consider the impact on the sector's available carbon budget, as well as the emissions and production projections used in the SDA pathways.

- Allocate CO_2 emissions to individual SDA pathways.

- If necessary, supplement and/or adjust emissions projections for each of the primary chemicals, and other products, based on checks with other literature.
  - The SBTi will ensure compatibility in modelling approach and assumptions[15] between sources before supplementary data are used.
  - Consider whether to factor in co-production of CO for current SMR based hydrogen production.

We will aim to provide clarity on how to account for byproducts from primary chemical production, if the byproducts are not to be considered part of the production volume, especially for HVC.

Generation of new primary data, such as assessing technologies or impacts on overall production cost, is not foreseen.

Step 4: Consider non-CO_2 GHG emissions.

The project's EAG has indicated that process emissions of N_2O, and fugitive emissions of CH_4 from both upstream and in-sector sources are particularly relevant for the chemicals industry. Fluorinated gases with high global warming potentials, such as HFCs, are also produced by the chemicals industry. The IEA NZE scenario does not include non-CO_2 emissions. Therefore, the SBTi will consider whether to account for non-CO_2 gases in SDA pathways, or if emissions of non-CO_2 GHGs are better handled

[15] Key scenario assumptions to be evaluated include assumed energy pricing, CO_2 pricing, production growth/decline assumptions, and technology readiness and implementation.

under SBTi's cross sector target setting guidance. Nitric acid production is currently, in some regions, a significant contributor of N_2O emissions in the sector; however, (cost-effective) abatement measures are readily available to greatly reduce these emissions. In the absence of emission scenarios for N_2O emissions, the SBTi will consider alternative target-setting approaches that consider the availability of abatement technologies.

Step 5: Accounting for scope 2 emissions from electricity and steam consumption.

The SBTi's SDA methodology combines scope 1 and 2 emissions within SDA pathways. Please the publication on the SDA Methodology for details on how scope 2 emissions are included (SBTi, 2015). This methodology requires projections of electricity consumption for the sources covered by the pathway to allow for a calculation of projected scope 2 emissions. The intensity of scope 2 emissions in industrial sectors in each year are assumed to follow the SBTi's SDA pathway for the power sector. In the case of the chemicals sector, the SBTi will assess whether the power sector pathway emission factor should be applied to the additional electricity use due to electrification, or whether a different factor is more appropriate, due to the expectation that major new electricity demands would be developed to use renewable sources from the start.

As electrification can well be a key scope 1 emission reduction lever for the chemicals sector, the sector's electricity consumption could increase very significantly in the future. Apart from ammonia, the IEA NZE scenario does not provide a baseline or forecast on the electricity used in the chemicals sector. Other scenarios and models provided by other sources predict a large increase in electricity demand of the sector due to the implementation of energy-intensive production routes, such as hydrogen production via electrolysis. In order to model scope 1 and 2 emission trajectories consistently, the SDA will require viable electricity usage scenarios at the level of the individual products for which an SDA is prepared (e.g., ammonia, methanol and HVCs). The SBTi will assess whether it is possible to project future electricity consumption from the available data (e.g., projected production technology mix and the associated energy intensities).

The SBTi will also consider how to treat emissions from consumed electricity and heat that are generated within a company's operational boundary.

- A key question is whether such emissions are modelled using the power sector pathway or using the scope 1 emissions pathways. Emissions resulting from the generation of steam procured externally will likely need to be reduced at a rate equivalent to cross-sector emissions; therefore, it is unlikely that the SBTi will model such emissions under the SDA pathways. However, we will assess the scope and relevance of such emissions within total sector emissions. IEA models the emissions associated with the generation of heat imported by chemical plants in the sector in which it is generated, following IPCC guidelines, and doesn't model the chemical sector's export of heat. (IEA, 2022b).

In summary, the SBTi will evaluate the feasibility of establishing joint "scope 1 and 2" pathways for the individual product SDAs in the next phase of this project.

Step 6: Company guidelines on scope 1 and 2 target-setting.

The SBTi will develop detailed guidance for how companies can utilize the newly developed SDA pathways and other criteria for setting targets. Such guidance will include, but will not be limited to:

- Criteria on which emissions sources must be included in targets set using an SDA pathway, and which emissions sources may optionally be included. These criteria will largely be based on the sources accounted for in the underlying emissions scenario, including any adjustments made by the SBTi.
- Guidelines on how to account for emissions from electricity generated within a company's operational scope (i.e., scope 1 emissions) vs. emissions from purchased electricity (scope 2).
- Criteria on how to use the SDA target-setting tool to set a target.

Scope 3 Emissions Target Setting

The chemical industry has many, heavily intertwined, value chains.

- Some companies operate a full value chain (producing high value chemicals from naphtha and converting these into polymers like polyethylene). Others operate only part of such a value chain.
- Companies often procure many (chemical) feedstocks, from a multitude of suppliers, for each of their plants. These suppliers often also have a multitude of suppliers.
- Companies often make a multitude of chemical products, which are used in even more applications, in even more countries – each with their own way for converting the chemicals into products (scope 3 category 10) and for dealing with waste (scope 3 category 12).

For plastics production there is potentially good benchmark data available for upstream (primary chemicals manufacturing) and there may be some typical data available for downstream (polymers and plastics manufacturing) value chain emissions; however, this is not true for other products. Only around 40% of the carbon used for organic chemicals and derived materials ends up in thermoplastic polymers (Carus 2022). Thus, the carbon embedded in other products (such as fibres, solvents and detergents) is relevant in sector scope 3 inventory calculations. Uncertainty around the downstream fate of sold products presents a significant hurdle to companies trying to calculate accurate scope 3 emissions.

The SBTi will thus aim to make the current guidance more specific for the chemical sector, and its many intertwined value chains, by:

- Providing guidance on when to prioritize the use of primary data (emission factor and/or activity data obtained from the specific relevant actors in the value chain [like suppliers]), and when to use typical data (for example from LCA databases or spend-data).
- Providing an overview and recommendations on how to use available data resources when developing scope 3 inventories and setting targets.

The SBTi's cross-sector near-term target setting criteria require that if a company has scope 3 emissions that consist of 40% or more of total scope 1, 2 and 3 emissions, it shall set a scope 3 target. The scope 3 target boundary shall include at least 67% of scope 3 emissions. Different methods for setting scope 3 targets are possible, including amongst others the absolute contraction method and a supplier / customer engagement approach.

SBTi's Chemicals Scoping Report suggested a focus on scope 3 categories 1, 10, 11 and 12. Annex 3 presents evidence that these categories are the most relevant for the industry, and thus warrant specific guidance. Within these categories, we expect the following sector-specific hot-spots to be relevant from the perspective of overall emissions and from the perspective of a need for guidance.

Categories 1 and 3 for Fossil-based Resources

Emissions originating from the upstream extraction, transport, and refining/production of fossil-based materials are especially relevant for the chemicals sector, as the sector consumes large quantities of these materials for energy and non-energy (i.e., feedstock) purposes. Of particular concern are emissions of CH_4 from fossil fuel extraction and transport, and emissions generated via the consumption of energy during the refining/production phase for fuels and feedstocks. In consideration of this, SBTi's Chemicals Scoping Report states: "Consider development of intensity pathways for the production of chemicals sector feedstocks including naphtha, ethane, and methane. These pathways could inform scope 3, category 1 targets for companies in the chemicals sector." The relevance of this issue has been confirmed with the project's EAG. Emission factors for upstream emissions further depend heavily on the region. The SBTi will consider if and how to develop sector specific guidance for this category, specifically considering the following:

- Upstream emissions from the extraction and production of fossil-based products are not unique to the chemicals sector, but the scale of consumption by the sector is uniquely significant. The SBTi has instituted mandatory targets for scope 3 category 1 emissions in other energy-intensive sectors[16], and we will consider whether such a requirement may also be relevant for the chemicals sector to ensure that this significant emissions source is addressed.

- Key fossil-based feedstocks for the chemicals sector include naphtha, traditionally produced in refineries from fossil-based materials alongside fossil fuels and ethane, obtained as a component of natural gas. Consideration of emissions from production of these feedstocks will be done in tandem with the SBTi's in-development guidance for the oil & gas industry.

We will align the chemicals sector guidance with key existing SBTi sources on scope 3 category 1 and 3 emission reduction pathways for fossil-based materials.

The scope 1 (and likely scope 2) SDA pathways for individual primary chemicals may be available as an option for downstream companies to cover emissions from the production of these chemicals in scope 3 category 1.

Category 10, Processing of Sold Products

Emissions from the processing of sold products in the chemicals value chain were identified along with the other downstream scope 3 categories as an area in need of additional guidance due to low data availability. Companies accounting for category 10 emissions will benefit from the guidance developed for the downstream categories, therefore we do not expect to specifically address category 10 in this project.

Category 11, Use of Sold Products for Fertilizer

GHGs are emitted when nitrogen-based fertilizers (N-fertilizers) are applied in the field. N_2O is generated and emitted via the natural soil nitrogen cycle. CO_2 emissions are also generated from the carbon contained in urea-based fertilizers. These emissions are significant in scope 3 category 11 for producers of N-fertilizers in the chemicals industry.

- There are many sources available that address sources of and mitigation of GHG emissions from fertilizer application (refer to Annex 5).
- While it may be difficult to eliminate all fertilizer-related category 11 emissions, emissions can be reduced through mitigation measures that optimize factors including:
    - Right source: Mineral vs organic sourcing, and use of the optimal substance when mineral.

[16] The SBTi's guidance for the cement industry requires companies to set targets on scope 3 category 1 emissions from purchased clinker.

  - Right rate: Depending on soil nutrient supply (from organic sources and existing soil levels) and plant demand.
  - Right time: Depending on (the timing of) crop uptake, (dynamics of the) soil supply, weather factors, nutrient loss risks and field operation logistics.
  - Right place: Depends on root-soil dynamics and managing spatial variability and the tillage system.

- The guidance will not assess the factors listed above in practice, but will:
  - Based on existing scenarios / literature sources aim to establish guidance on target-setting for fertilizer use-phase GHG emissions[17].
  - Recognizing there are significant regional differences in types of fertilizers applied[18], the aim is to establish one *global* reduction pathway, in line with the SBTi's current stance on industrial emissions pathways.
  - Consider factors such as in which form the N-fertilizer is applied to the field (as ammonia, ammonium nitrate or urea) and how to account for the CO_2 emissions from urea on the field.

- SBTi's recent FLAG publication has pathways for N_2O emissions amongst others from the field, leaching and runoff. These will be applicable to fertilizer companies' scope 3 category 11 targets and will be considered in the chemicals sector guidance.

Categories 1, Purchased Goods and Services, and 12, End-of-life of Sold Products Focusing on Plastics

There are many sources (refer to Annex 5) available that address emissions of embedded carbon during the end-of-life phase of chemical products, in particular fossil-based plastics.

In the chemicals sector guidance, the SBTi will aim to:

- Provide guidance on scope 3 categories 1 and 12 emission calculations in case of:
  - Waste incineration.
  - Landfilling.

[17] Scope 3 – category 11.
[18] For example, for the delivering of N-nutrient, in the USA, mainly ammonia and urea are used, while Europe mainly uses ammonium nitrate and urea.

   - Recycling, specifically how emissions from the recycling process are to be accounted for, and how such materials are considered as replacements against virgin fossil-based materials.

- Assess whether sectors using a significant amount of plastics have scope 1, 2 and 3 trajectories that could inform a downstream scope 3 target for plastic raw material producers.

Specifically for CCU, the SBTi will consider whether it is helpful to treat CCU differently for:

- Bio-based and/or DAC based CO_2

  vs

- Fossil-based CO_2

Multiple Scope 3 Categories for Bio-based Materials

Bio-based fuels and feedstocks are available as an alternative to fossil-based materials and are expected to increase in adoption across the industry as a replacement for fossil-based products. Bio-based materials still have associated upstream scope 3 emissions from their production and transport, and chemical companies are expected to consider scope 3 category 1 emissions from purchased bio-based materials.

Bio-based materials also present challenges for downstream scope 3 emissions accounting. Bio-based materials include embedded carbon that originated from biological sources; therefore, there are associated atmospheric carbon removals to be considered alongside the eventual emissions. The SBTi's current target setting criteria include requirements on accounting for emissions from the use of bioenergy. As part of this project, the SBTi will explore guidance on downstream scope 3 emissions related to bio-based materials considering the available data, specifically the GHG Protocol's Guidance for the Land Sector and Removals.[19]

[19] The GHG Protocol Land Sector and Removals Guidance has been published as a draft and is open for public comment as of the publication of this report.

SECTORAL INITIATIVES AND COLLABORATION

The project's next phases will be informed by our EAG – with whom regular meetings are ongoing. The EAG will also be asked to review draft key deliverables before these are issued to the wider audience. Draft deliverables will then be made public to receive feedback from a wider stakeholder group. Ultimately the SBTi transparently decides whether / how to implement stakeholder feedback.
During the process, there can be reasons to interact specifically with a few outside organizations identified to be working on similar / related projects, such as the following non-comprehensive groups:

- Together for Sustainability: see Annex 6.
- WEF Scope 3 Task Force: see Annex 5.
- MPP STS work: see Annex 5.
- WBCSD SOS 1.5, Pathfinder.

ANNEX 1: OVERVIEW OF THE GLOBAL CHEMICAL INDUSTRY'S CURRENT SCOPE 1, SCOPE 2 AND SCOPE 3 EMISSIONS

The tables below provide a summary of the current total emissions (scope 1, 2 and 3) of the chemicals sector. In this project, all sources provided as part of the survey carried out during the development of the 2020 SBTi Chemicals Scoping Report (SBTI, 2020) (Page 52) have been considered.

Scope 1 emissions for the whole sector are currently estimated to be ~1.3Gt CO_2. Note that the data below are reported in the units (CO_2 or CO_2e) used in the original reports.

Source	Baseline year	Scope 1 emissions	Comments
IEA Net Zero report (IEA, 2021b)[20]	2019	1.34 Gt CO_2	--
OECM model (ISF, 2022)	2019	1.26 Gt CO_2	--
Zero-Emission Pathway for the Global Chemical and Petrochemical Sector (Saygin & Gielen, 2021)	2017	1.10 Gt CO_2	--
Electrification of the chemical industry—materials innovations for a lower carbon future (Eryazici, Ramesh & Villa, 2021)	2021	Current draft SBTi interpretation[21]: 1.16 Gt CO_2e	Includes non-CO_2 emissions (main contributors CH_4 and N_2O) and excludes downstream emissions
Planet Positive Chemicals (Systemiq, 2022)	2020	0.6 Gt CO_2e	Only primary chemicals

Scope 2 emissions vary significantly across the various sources listed below; this is likely due to differences in the sector boundary. A range of ~0.4 – 0.7 Gt CO_2 is observed. Again, the data below are reported in the units (CO_2 or CO_2e) used in the original reports.

[20] Note in the report it is assumed the IEA Ammonia Technology Roadmap report (IEA, 2021c) and the IEA, Direct CO_2 emissions from primary chemical production in the Net Zero Scenario, 2015-2030, (IEA, 2021a) are both consistent with the IEA NZE model. A further IEA source "IEA, Direct CO_2 emissions from primary chemical production and CO_2 intensity in the Net Zero Scenario, 2000-2030" (IEA, 2022a) published in September 2022 appears to provide updated primary chemical emissions, this source has currently not been included in this report to ensure consistency across all sources and values. This source will be evaluated further in the next phase of this project under any implications of the values.

[21] It is assumed that scope 1 emissions in this report are reported under heat and direct emissions from raw materials and intermediates.

Source	Baseline year	Scope 2 emissions	Comments
IEA Net Zero report (IEA, 2021b)	2019	Not provided	--
OECM model (ISF, 2022)	2019	0.74 Gt CO_2	--
Zero-Emission Pathway for the Global Chemical and Petrochemical Sector (Saygin & Gielen, 2021)	2017	0.6 Gt CO_2	--
Electrification of the chemical industry—materials innovations for a lower carbon future (Eryazici, Ramesh & Villa, 2021)	2021	Current draft SBTi interpretation[22]: 0.43 Gt CO_2e	Includes non-CO_2 emissions (main contributors CH_4 and N_2O) and excludes downstream emissions
Planet Positive Chemicals (Systemiq, 2022)	2020	0.2 Gt CO_2e	Only primary chemicals

Scope 3 emissions also vary significantly across the various sources, likely due to the lack of available data on all scope 3 categories. A range of 1.0[23] – 2.5 Gt CO_2e is observed. Inherent to scope 3 accounting, comparison is difficult across the various sources as the category consideration can vary.

Source	Baseline year	Emissions	Comments
IEA Net Zero report (IEA, 2021b)	2019	Not provided	--
OECM model (ISF, 2022)	2019	2.52 Gt CO_2e	Includes non-CO_2 emissions
Zero-Emission Pathway for the Global Chemical and Petrochemical Sector (Saygin & Gielen, 2021)	2017	Not provided	--
Electrification of the chemical industry—materials innovations for a lower carbon future (Eryazici, Ramesh & Villa, 2021)	2021	Current draft SBTi interpretation[24]: 0.99 Gt CO_2e	Includes non-CO_2 emissions (main contributors CH_4 and N_2O) and excludes downstream emissions

[22] It is assumed that scope 2 emissions in this report are reported under electricity emissions from raw materials and intermediates.
[23] Excluding scope 3 downstream emissions.
[24] It is assumed that scope 3 emissions in this report are reported under all emissions (heat, electricity, and direct emissions) due to the production of final products, feedstocks, and fuels. This includes gate to gate emissions only and doesn't include downstream emissions.

Planet Positive Chemicals (Systemiq, 2022)	2020	1.5 Gt CO_2e	Only primary chemicals

We hope to benefit in this project from data that the International Council of Chemical Associations (ICCA) may have on the GHG emissions of the global chemical industry, and, for Europe and globally, from Cefic's iC2050 model (Cefic, 2022). We expect to also benefit from the insights published by Bauer (2022) and the National Inventory reports sent to the United Nations Framework Convention on Climate Change (UNFCCC) annually by various countries.

ANNEX 2: RATIONALE FOR FOCUS ON AMMONIA, METHANOL, HYDROGEN AND HIGH VALUE CHEMICALS

The production of a limited number of products generates most of the chemicals sector's scope 1 emissions. The IEA's Energy Technology Perspectives report (IEA, 2020) groups ammonia, ethylene, methanol, propylene, and benzene, toluene, and xylene (BTX) as primary chemicals which serve as the building blocks for most of the industry. The global production volumes of these seven chemicals account for around two-thirds of the energy consumption in the sector (IEA, 2021c, Page 46). Table 2 shows emissions from the production of these chemicals (IEA, 2021c, Page 47). Current IEA modelling continues to focus on these chemicals, as many abatement routes rely on them.

Table 2: Breakdown of global emissions from the chemical sector in 2020 (IEA, 2021c).

Chemical	Emissions (Mt CO_2)
Ammonia	450[25]
Methanol	220
HVCs	250

In the next phase, we will also consider data included in IEA's recently published World Energy Outlook (IEA, 2022d).

[25] For the sake of clarity: IEA's modelling doesn't consider CO_2 generated during the production of ammonia that is captured and converted to urea to be emitted in the chemical sector, these emissions are accounted for in the correspondent sectors where urea is used. IPCC GHG accounting guidelines are followed to avoid double counting since IEA covers all the sectors (IEA, 2022b).

ANNEX 3: RATIONAL FOR THE FOCUS ON SCOPE 3 CATEGORIES 1, 10, 11, 12

The Relevance of Scope 3 for the Chemical Industry

CDP (2022) states that scope 3 emissions account for nearly 77% of the total emissions of the chemical sector. Kearney (2022), states that scope 3 accounts for at least 75% of the chemical sector emissions. Carus (2022) states that ~2/3 of the greenhouse gas footprint of chemicals stems from the carbon embedded in the molecules. COMET (2022) reports that for plastics the scope 3 category 1, 3 and 12 emissions add up to 60% of the total plastic value chain emissions. Other sources, shown in Table 3, also conclude that addressing the sector's scope 3 emissions is relevant. It therefore is imperative that these emissions be included in the boundary of both short-term and long-term net-zero targets.

Which Scope 3 Categories are More Relevant?

CDP (CDP, 2022 - page 18) suggests scope 3 categories 1 (purchased goods & services), 11 (use of sold products) and 12 (end of life treatment of sold products) could be the most relevant categories for chemical companies, as Figure 2 shows. This conclusion should be considered within the context that response rates vary per category.[26]

[26] Note that not all companies have reported for all scope 3 categories: 73%, ~15%, 25% and ~35% respectively for categories 1, 10, 11 and 12. Ignoring the category "upstream transportation and distribution", as no need for guidance specific for the chemical sector is expected here, #4 would be the "processing of sold products" (category 10).

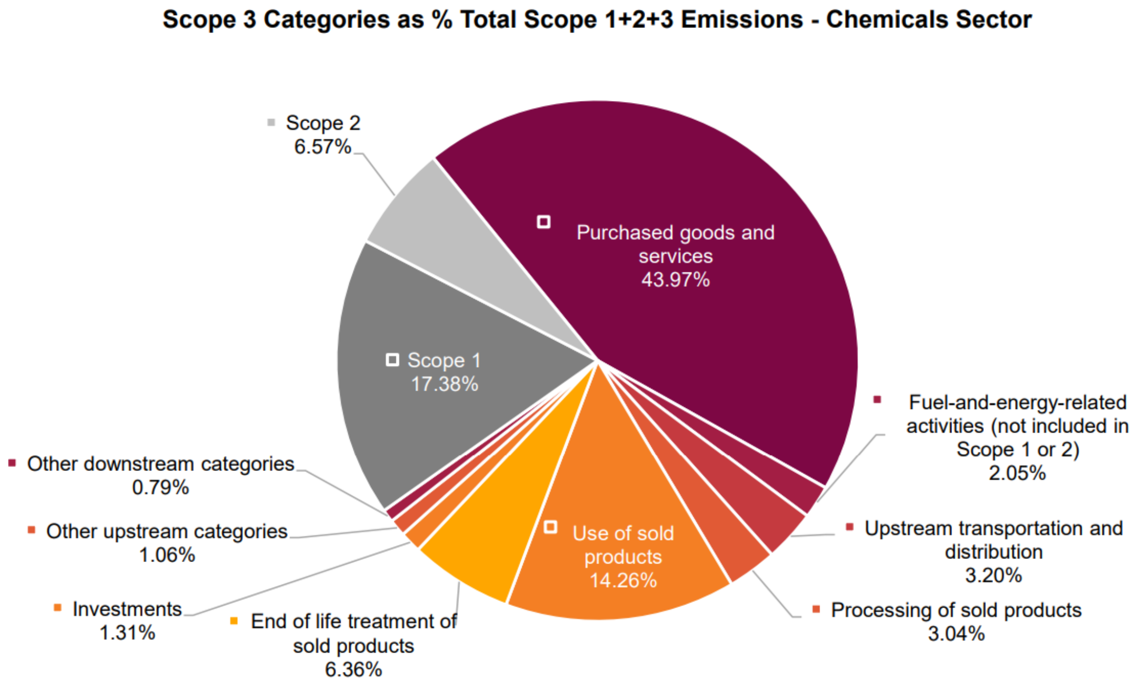


Figure 2: GHG emissions for each scope and scope 3 category as percentage of overall (scope 1, 2 and 3) emissions reported for the chemical sector (CDP, 2022).

Kearney (2022) gives a similar impression, see Figure 3.

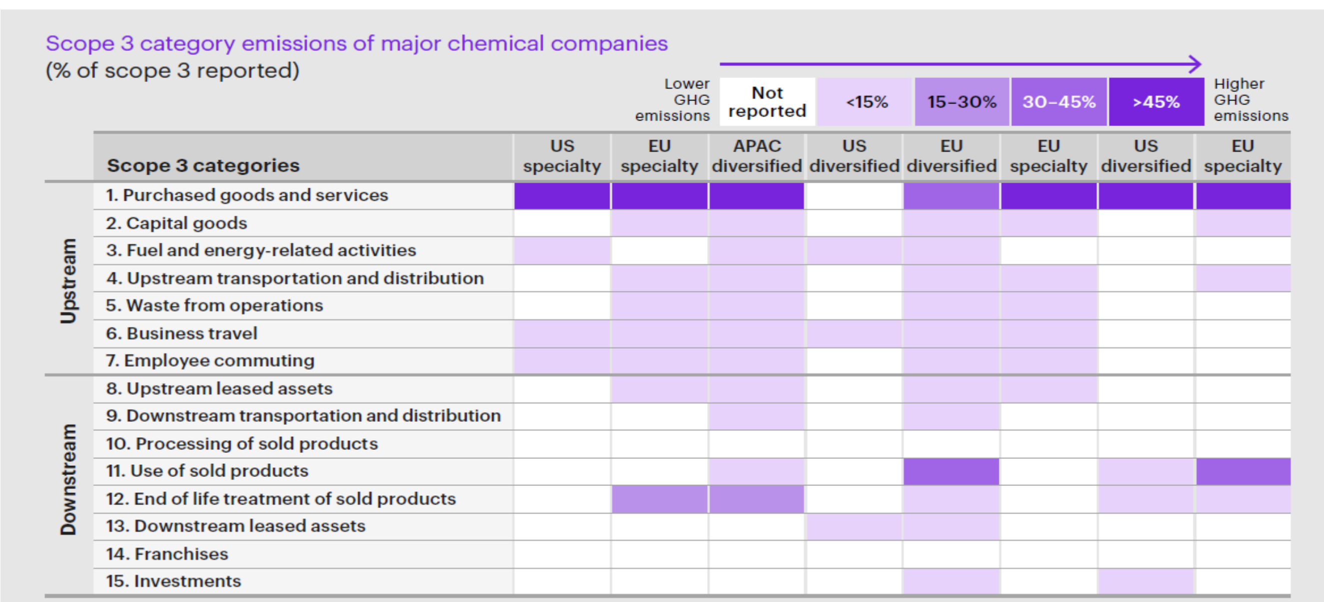


Figure 3: Breakdown of scope 3 emissions over the various categories for several types of US, EU or Asia-Pacific specialty / diversified chemical companies (Kearney, 2022).

Chemical Sector Scope 3 Hotspots

Table 3 summarizes literature sources informing our choice for major scope 3 hotspots for chemical sub-sectors.

Table 3: Literature sources describing scope 3 emissions per category per sub-sector.

Source	Chemical subgroup	Major scope 3 categories	Our interpretation
Pharmaceutical Supply Chain Initiative, 2020	Pharmaceuticals	This report presents emissions data in CO_2e for 11 scope 3 categories based on the CDP data submitted by pharmaceutical companies. The report highlights 6 major scope 3 categories as hotspots	Purchased Goods & Services is by far the biggest category, followed by Use of sold products, Capital Goods, Fuel & energy related emissions, Waste generated in operations, Downstream Transportation & Distribution. Other categories have smaller emissions
Energy Transitions Commission (ETC), 2020	Plastics	Product use & End of Life emissions	As per this report, the "use/demand-side" emissions forms nearly 50% of the total emission from plastics as a whole
Kearney, 2022	Multiple - Ammonia, Methanol, Ethylene, Propylene & Benzene	Purchased Goods & Services	As per this study, PG&S accounts for more than 50% of scope 3 emissions. The data considered for analysis is company sustainability report & their own analysis
Mission Possible Partnership (MPP), 2022	Ammonia	Use phase emissions (80% of total scope 3)	As per the report, emissions from use-phase of nitrogen fertilizers were around 400 MT CO_2e in 2020 (nearly 50% of the total emissions across the supply chain)

This table confirms the SBTi Chemicals Scoping Report's (SBTi, 2020) earlier conclusion to focus on end-of-life emissions / alternative feedstocks for plastics and use phase emissions for fertilizers.

The next phase of this project will also focus on providing guidance on how to treat feedstock which can be used as a raw material (covered under Category 1[27]) and also used as fuel (covered under Category 3[28]), for example methane. We expect to also benefit from the insights published by Bauer (2022).

[27] Category 1 is defined as Purchased goods and services, includes emissions generated during the extraction, production, and transportation of goods/services purchased or acquired by the reporting company.
[28] Category 3 is defined Fuel and energy related activities, including emissions generated during the extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company.

ANNEX 4: SECTORAL SCOPE 1 AND 2 DECARBONIZATION SCENARIOS

Available Emissions Pathways for the Chemicals Industry

The following sources provide a decarbonisation pathway for the chemicals sector on a global and/or regional basis. These will be reviewed as part of the next phase of this project.

- IEA Net Zero by 2050 report (IEA, 2021b).
- UTS Institute for Sustainable Future's One Earth Climate Model: Sectoral Pathways to Net-Zero Emissions (ISF, 2022).
- Zero-Emission Pathway for the Global Chemical and Petrochemical Sector (Saygin & Gielen, 2021).
- Electrification of the chemical industry—materials innovations for a lower carbon future (Eryazici, Ramesh & Villa, 2021).
- Planet Positive Chemicals (Systemiq, 2022).
- German roadmap chemicals strategy for sustainability (Geres et al., 2019).
- Roadmap for the Dutch Chemical Industry towards 2050 (Stork and Lintmeijer 2018).
- Industrial Decarbonization roadmap report by U.S. Department of Energy (US DoE, 2022).
- ICF's Europe Industrial Innovation: Pathways to deep decarbonisation of Industry (ICF, 2019).
- World Economic Forum in collaboration with Accenture's Net-Zero Industry Tracker based on the IEA's NZE model scenario (WEF, 2022a).
- Mission Possible Partnership Ammonia Transition Strategy report (MPP, 2022).
- Petrochemicals and Climate Change, Tracing Globally Growing Emissions and Key Blind Spots in a Fossil-Based Industry (Bauer et al., 2022).

Available Growth Projections for the Chemicals Industry

The following sources provide a summary of growth projections for the chemicals sector. Phase 2 of the project will focus on developing this list further and research in other models such as CEFIC, ICCA, ICIS and similar market research projections – including the suggestions received in the 2020 survey reported in the SBTi Chemicals Scoping Report. This will help strengthen and verify NZE's growth projections.

- IEA Net Zero by 2050 report (IEA, 2021b).

- UTS Institute for Sustainable Future's One Earth Climate Model: Sectoral Pathways to Net-Zero Emissions (ISF, 2022).
- Zero-Emission Pathway for the Global Chemical and Petrochemical Sector (Saygin & Gielen, 2021).
- Planet Positive Chemicals (Systemiq, 2022).

ANNEX 5: SECTORAL SCOPE 3 DECARBONIZATION SCENARIOS

Available Scope 3 Decarbonization Pathways

Select sources which include details on scope 3 decarbonization pathways, sub-sectors covered & the associated geography are shown in the table below.

Table 4: Overview of sources with scope 3 decarbonization pathways and their coverage.

Source	Sub-sectors considered	Decarbonization pathway or scenario?	Major scope 3 category addressed	Geography
Kearney, 2022	Products: Ammonia, Methanol, Ethylene, Propylene, Benzene, Chlor-Alkali	Pathway, provides abatement options for each of the products considered	PG&S	US & Europe (and APAC)
Energy Transitions Commission (ETC), 2020	Plastics	Pathway	End of Life & Use phase emissions	Global
Mission Possible Partnership (MPP), 2022	Fertilizer	Scenarios – BAU, Lowest Cost, Fastest Abatement	Use phase emissions	Global

Decarbonization Scenarios for Plastics

ETC (2020), COMET (2022), ETC/WMGE/EEA (2021), McKinsey & Company (2022), Systemic (2022a), TfS (2022), WBCSD (2013) and Zheng, J., Suh, S (2019) will be considered as well.

Decarbonization Scenarios for Fertilizers

MPP (2020), ICF (2013), IFA (2018), IFA/Systemiq (2022), IFA (website), McKinsey & Company (2020) and SBTi (2022b) will be considered as well.

WEF Scope 3 Task Force

This task force (WEF 2022b) aims to develop a revised framework for scope 3 emissions assessment and target setting methodology that can be widely adopted by manufacturers of chemicals and advanced materials, and to establish a pathway to its adoption. It will deliver an agreed framework for scope 3 emissions assessment, a proposed methodology for target setting and a proposed implementation plan for the sector.

ANNEX 6: SPECIFIC SCOPE 3 GUIDANCE / METHODOLOGIES RELEVANT FOR THE CHEMICALS SECTOR

Our literature search has found the following sources describing specifically how the chemical industry may assess their scope 3 emissions:

Organization	Year	Categories addressed				
		1	3	10	11	12
WBCSD (WBCSD, 2013)	2013	Y	Y	N	Y*	Y
Scope 3 Reporting (GHG Protocol, 2011a & b)	2011	Y	Y	Y	Y	Y
Product Carbon Footprint Guidelines (Together for Sustainability, TfS, 2022)	2022	Y	Y	N	N	***
PACT Pathfinder Framework (WBCSD, 2021)	2021	Y	Y	N	N	Y**
BASF Methodology for Product Carbon Footprint calculation (BASF 2021)	2021	Y	Y	N	N	N
Global Compact Network Germany (Global Compact Network Germany, 2017)	2017	Y	N	N	N	N
GHG Protocol (Land sector & Removals Guidance, Part 1) (GHG Protocol 2022)	2022	N	N	N	Y	Y

(*only direct emissions accounted, **optional if discarded – if the product at end-of-life is recycled, then emissions from recycling will be included, *** end-of-life emissions are addressed when necessary because of impact on category 1 emissions).

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