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Barriers, Challenges, and Opportunities for Chemical Companies to Set Science-Based Targets

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This document presents the results of the Science Based Targets initiative's chemicals sector scoping project with considerations for further target-setting method development. To summarize existing resources and support further work, the document provides an overview of current chemical company science-based targets, a proposed sector boundary for company activities, results of a stakeholder survey, and considerations for further research.

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1. Introduction and Overview

The chemicals sector plays a central but complex role in the transition to a low-carbon economy, not least because of the current ubiquity of and increased demand for chemicals in low-carbon and energy-saving technologies. While chemical products are expected to contribute to the well-below 2°C (WB2D) climate stabilization outcome described in the 2015 Paris Agreement, emissions related to chemical production will need to be reduced to maintain global emissions budgets. As of 2020, the chemicals value chain is the third-largest industrial subsector source of greenhouse gas (GHG) emissions behind cement and steel.

The chemicals sector's annual global scope 1 GHG emissions amount to approximately 1.8 gigatons of carbon dioxide equivalent (Gt CO_2e) (of which non-CO_2 GHG emissions are estimated at 400 megatons [Mt] CO_2e) (IEA 2020).[1] While the chemicals sector has achieved large energy efficiency improvements—more than a 55 percent improvement in the European Union (EU) between 1991 and the mid-2010s—and sporadic emissions reductions, including in the United States from 2000 to 2015, high production growth has broadly overtaken these shifts to drive aggregate global emissions growth (Rissman et al. 2020; Aden 2017; Zheng and Suh 2019). Climate science indicates that global emissions need to be reduced by approximately 75 percent between 2020 and 2050 to limit warming this century to well-below 2°C (WB2D) above preindustrial levels; least-cost energy and climate modeling of the chemicals sector indicates that it needs to reduce emissions by more than 50 percent between 2014 and 2050 to support a WB2D scenario (SBTi 2019; IEA 2017). At present, SBTi addresses chemical companies in the same way as the rest of the economy without specific attention to sector-specific emissions sources or intensity pathways.

Three factors that differentiate the chemicals sector from its energy and emissions-intensive peers are its high use of fossil fuels as feedstocks (rather than for energy or heat), its broad variety of products, and its high degree of intermediate goods trade. In 2018, the chemicals sector accounted for 14 percent of total global oil demand. It is also the largest industrial consumer of oil and gas, half of which is used as feedstock (IEA 2020). Feedstock use, whereby hydrocarbons are incorporated into chemical products rather than consumed for energy, leads to high potential end-of-life (EOL)–related emissions. Estimates of end-of-life related emissions depend on assumptions such as the portion of materials that are recycled, incinerated, or landfilled. One plastics-focused study estimated end-of-life to account for 9 percent of total life cycle emissions (Zheng and Suh 2019), and the Dutch (Stork and Lintmeijer 2018) and German (Geres et al. 2019) chemicals sectors' 2050 energy and climate roadmaps estimated scope 3 EOL emissions would amount to approximately the same order of magnitude as the sector's scope 1 and 2 emissions if all products were to be incinerated at the end of their useful life

[1] IEA's ETP 2020 reports ~1.4 gigatons of carbon dioxide (Gt CO_2)/year. Appendix A, Question 13 lists additional data sources describing the current GHG emissions of the global chemicals sector; Section 5 of this report includes information on non-CO_2 GHG emissions.

span. While estimates vary, it is clear that scope 3, and particularly category 12 (End-of-life), emissions are material for the sector broadly.

Because per-capita demand for chemical products does not exhibit the same saturation effects as other industrial sectors, chemicals production is projected to grow more quickly than steel and cement through 2030, with significant differences across the range of products (IEA 2020).[2,3] The chemicals sector's GHG emissions and their abatement are thus central challenges for achieving global climate stabilization. The Science Based Targets initiative (SBTi) aims to refine the chemical sector's greenhouse gas emissions reduction pathway with a holistic approach (including scope 3 value chain emissions). Intermediate science-based targets ensure that companies start in time and stay on track, even when the average lifetime of chemical plants is long (upstream units such as steam crackers are typically operated for 30 years or longer) (IEA 2020).

SBTi is a voluntary platform that supports company climate ambition through transparent and robust GHG emissions reduction targets. In recognition of the central importance of the chemicals sector for achieving broader climate stabilization, the SBTi launched a chemicals sector scoping project in February 2020. The World Resources Institute (WRI) leads this project with technical support from Guidehouse consulting. To engage a broad range of stakeholders, the project included an Expert Advisory Group, stakeholder e-mail list, and a public survey that was conducted during the summer of 2020. This document presents results of the SBTi chemicals sector scoping project and considerations for further method development. The scoping document covers existing SBTi methods; chemical companies with science-based targets (SBTs); stakeholder survey results; and considerations for further research and method development. The further research section identifies physical intensity pathways for key products, scope 3 resources, and new end-of-life target formulations as recommended next steps. The appendices provide detailed results of the stakeholder survey and other supporting information.

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[2] IEA's Energy Technology Perspectives (ETP) 2020 compares production growth for chemicals (high-value chemicals, ammonia, and methanol), with steel and cement until 2030. This source also indicates that there will be average annual growth rate differences between various products—for example, currently 3–4 percent per year for various plastics resins and around 1 percent per year for ammonia. Note that the growth rate of specific chemical products is uncertain and influenced by technical innovations and material substitutions.

[3] Appendix A, Question 17 provides an overview of sources that could be used to address future growth of the chemicals sector in Phase II of the SBTi chemicals sector scoping project.

2. SBTi Background and Current Targets

The SBT initiative mobilizes companies to set science-based targets and boosts their competitive advantage in the transition to a low-carbon economy. The initiative is a collaboration between the Carbon Disclosure Project (CDP), the United Nations Global Compact (UNGC), World Resources Institute (WRI), and the World Wide Fund for Nature (WWF), and is one of the We Mean Business coalition commitments. The chemicals sector scoping project is one of SBTi's ongoing sector development projects. Targets adopted by companies to reduce GHG emissions are considered "science-based" if they 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 preindustrial levels and to pursue efforts to limit warming to 1.5°C. Among companies globally, there is a growing momentum for science-based target setting through the SBTi. As of December 2020, 1,090 companies and financial institutions have publicly joined the SBTi, among which 520 companies have reviewed targets that meet SBTi criteria (SBTi 2020a, "Companies Taking Action").

The pace of companies joining SBTi doubled for the period from April 2018 and October 2019 compared to the previous 36 months. Likewise, between November 2019 and October 2020, 193 scope 1 and 2 targets have been approved by the SBTi (57 percent of which are 1.5°C–aligned), not including the streamlined small and medium-sized enterprises (SME) service. This shows a major increase compared to previous years, with the SBTi approving on average 16 targets per month, compared to an average of just 6 per month over the previous four years. When SBTi was launched in 2015, science-based target setting emerged as a novel corporate sustainability practice. The onset of the global COVID pandemic in 2020 has not slowed the pace of company commitments such that SBTi has exceeded its "1,000 committed companies by end of 2020" goal. Today, SBTs are becoming a recognized vehicle for transparent and robust corporate climate ambition.

SBTi Target-Setting Methods

SBTi presently uses three main publicly available target-setting methods for **scope 1 and 2 targets**: absolute emissions contraction, the Sectoral Decarbonization Approach,[4] and economic intensity contraction. More background on SBTi target components is available in Appendix C.

SBTi Criteria

To ensure target rigor and credibility, SBTi has published a range of mandatory criteria for all company SBTs. As of 2020, there are more than 20 criteria that are updated annually and can be reviewed in detail in the SBTi criteria resource ("Resources," SBTi 2020c). The following is a

[4] While the first version of the Sectoral Decarbonization Approach presented an economic intensity pathway for chemicals and petrochemicals (Krabbe et al. 2015), the SDA is generally a physical intensity method.

condensed, but not exhaustive, list of the key elements of the criteria most relevant for chemical companies:

- An SBT shall cover a minimum of 5 years and a maximum of 15 years from the date the target is publicly announced. Companies are also encouraged to develop long-term targets (e.g., up to year 2050).
- The boundaries of a company's SBT shall align with those of its GHG inventory.
- SBTs shall cover at least 95 percent of company-wide scope 1 and 2 emissions.
- The emissions reductions from scope 1 and 2 sources shall be aligned with well-below 2°C or 1.5°C decarbonization pathways.
- Companies shall use a single, specified scope 2 accounting approach ("location-based" or "market-based") for setting and tracking progress toward an SBT.
- Direct emissions from the combustion of biomass and biofuels, as well as GHG removals associated with bioenergy feedstock, must be included alongside the company's inventory and must be included in the target boundary when setting an SBT. If biogenic emissions from biomass and biofuels are considered climate neutral, the company must provide justification of the underlying assumptions. (Any other GHG removals that are not associated with bioenergy feedstock are currently not accepted to count as progress toward SBTs or toward net emissions in the inventory.)
- If a company has significant scope 3 emissions (over 40 percent of total scope 1, 2, and 3 emissions), it shall set a scope 3 target.
- Scope 3 targets generally need not be science-based but should be ambitious and measurable and clearly demonstrate how a company is addressing the main sources of value chain GHG emissions in line with current best practice.
- The scope 3 target boundary shall include the majority of value chain emissions, for example, the top three emissions source categories or two-thirds of total scope 3 emissions.[5] The nature of a scope 3 target will vary depending on the emissions source category concerned, the influence a company has over its value chain partners, and the quality of data available from those partners.
- SBTs should be reviewed at a minimum every five years to reflect significant changes that would otherwise compromise their relevance and consistency. In general, a company must recalculate its targets if:
    - scope 3 emissions become 40% or more of overall scope 1, 2 and 3 emissions;
    - exclusions in the inventory or target boundary change significantly and/or exceed allowable exclusion limits (more than 5% of scope 1 and 2 emissions and/or more than 32% of scope 3 emissions);
    - methodology for calculating the base year inventory (e.g., improved emissions factors or access to primary data) changes;

[5] Per SBTi target validation criteria, scope 3 targets must cover at least two-thirds of total mandatory scope 3 emissions, as defined in Table 5.4 of the GHG Protocol Scope 3 standard.

  - methodology for calculating the target (e.g., growth projections or other assumptions) changes;
  - or change in company structure (e.g., an acquisition or divestment) significantly changes the inventory, target boundary, or target ambition, at which point SBTi will reassess the company's targets. Companies are expected to determine significant changes.
- Offsets and avoided emissions shall not count toward SBTs.[6]

Acceptance and implementation of the scope 3 criteria have been a signal achievement of the SBT initiative insofar as companies did not previously take such responsibility for their value chain emissions. Chemical companies can choose from the following methods for setting **scope 3 targets**:

- **Absolute contraction:** Reduce absolute emissions by a minimum of 1.23 percent annually to keep global temperature increase within 2°C.
- **Physical intensity:** Reduce emissions intensity per physical activity or production output with a unit that's representative of a company's portfolio (e.g., tonnes GHG per tonnes of chemical product), which, when translated into absolute emissions reduction terms, does not result in absolute emissions growth, and leads to linear annual intensity improvements equivalent to 2 percent, at a minimum.
- **Economic intensity:** Reduce emissions intensity per value added by at least an average of 7 percent year-on-year.
- **Supplier/customer engagement:** Reduce emissions by committing to drive the adoption of SBTs among suppliers or customers (Tier 1) over a maximum five-year time frame.

These methods and criteria have served as the basis for the first wave of chemical company SBTs described below.

Chemical Companies with SBTs

As of December 2020, the SBTi recognizes 29 chemical companies that have publicly committed to setting science-based targets, of which 11 have approved targets that meet all the current target-setting criteria. Two of the approved chemical company targets are aligned with 1.5°C stabilization this century—the most ambitious level of target. Considering the chemicals sector's diverse product mix and circumstances, there is no single approach or method for all chemical companies, and companies are free to choose among the methods to set their targets. Appendix D provides a detailed overview of the companies and the targets they have set. The target language and summary emissions in Figure D1 show the extent of emissions covered,

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[6] The SBTi is preparing separate net-zero guidance that covers offsets, compensation, and neutralization; however, net-zero targets are intended to complement and extend beyond company SBTs, not replace or supplant them. SBTi is not considering including offsets or avoided emissions in SBTs.

reflecting that scope 3 emissions generally form a significant portion of the sector's overall climate impact.

3. Scope and Composition of Chemicals Sector

When developing target-setting resources for the chemicals sector, it is relevant to establish what is, and what is not, covered by company SBTs.[7] As SBTi sector modeling has thus far been based on the International Energy Agency's (IEA's) Energy Technology Perspectives (ETP) scenarios, the SBTi chemicals sector scoping project proposes to adopt the sector boundary and definition for the chemicals sector used by the IEA in its ETP to maintain consistency.[8]

The industrial sector scoping in the IEA's ETP (2020) modeling is based on the International Standard Industrial Classification (ISIC) (UN DESA 2008) with the chemicals sector covering **Divisions 20 and 21,**[9] specifically the following:

- **Division 20**: Manufacture of chemicals and chemical products
    - This division includes the transformation of organic and inorganic raw materials by a chemical process and the formation of products. It distinguishes the production of basic chemicals that constitute the first industry group from the production of intermediate and end products produced by further processing of basic chemicals that make up the remaining industry classes.
    - **Group 201**: Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics, and synthetic rubber in primary forms:
        - This group includes the manufacture of basic chemical products, fertilizers, and associated nitrogen compounds, as well as plastics and synthetic rubber in primary forms.
    - **Group 202**: Manufacture of other chemical products:
        - This group includes the manufacture of chemical products other than basic chemicals and man-made fibers. This includes the manufacture of a variety of goods such as pesticides, paints and inks, soap, cleaning preparations, perfumes and toilet preparations, explosives and pyrotechnic products, chemical preparations for photographic uses (including film and sensitized paper), gelatins, composite diagnostic preparations, etc.
    - **Group 203**: Manufacture of man-made fibers:
- **Division 21**: Manufacture of pharmaceuticals, medicinal chemicals, and botanical products (no further disaggregation in ISIC)

[7] In the Expert Advisory Group (EAG) of September 9, 2020, eight participants considered the lack of one overarching taxonomy a barrier toward setting science-based targets, six did not, and three had no opinion. The sector scope will inform the distribution of scope 1, 2, and 3 emissions for individual companies.

[8] Additionally, there was an absence of a clear preference from the chemical companies in the SBTi Chemicals Sector Survey Findings (see Appendix A, Question 5); the Carbon Disclosure Project (CDP) taxonomy seems to be commonly used, but due to the relatively limited amount of respondents (32), no firm conclusion can be drawn.

[9] Personal communication with Industry Lead, Energy Technology Policy Division at International Energy Agency (IEA), November 2020.

The chemicals sector includes bottom-up IEA ETP (2020) modeling of the following:

- High-value chemical production (IEA's ETP defines these as ethylene, propylene, benzene, toluene, and xylene[10]; production routes include steam cracking, bioethanol dehydration, naphtha catalytic cracking, propane dehydration, methanol-to-olefins, and methanol-to-aromatics)
- Methanol- and ammonia-production (both fossil fuel–based and biomass-based and electrolysis-based).

The other parts of the chemicals sector are covered in a more crosscutting manner:

- Fuel and emissions associated with any electricity generation are accounted for in the power sector.
- Fuel and emissions for heat, unless sold as imported heat (e.g., like a district heating network) are recorded within the chemical sector boundary.
- In case of carbon capture and utilization (CCU), the energy required to capture CO_2 (and associated emissions) is included in the sector supplying the CO_2.

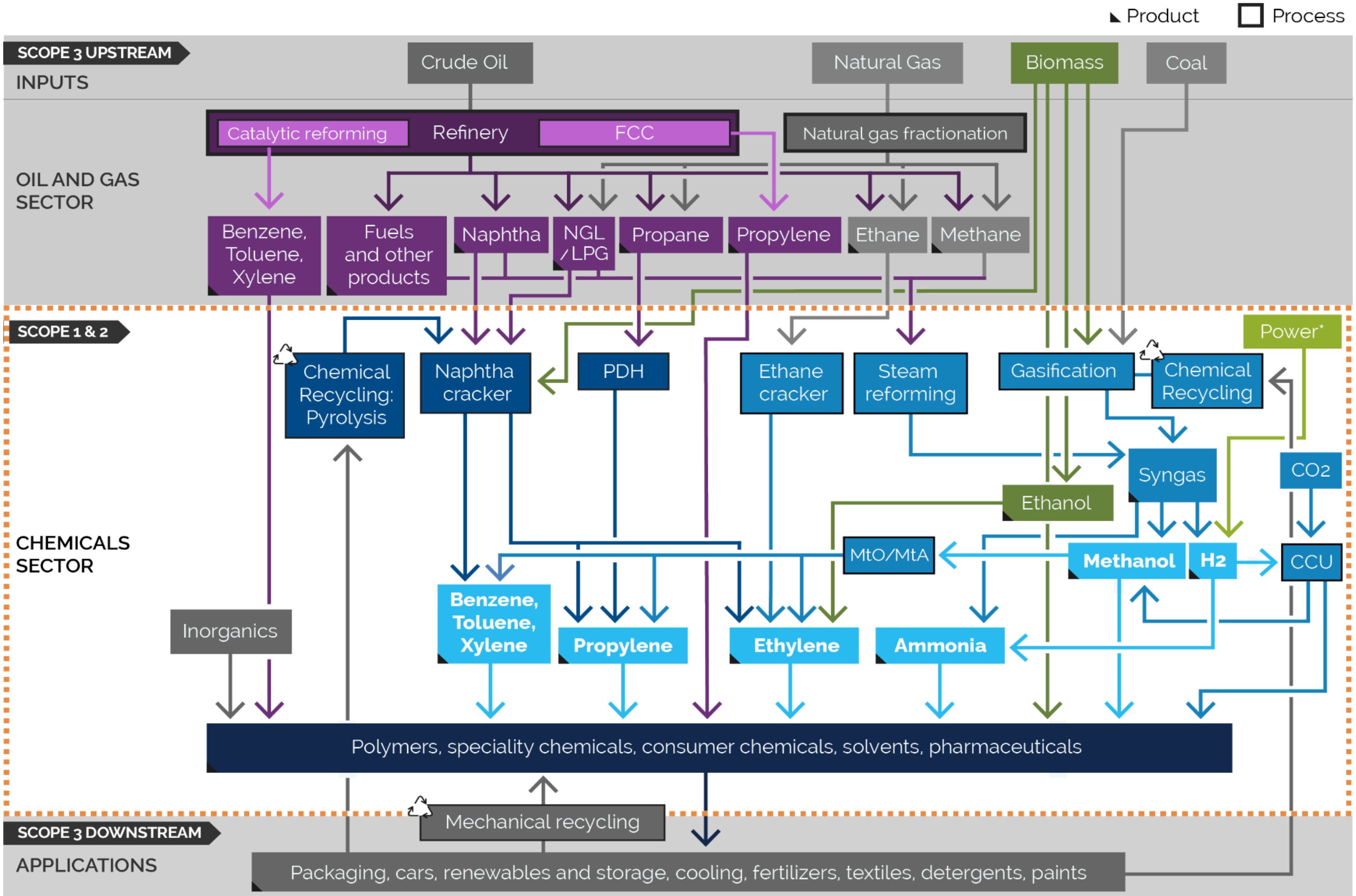
IEA's ETP (2020)[11] further indicates the following:

- The production of **biofuels**[12] is covered within the fuel transformation model on the supply side, not in the chemicals sector.
- The production of **naphtha**[13] in refineries, and the production of propane in refineries, are both *not* included in the scope of the chemicals sector in IEA's modeling, but within the refining model on the fuel transformation side. The conversion of naphtha to high-value chemicals and propane dehydrogenation to produce propylene are covered in the chemicals sector.
- In general, any **methanol/ammonia** that is used in the future purely as a green transportation fuel is covered within the fuel transformation sector—the chemicals sector model covers the quantities used for existing and industrial applications.
- To illustrate how the model deals with **carbon capture and utilization** and **hydrogen use**: Production of methanol to satisfy existing and industrial demand for methanol, by combining green hydrogen (from electrolysis) with CO_2 is modeled (as electricity demand) within the chemicals sector; the CO_2 is sourced in the supply model. The energy consumption for the capture of CO_2 is accounted for in the supply sector.
- The production of **pharmaceuticals.**

The resulting scope of the chemicals sector is visualized in Figure 1 below.

[10] This definition of high-value chemicals is used throughout this document.
[11] Personal communication with a key author from IEA ETP 2020.
[12] The desire for consistency with the IEA modelling scope is taken above the preference to include biofuels in the scope of the chemicals sector, as expressed in the survey (see Appendix A, Question 7). Reasons for inclusion included the chemical nature of the production of biofuels and the similarity between the production processes. Biofuels are linked to chemical businesses and chemical production—the only difference is feedstock composition. Furthermore, the GHG emissions abatement levers are similar to bioplastics and biochemicals.
[13] Many chemical companies agreed that as a raw material, naphtha production emissions should be included in scope 3 and not scope 1 and 2 (seven participants of the Expert Advisory Group of September 9, 2020, supported this, four opposed, and seven had no opinion).

Figure 1: Visualization of Chemicals Sector Components and Boundaries



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.

The middle band with the dotted border in Figure 1 represents the scope of the chemicals sector. The colors are used to distinguish between various product and process flows. This boundary indicates scope 1 and 2 emissions from processes inside and outside the chemicals sector as follows:

- *Scope 1 and 2 emissions* of the chemicals sector:
  - Scope1 and 2 emissions
  - Steam crackers producing ethylene, propylene, benzene, toluene, xylene
  - Production of hydrogen/syngas, and production of ammonia and methanol
  - Production of bio-based chemicals
  - Production of CCU-based chemicals
  - Chemical recycling[14]; continued inclusion in the chemicals sector requires further assessment
  - Production of industrial gases[15]
  - Pharmaceuticals[16]

- *Scope 3 emissions* of the chemicals sector:
  - Production of naphtha in refineries
  - Production of propylene (fluidized catalytic cracking [FCC]) and benzene, toluene, and xylene (BTX) (catalytic reforming) in refineries
  - Production of ethane as side product of natural gas
  - Mechanical recycling

The aim of this figure is to provide a consistent boundary for chemicals and oil and gas sector emissions accounting. This boundary implies that there will be companies operating refineries and, for example, steam crackers, which may well be required to combine the approaches of both sectors when setting targets. SBTi already allows companies to combine approaches and targets where they cross multiple sectors. In this case overlap may sometimes be unavoidable among companies operating in different parts of the value chain starting from the oil and gas sector all the way downstream to the production of downstream goods such as polymers.[17] One implication of this proposed approach is that oil and gas companies would be expected to continue to include refinery-related emissions in their scope 1 and 2 targets, and that these would be scope 3 emissions for chemical companies (unless the chemical companies also own and operate the refineries—as chemical companies are typically doing currently).

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[14] Not all chemical recycling routes have been visualized.
[15] Hydrogen (in light blue in Figure 1) is one example of an industrial gas; others (not shown in the figure) include carbon monoxide (CO), nitrogen (N_2), and carbon dioxide (CO_2) (a non-exhaustive list).
[16] Inclusion of pharmaceuticals in the scope of the chemicals sector is in line with the preference expressed in the survey, noting that most respondents did not have an opinion. Reasons for support: chemicals are used to produce pharmaceuticals, which is an industry expected to grow, and the challenges associated with collecting data on "purchased goods" emissions. Reasons for dissent: differences in produced quantities, ancillary materials, footprint per ton, regulatory oversight, and the industry structure.
[17] More detail on the position of FCC and catalytic reforming is presented under "Disaggregating the Chemicals Sector" discussion below.

Forward options: In principle the scope of the chemicals sector has been defined above, which chemical companies may reference when setting SBTs. However, there still are uncertainties to be tracked, which could change the scope choices outlined above. Going forward:

- The dividing line between "oil and gas" and the "chemicals" sectors must be consistently drawn by chemicals and oil and gas companies.
- The implications of moving the pharmaceuticals sector to the chemicals sector need to be assessed for pharmaceutical companies. As of December 2020, there are 25 companies self-classified under the pharmaceuticals, biotechnology, and life sciences sector that have committed to set SBTs, of which 19 have approved SBTs. These companies will not be expected to update their targets based on the proposed sector boundary and should continue to reduce emissions using sector-agnostic pathways. The SBTi is still exploring the proposed chemicals sector boundary specifically for pharmaceutical companies; thus, companies that plan to commit or set an SBT should proceed using existing SBTi company guidance and methods.
- The SBTi-wide desire to build sector-level 1.5°C physical intensity pathways (which the IEA has not published) needs additional research.
- Assessment and guidance are needed to determine which recycling processes fall under the chemicals sector and which fall under International Standard Industrial Classification of All Economic Activities (ISIC), Division 38, Group 383, Class 3830, Materials Recovery[18] (UN DESA 2008)— this includes the pyrolysis and gasification processes visualized in the chemicals sector in Figure 1 above. Inclusion in the latter category could in some cases reduce the demand for production of chemicals. The impact of mechanical and chemical recycling processes falling inside or outside the scope of the chemicals sector should be assessed when further developing the methodology.
- When basing the trajectories for individual products on IEA's ETP, consider accounting for the production of chemicals that IEA models in other sectors (such as methanol and ammonia used as fuels, and propylene and BTX made in refineries).
- 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.

Disaggregating the Chemicals Sector

The chemicals sector is diverse and heterogeneous. Depending on where a chemical company sits in the value chain, it may produce building blocks such as high-value chemicals (including ethylene and propylene) and ammonia through very energy-intensive processes, resulting in large scope 1 and 2 emissions. At the same time, chemical companies produce complex specialty chemicals and often purchase building blocks requiring significantly less energy, resulting in relatively low scope 1 and 2 emissions and larger scope 3 emissions in category 1

[18] ISIC Division 38, Group 383, Class 3830—Materials Recovery—is relevant for chemical recycling and for chemical companies that operate mechanical recycling processes.

(Purchased goods and services). Furthermore, the chemicals sector produces an enormous number of different products (IEA 2020). Finally, process emissions, which occur during the production of some chemicals, require separate abatement levers. Given this diversity, there is a compelling case to disaggregate the chemicals sector when developing sector-specific guidance for setting SBTs, albeit it is not possible to address all products individually.

"*We produce many tens of thousands of products in many countries*"—Anonymous chemical company respondent.

Respondents to the survey indicated that disaggregating the chemicals sector could be done at production group level (e.g., plastics, surfactants, solvents) or at product level (e.g., ammonia) and potentially at subsector level (e.g., "base organics" and "polymers"). The disaggregation of the chemicals sector could be done in the following ways:[19]

- Develop new pathways for **key individual products**, such as ammonia; and/or
- Cover all the other products with specific pathways for **product groups** or **subsectors**.

Key individual products

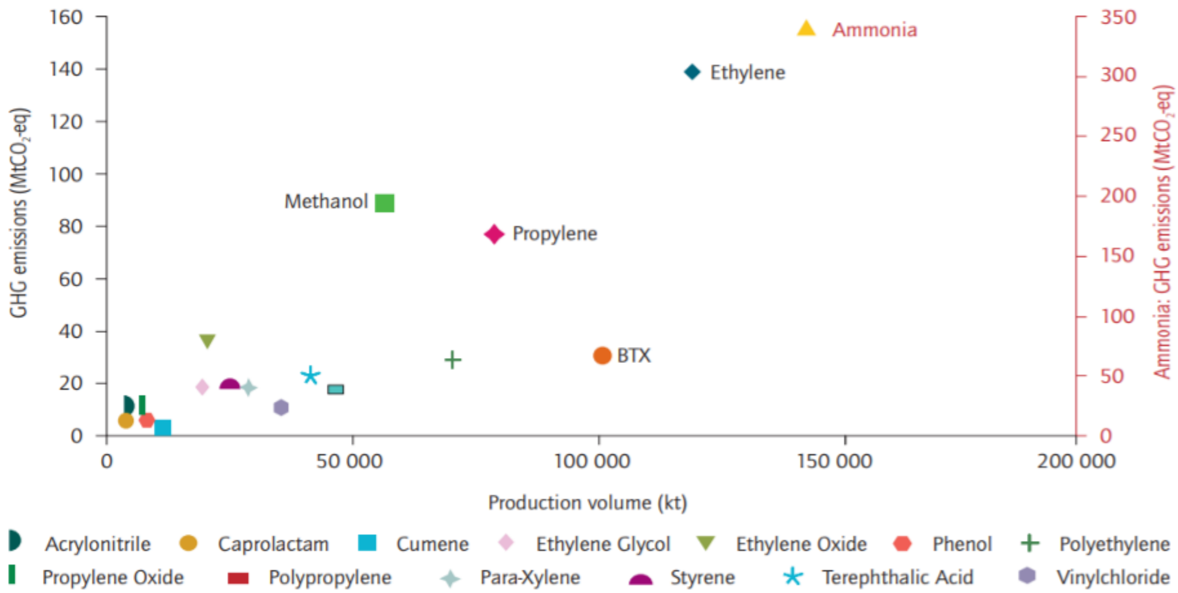
The production of a limited number of products generates most of the chemicals sector's scope 1 emissions. The production of the 18 highest-volume chemicals emits more than ~75 percent of the chemicals sector's scope 1 and 2 greenhouse gas emissions globally, as shown in Figure 2 (IEA, ICCA, and DECHEMA 2013). European Commission et al. 2009 also indicates the dominance of a limited number of chemicals products in the overall sector greenhouse gas emissions[20]. As building blocks for the rest of the chemicals industry, these chemicals represent a significant opportunity to reduce scope 3, category 12, end-of-life treatment of sold products emissions.[21]

[19] The survey gives further thoughts on subdivision criteria (Appendix A, Question 19).

[20] This report by the European Commission et al. (2009), "Methodology for the Free Allocation of Emission Allowances in the EU ETS Post-2012 Sector Report for the Chemical Industry" states that the top 18 most emission-intensive activities in Europe emit 89 percent of the (petro)chemical sector's GHG emissions (based on communication with CEFIC in 2009); note that this percentage will now likely be somewhat lower with the abatement of nitrous oxide (N_2O) emission in nitric acid production—in this data set, it is shown as the top emitter.

[21] High-value chemicals (defined by the IEA as ethylene, propylene, benzene, toluene, and xylene) represent the start of the current, fossil-based, hydrocarbon value chains, while ammonia represents the fossil-based start of the N-component of fertilizers. Replacing these production routes with, for example, bio-based, recycled, or carbon capture and utilization (CCU)–based low carbon routes offers the potential to mitigate these emissions (directly, such as recycling materials, or indirectly, such as first capturing CO_2 from the air as feedstock for hydrocarbons that are incinerated at the end of their life).

Figure 2: Global Greenhouse Gas Emissions versus Production Volumes of Top 18 Chemicals, 2010



Notes: GHG = Greenhouse gas; Mt CO_2e = Megatons carbon dioxide equivalent; BTX = Benzene, toluene, xylene; Kt = kilotonne. GHG emissions for olefins in this figure represent that of steam cracking process. Ammonia is presented on a different axis on the right. Figure is based on CO_2 emissions only and does not include other greenhouse gases.
Source: IEA, ICCA, and DECHEMA 2013.

The IEA's recently published ETP (2020) calls ammonia, ethylene, methanol, propylene, and benzene, toluene, and xylene (BTX) the "seven chemical building blocks underpinning the industry." The global production volumes of these seven chemicals represents approximately two-thirds of the chemicals sector's energy use[22] (ETP 2020); they are listed in Appendix E. Additionally, Figure 2 illustrates that the production of these chemicals leads to the highest greenhouse gas emissions. Current IEA modeling continues to focus on these chemicals, as many abatement routes rely on them.[23]

Product Groups or Subsectors

The IEA does not subdivide the chemicals sector further than the seven building blocks mentioned above and "the rest." The International Standard Industrial Classification (ISIC) (see earlier Classes 201, 202, 203, and Division 21) in essence divides the chemicals sector into basic chemicals and others (with some further disaggregation for "others"), which does not seem to provide a practical disaggregation for the purpose of target setting.

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[22] The other portion is spread out among smaller categories of products; see Figure 2.
[23] Abatement routes include several CCU routes (e.g., methanol, potentially followed by methanol-to-olefins), bio-based routes toward ethylene and BTX, bio-naphtha, electric cracking, and using pyrolysis oil as cracker feedstock. Not covered by these seven building blocks are, among others, functional CCU (to produce polyols), functional bio-based chemicals (such as polylactic acid), and mechanical recycling. Within chemicals, ammonia accounts for close to 50 percent of cumulative emissions, methanol, and high-value chemicals account for about 25 percent each.

However, the activity group classification used by CDP could provide a more detailed subdivision, distinguishing the following:

- Agricultural chemicals
- Basic plastics
- Biofuels
- Inorganic base chemicals
- Nitrogenous fertilizers
- Other base chemicals
- Personal care and household products
- Specialty chemicals

In the survey, and in the second Expert Advisory Group meeting, the question was raised whether industrial gases should be treated as a separate sector, subsector, or product group.

Moving forward, the intention is to subdivide the chemicals sector into several products, at a minimum:

- The seven building blocks identified above:
    - High-value chemicals (ethylene, propylene, benzene, toluene, xylene)
    - Ammonia
    - Methanol
- Given the central and increasing role of hydrogen, it could also be logical to treat H_2 as a key individual product.[24]

The remainder of the chemicals sector can then be further subdivided into some product groups or subsectors (e.g., for "industrial gases" such as nitrogen [N_2], carbon monoxide [CO], and carbon dioxide [CO_2], or fertilizers). In this product group/subsector approach, it is important to consider how to deal with **functional bio-based chemicals** (different molecules providing the same functionality as their fossil-based equivalent); likewise, for **functional CCU chemicals**.

Most of the individual products included here (propylene, benzene, toluene, xylene, ammonia, and methanol) are produced in the chemical industry, but some may also be produced in other sectors in the future. When developing new intensity pathways, the emissions impact of varying processes and sectors for a given product should be taken into consideration. Product intensity pathways need to be reconciled to maintain consistency and to avoid creating loopholes. Options to maintain consistency could include moving all production routes for given products to a particular sector.

[24] Treating hydrogen as a key individual product comes with additional challenges, as green hydrogen is also an abatement lever for the production of many other key products. Note that hydrogen is included here in "industrial gases."

4. Summary of Stakeholder Survey Results

During the summer of 2020, SBTi conducted a public survey to gather chemicals sector stakeholder perspectives on scope 3 data, sector low-carbon transformation, and the challenges and opportunities for setting company SBTs.[25] The survey was completed by 59 respondents, of whom 40 worked for chemical companies. In their survey responses, employees of chemical companies indicated a variety of challenges to setting science-based targets (Appendix A, Question 11).[26] A relatively high share of respondents (>30 percent) indicated the following six barriers to target setting; these are listed in order of decreasing "popularity" below.

1. Scope 3 Data Availability

The diversity and wide use of products across numerous sectors' supply chains compounds the scope 3 challenges faced by chemical companies. Low availability and quality of data was the top issue referenced by survey respondents. Current SBTi practice of accepting screening and estimated scope 3 data helps companies that are new to developing company GHG emissions inventories. Respondents noted that current reporting on scope 3 can be onerous for suppliers and difficult for purchasing companies and suggested this could be improved by making relevant data available in a centralized and automated manner, for example, by building on current life cycle assessment (LCA) and benchmarking information.

2. Technological Readiness

This point is summarized by a company respondent who indicated that "the technological readiness for some of the high-CO_2 abatement projects is too low." Chemicals sector stakeholders perceive an urgency to develop and scale up innovations, including the need for sufficiently affordable renewable energy that could impact the GHG emissions reduction trajectories of some product groups differently than others, and should be considered when subdividing the chemicals sector into subsectors. Companies also mentioned the lack of SBTi acknowledgment of their long-term research and development (R&D) investments as a challenge for accelerating technological transformation. The concern about technological readiness also links with questions about SBTi treatment of negative emissions technologies in companies' SBTs and net-zero target formulations.[27]

3. Business Model Uncertainty

"Clients are not willing to pay more for products with a lower greenhouse gas footprint."[28] While SBTi provides information about the business case for mitigation in SBTi's Science-Based Target Setting Manual (SBTi 2020d), cost allocations vary per sector and company.[29] When clients of the chemicals sector set science-based targets, they often commit to reducing their

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[25] Detailed survey results, including a description of survey respondents, is available in Appendix A.
[26] Based on respondents who indicated they work for a chemical company.
[27] The SBTi is developing a standard to guide company net-zero target setting; through their SBTs, companies are expected to continue reporting and reducing their scope 1, 2, and 3 emissions; additional information is available at https://sciencebasedtargets.org/net-zero.
[28] This is a representative sentiment selected by survey participants rather than an individual quote.
[29] The SBTi manual is available at https://sciencebasedtargets.org/resources/files/SBTi-manual.pdf.

scope 3 emissions from purchased goods and services, which are direct emissions from chemical companies. This contributes to a growing demand for chemical companies to set science-based targets.

4. Method Availability

As discussed above and detailed in Appendix D, many chemical companies have used existing sector-agnostic methods to set SBTs. However, some have expressed a preference to postpone their science-based target development until the development of sector-specific physical intensity or other methods become available. While this project reflects SBTi recognition of the sector's importance and intention to develop further resources, chemical companies are encouraged to work with SBTi to set GHG mitigation targets in the absence of physical intensity methods for all products.

5. Policy Links

The uncertainty around future costs of emitting GHGs makes it difficult for companies to determine the correct timing of investments and GHG emissions reduction measures. Furthermore, respondents noted that current policies primarily cover the sector's scope 1 and 2 emissions, while science-based target setting also aims at reducing scope 3 emissions. Related to the policy point, one company suggested differential carbon taxes linked to emissions intensity to incentivize effective mitigation actions. SBTi is exploring how the initiative can best connect sector and company criteria with policy and regulatory mechanisms.

6. Cooperation over the Value Chains

"The process of involving our suppliers or other new partners in the reduction of the scope 3 emissions will be too challenging."[30] While this challenge exists for all industrial sectors, chemical companies have vocalized that it may be more challenging for the sector, given the difficulty of accessing primary data on downstream categories including end-of-life (EOL) emissions. This is related to the perception that delivering on scope 3 targets is outside of the chemical companies' control due to the following:

- Limited leverage (as the few chemical companies upstream in the value chain have many clients); and
- High diversity and limited data availability (many different products, produced in many countries with even more applications).

While the first group of leading chemical companies have already set and begun to implement supplier engagement targets, increased engagement with investors, advocacy groups, and other stakeholders will be important for catalyzing broader cooperation across value chains. This broader coordination will also be influenced by the SBTi Net Zero Standard and the negative emissions accounting considerations mentioned above.

[30] This is a representative sentiment selected by survey participants rather than an individual quote.

Other Issues Not Specified in the Survey

- **Emissions-intensive growth:** Using the most widely adopted SBT method—absolute contraction—poses a challenge for chemical companies because of expected high demand growth for chemical products.
- **Time frame:** During this scoping phase, some chemical companies indicated that the 5 to 15–year time frame of SBTs is too short for low-carbon technology to materialize, as the typical life span of a chemical plant is 30 years (or more). In its 2020 ETP report, the IEA estimates that "it will take at least 25 years to replace all the chemical production capacity around the world, including that associated with plants that will be built in the coming years."[31] Concerns about emissions lock-in and stranded assets suggest that investment should be directed away from fossil fuel- and emissions-intensive assets.
- **Company size:** One company suggested that SBTi differentiate "large" and "other" companies based on total emissions footprint to reflect mitigation feasibility. In 2020, SBTi introduced a separate SME track for small and medium-sized companies that provides flexibility beyond the company track. A general dynamic indicated by the 520 companies with approved SBTs is that large companies have the resources and capacity to lead in reducing their emissions.

While chemical-specific guidance will not resolve all barriers and challenges, it can help to eliminate some and to make science-based target setting more feasible for a growing number of chemical companies. In that light, it is encouraging that more than 80 percent of chemical company respondents to the survey indicated that their company is at least considering SBTs (Appendix A, Question 3)[32] for a variety of different reasons.

The following six questions summarize ongoing sector challenges:

- Where are the boundaries of the chemicals sector?
- Given its heterogeneity, how can the sector be disaggregated meaningfully and effectively?
- 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?
- How should companies measure and address their scope 3 emissions linked with data availability and EOL treatment of sold products emissions?

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[31] IEA's (2020) ETP 2020; this remark should by no means be interpreted as IEA stating that nothing can be done in the short to medium term, as it further states, "In the short to medium term (2020–40), technology performance improvements and switching to alternative fuels provide a considerable portion of emissions savings in the Sustainable Development Scenario, accounting for around 30 and 40 percent, respectively, of reductions relative to the Stated Policies Scenario."

[32] There may be a bias among the respondents (since willingness to answer the SBTi Chemicals Sector Survey could well indicate an above-average interest in science-based targets); nevertheless, respondents worked for many different chemical companies, including companies operating upstream in the value chain (the most energy-intensive part).

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

These challenges are discussed in the following sections. Inspiration on how to tackle some of the other abovementioned challenges can also be found in Appendix A, Question 10.

5. Considerations for Further Research and Method Development

This section provides discussion of chemicals sector–specific considerations for expanding SBT adoption and implementation. The discussion is categorized into scope 1 and 2 emissions; scope 3 emissions; other greenhouse gases; and recommended next steps.

Scope 1 and 2 Emissions

As fossil fuel combustion is a large source of GHG emissions in the chemicals sector, developing processes to reduce scope 1 emissions is the top priority. Promising scope 1 and 2 mitigation options include electrification (e.g., of naphtha or steam crackers), new catalysts (e.g., to produce ethylene from methane), energy efficiency improvements, and green hydrogen feedstock use (Rissman et al. 2020). This scope 1 and 2 discussion covers electricity-related mitigation options, process emissions, and fugitive emissions.

Electricity-Related Mitigation

In parallel with the rest of the economy, chemical companies are increasing the electricity share of their total energy use. In 2019, electricity made up approximately 10 percent of total chemicals sector energy use; by 2070, it is expected to increase to 25 percent in the IEA's ETP (2020) Sustainable Development Scenario. Electricity is used to produce chlorine and is used in many other processes including pumps and compressors. As clean, renewable electricity becomes cheaper and more plentiful, it can also be used for electrolysis in primary chemical production, as well as for low/medium temperature process heat when converting primary chemicals to intermediate and end-use chemical products. Furthermore, there is current research into electrifying the steam cracking process with which high-value chemicals are formed, but the technology has not yet been commercially deployed.

Approximately 90 percent of respondents to the SBTi Chemicals Sector Survey (Appendix A, Questions 15 and 16) reported having data on electricity use and self-production. This supports the potential integration of chemicals sector electricity-related emissions with the SBTi Sectoral Decarbonization Approach (SDA) power sector pathway (grams of carbon dioxide per kilowatt-hour [g CO_2e/kWh]).

Combined heat and power (CHP) is used regularly in the chemicals sector and presents a near-term efficiency opportunity; at the same time CHP poses an emissions accounting challenge for some companies. CHP installations, when owned and operated by the chemical company, are included in the company's scope 1 emissions.[33] While some companies sell the electricity produced, others consume the electricity they produce themselves.

[33] These displace scope 2 emissions when the company uses the electricity produced in its own processes.

Forward Option:

- Integrate growing chemicals sector electricity use with SBTi SDA 1.5°C and well-below 2°C pathways for electricity generation.
- Develop typical CHP scenarios to help chemical companies better understand how to incorporate electricity into science-based target setting,[34] and build off the GHG Protocol's Guidance on CHP (WRI and WBCSD 2006) as additional guidance for chemical companies producing electricity for their own use, selling electricity, and procuring and/or selling heat to others.
- When using the IEA's ETP modeling, ensure consistency regarding CHP-generated electricity and heat-use emissions accounting.

Process Emissions

Approximately 15 percent (200 Mt CO_2) of total chemicals sector carbon emissions are estimated to come from production processes.[35] These are caused by reactions (other than energy-related activities) that generate CO_2 and reflect the difference in carbon content between the feedstock and the product[36]; note that non-CO_2 gases can also form process emissions—these are dealt with below. These process emissions are well tracked and reported (Appendix A, Question 21).[37] A small majority among respondents of the survey (Appendix A, Question 22)[38] suggested that process emissions should be considered separately from fuel-related scope 1 emissions when determining target trajectories; reasons included differences of emission sources and abatement measures and unique abatement challenges. While SBTi will continue to use the Greenhouse Gas Protocol Corporate Standard and Corporate Value Chain (Scope 3) Standard to guide company baseline inventories, it will consider explicit treatment of process emissions in chemical companies' target formulations.

Forward Option: The specific nature of process emissions can be considered in the methodology development—to the extent that approaches to cover specific products do not already do so.

Fugitive Emissions

Fugitive emissions result from intentional or unintentional release of gases or from pressurized equipment leaks and other unintended or irregular releases. In chemical plants, methane leakage contributes to total greenhouse gas emissions.[39] The majority of survey respondents

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[34] The additional CHP rresources could address the following situations:

- A chemical company owns a CHP and sells electricity
- Identifying the point at which there is a mitigation benefit from replacing CHP with grid-procured heat and electricity

[35] This excludes non-CO_2 GHG emissions; these are discussed in a later chapter.
[36] Not intended here as formal definition of process emissions.
[37] 93 percent of respondents working for a chemical company indicated tracking and reporting process emissions.
[38] 61 percent of respondents.
[39] Consistent with the GHG Protocol, methane is included as one of seven key GHGs; however, other volatile organic compounds (VOCs) are not included though they may produce an indirect greenhouse effect.

working for a chemical company reported not knowing or only partially knowing the amount of fugitive emissions in their plants (Appendix A, Question 23).[40] Although the GHG Protocol requires companies to estimate these emissions, only about half of respondents were able to answer the question on the share of scope 1 emissions that were formed by fugitive emissions, with most percentages below 5 percent, and around half of the answers below 1 percent (Appendix A, Question 24).[41] All in all, the initial impression among respondents is that these emissions form a small percentage of the chemicals sector's overall scope 1 emissions but the quantities are not well known. One related consideration for future work is whether to add a data-reporting requirement specifically on fugitive emissions, so companies provide an estimate justifying choice of emission factors. Alternatively, default leakage rates could be explored.

Forward Option: When developing chemicals resources, consider whether to provide additional methods or requirements on modeling and mitigating fugitive emissions.

Scope 3 Emissions

Since its inception in 2015, a signal achievement of the SBTi has been companies' ownership of value-chain emissions via their and financial institution scope 3 emissions inventories. Indeed, most companies with approved SBTs have set scope 3 emissions reduction targets (SBTi 2020d), and this is expected to be the same for chemical companies.[42] As detailed above, SBTi criteria require companies set a scope 3 target if a company's scope 3 emissions account for 40 percent or more of total scope 1, 2, and 3 emissions, where aggregate scope 3 targets must collectively cover at least two-thirds of the total scope 3 emissions (SBTi 2020d).

"*SABIC agrees with the use of scope 3 emissions accounting to understand full value chain climate impacts of chemicals production. As such, SABIC is compiling a full scope 1, 2, and 3 emissions inventory, including emissions from purchased feedstocks and emissions related to the end-of-life treatment of sold products, that SABIC intends to publish*"—
Frank Kuijpers, General Manager Corporate Sustainability at SABIC.

Figure *3* below illustrates the 15 categories of upstream and downstream scope 3 emissions, with emphasis on the most material categories for chemical companies (categories 1, 10, 11, and 12).[43]

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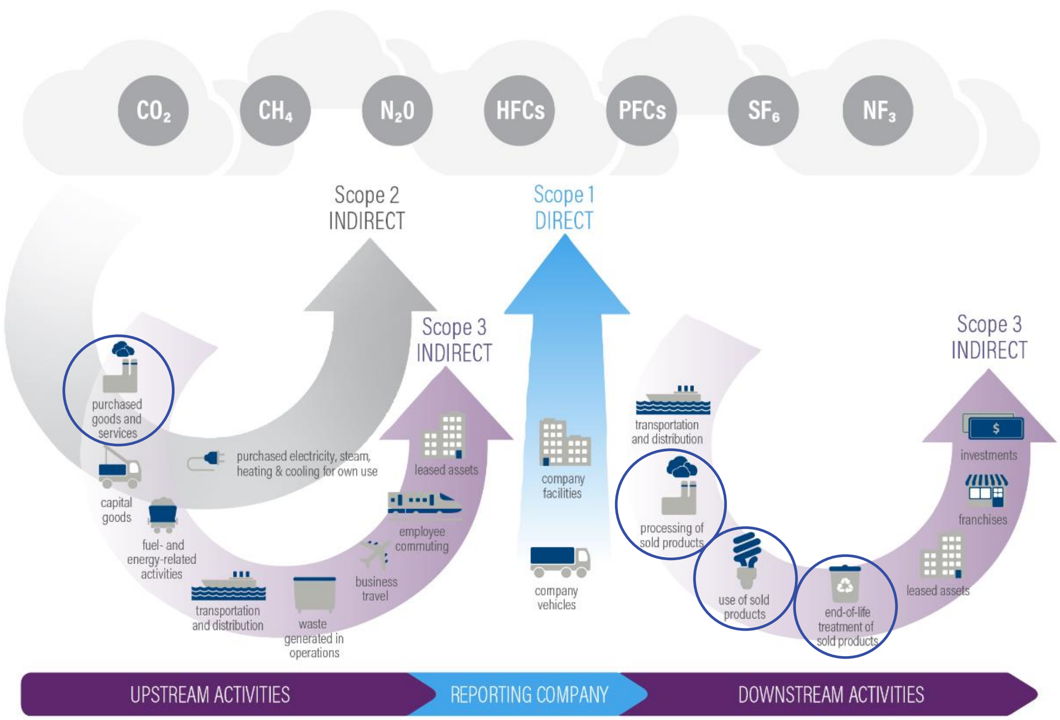
[40] Among respondents, 59 percent reported not knowing or only partially knowing.
[41] Only 18 out of 39 respondents; other percentages mentioned were 70 percent, 25 percent, and "approximately <10 percent."
[42] Especially when a simplified approach is used, assuming that all hydrocarbon products would be incinerated end-of-life.
[43] This corresponds to the top four focus categories indicated by survey respondents (refer to Appendix A, Question 9). More details are given in Appendix B.

Figure 3: Overview of GHG Protocol Scopes and Emissions across the Value Chain



Notes: CO_2 = Carbon dioxide; CH_4 = Methane; N_2O = Nitrous oxide; HFCs = Hydrofluorocarbons; PFCs = Perfluorocarbons; SF_6 = Sulfur hexafluoride; NF_3 = Nitrogen trifluoride.
Source: WRI and WBCSD 2011.

Data

Data availability and quality vary across scope 3 categories and are especially limited in categories without expenditure information, such as EOL-related emissions. Only about 25 percent of respondents working for chemical companies know what happens with their products at the end of life (Appendix A, Question 20), while approximately 50 percent indicated that this holds them back from currently setting an SBT (Appendix A, Question 11). On the other hand, most respondents working for chemical companies (Appendix A, Question 14)[44] know the amount of fossil energy use (relevant for scope 1 emissions) and the share that is used as feedstock (relevant when determining scope 3 emissions).

In recognition of company scope 3 data challenges, the SBTi manual (2020d) provides the following accounting guidance: “A useful approach to calculating scope 3 emissions is to first calculate a high-level screening inventory. Such an inventory can be used to directly set a target

[44] Among respondents working for chemical companies, 83 percent knew the amount of fossil energy use and the share used in feedstock.

or to identify high-impact categories for which more accurate data are needed. Over time, companies should strive to develop complete inventories and improve data quality for high-impact categories (e.g., collect primary data) to better track progress against targets."

This principle of "making the practical best of imperfect data" is in line with WBCSD's (2013) "Guidance for Accounting and Reporting Corporate GHG Emissions in the Chemical Sector Value Chain" to use default factors for end-of-life treatment until specific data are known. For example, for some products 80 percent landfilling and 20 percent incineration can be assumed for their end-of-life treatment; assume a default carbon content of chemical waste as 80 percent based on petroleum products, solvents, plastics; assume that (for some products) for landfill, 50 percent of the contained carbon is converted into CO_2 (global warming potential [GWP] = 1) and 50 percent into methane (GWP = 25). Default emissions factors are intended to provide preliminary screening methods and an incentive for companies to develop primary data collection mechanisms.

Another scope 3 data challenge chemical companies face is the prevalence of intermediate product trade. The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI and WBCSD 2011) indicates that when a company produces an intermediate product with many potential downstream applications, each of which has a different GHG emissions profile, it may be unable to reasonably estimate the downstream emissions associated with the various end uses of the intermediate product. "In such a case, companies may disclose and justify the exclusion of downstream emissions from categories 9, 10, 11, and 12 in the report (but should not selectively exclude a subset of those categories)" (WRI and WBCSD 2011, 61). Some chemical companies are using product mass balance and carbon material flow analyses to estimate and track downstream emissions.

Building on this, the Expert Advisory Group indicated that part of the scope 3 target could incentivize improving data availability by focusing on cooperation with value chain partners in emission hotspots. Companies could then prioritize data quality improvement for activities that have relatively low data quality and relatively high emissions (WRI and WBCSD 2013b).

For example, for purchased goods, companies can use (a mix of) the following data sources, with increasing accuracy:

1. Input/output approach, use databases (e.g., the DEFRA [2020] database) to calculate emissions per spending category
2. Building the life cycle approach, use a life cycle assessment or related databases of single products, and multiply the activities relating to upstream part with the volume to estimate the upstream scope 3 emissions
3. Tier 1 suppliers/customers provide GHG emissions of their products (primary data), multiplied by the purchased/sold volume

The first two data sources are based on "typical" data, creating difficulties for effectively measuring progress. For the third data source, companies would benefit from guidance on securing more primary data, understanding potential implications when adjusting their baseline to reflect this increasing accuracy, and measuring progress of an abatement strategy against a base year using typical data. A solution for companies could be to ask suppliers to set SBTs, thus avoiding allocation and GHG accounting burdens.

Forward options: More resources could be provided to guide treatment of purchased goods and services (category 1) and downstream category 10, 11, and 12 emissions for chemical companies. Guidance could be provided on the following:

- How to work with and improve limited and low-quality data
- How to develop a hybrid method combining general data sets and primary supplier data
- How to measure progress when working mainly with secondary data
- How to improve data over time

Chemical companies could cooperate toward a shared database including the category 1 "Purchased goods" and category 12 "End-of-life" emissions of an increasing number of chemical products—building on existing LCA databases. Over time these data can be replaced by supplier-specific data. Such a process has already been effective for disseminating SBTs and for the broader emissions mitigation ambition for purchased goods in other sectors.

Relevant Scope 3 Categories

The Corporate Value Chain (Scope 3) Accounting and Reporting Standard provides companies with general guidance to assess their value chain emissions hotspots and on where to focus reduction activities. Given the special nature of the chemicals sector, further guidance for some scope 3 categories may be useful. Table B1 in Appendix B presents chemicals sector–specific reasons to provide sector-specific guidance for a subset of scope 3 categories, the percentage of respondents indicating that they would need sector-specific guidance, and the proposed way forward. In general, there is high priority to develop more resources and guidance for categories 1 and 12 and a medium priority to develop guidance for categories 10 and 11. Table ***B***

For **category 1 (Purchased goods and services)**, companies can choose from any of the scope 3 target-setting methods described above to set emissions reduction targets; however, faced with a high diversity of reactants (feedstocks/intermediates), this may be challenging for chemical companies, and it will be imperative to provide resources on how to standardize the collection and interpretation of data. To inform feedstock-related targets, it may be useful to develop intensity pathways for naphtha, ethane, and methane. More resources should also be developed for accounting and reporting emissions from purchased renewable-based and/or circular feedstocks (e.g., describing how to deal with upstream emissions from biomass and how to allocate emissions in the recycled materials value chain).

For **category 12 (End-of-life treatment of sold products)**, unique to the chemicals sector, many products generate emissions during disposal when they are incinerated or sent to landfill, thus more resources are required to increase the accounting and reporting of these emissions. With regard to circular feedstock targets and emissions accounting, resources and guidance for categories 1 and 12 should be complementary. More details on a proposed approach for category 12, End-of-Life sold products emissions target setting can be found in Appendix F.

Please refer to Table B1 in Appendix B for more details on chemicals sector–specific reasons for development of guidance for the **remaining scope 3 categories**.

Forward Option: The following should be resolved in the next phase of the SBTi chemicals sector scoping project:

- 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.[45]
- 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. Advantages and disadvantages of both approaches are presented in Appendix F.
- Further guidance should consider limited data availability for scope 3 data, and should thus partially use typical data, while stimulating further data collection.
- Additional resources should provide guidance on how to classify products as "durable," or which typical plastic/chemical products/product groups are "durable," as this can lead to a difference of more than a factor 50 in the scope 3, category 12 emissions; see Appendix F.
- How the guidance should be applied (and how to properly account for emissions) for cases of bio-based chemicals[46] (Update on Greenhouse Gas Protocol Carbon Removals and Land Sector Initiative," WRI and WBCSD 2020), recycling (mechanical and various forms of chemical recycling), CCU, and electrification, especially for category 12.

[45] In conformance with GHG Protocol and SBTi, this would likely only be mandatory when scope 3, category 12 emissions are material.

[46] The SBTi approach to bio-based energy and feedstock, land use, and negative emissions accounting will be informed by three new GHG Protocol standards and guidance: Carbon Removals Standard, Land Sector Guidance, and Bioenergy Guidance. This guidance could also clarify the emissions factor to be used for carbon (C) in case it is incinerated (as now, the WBCSD guidance [2013] seems to suggest that this produces 1 of CO_2 per tonne of C burnt).

Other Greenhouse Gases

Non-carbon Kyoto greenhouse gases also contribute to the chemicals sector's total emissions, as shown in **Table** below.

Table 1: Global, European Union, and US Greenhouse Gas Chemicals Sector Emissions

Gas	2010 global emissions (Mt CO_2e)[a]	2017 EU emissions (Mt CO_2e)[b]	2019 (part of) US emissions (Mt CO_2e)[c]
CO_2	1,200	120	160
HFC+PFC	210[d]	~4[b]	7.8[e]
N_2O	140	7.6	16
SF_6	12	~4[b]	See HFC+PFC
CH_4	4.9	~4[b]	0.3

Notes: Mt CO_2e = Megatonnes, carbon dioxide equivalent; CO_2 = Carbon dioxide; HFC = Hydrofluorocarbons; PFC = Perfluorocarbons; N_2O = Nitrous oxide; SF_6 = Sulfur hexafluoride; CH_4 = Methane; EU = 28 member countries of the European Union; note figure presents data with two significant figures of precision.

a. Chemicals, direct and indirect greenhouse gas.
b. Based on CEFIC's (2020) *2020 Facts & Figures of the European Chemical Industry* report (chemicals sector GHG emissions including pharmaceuticals). Total emissions for HFC+PFC, SF_6 + CH_4 around 4 Mt CO_2e.
c. Based on the emissions of 449 reporting installations, manufacturing organic or inorganic chemicals. The extent to which these installations cover the full chemicals sector is unclear.
d. HFC only.
e. All fluorinated GHGs.

Sources: Fischedick et al. 2014, 753; CEFIC 2020; US EPA 2020.

Although the scopes and the emissions from the three sources in Table 1 vary (e.g., direct vs. direct + indirect, by geography and year), and in recognition that substantial nitrous oxide (N_2O) emissions have been abated (especially in nitric acid production), stimulated by policies such as the European Union Emissions Trading System (EU ETS) and several clean development mechanism (CDM projects) since 2005, two conclusions can be drawn:

- The global chemical industry's direct CO_2 emissions are much bigger than the sum of the emissions of the other greenhouse gases.[47]
- More chemicals sector–specific guidance may be useful for companies to comply with SBTi criteria that require the inclusion of non-CO_2 Kyoto GHG emissions in their GHG inventory (with exclusions up to 5 percent), given the materiality of these gases in the chemicals sector, notably nitrous oxide (N_2O) and perfluorocarbons/hydrofluorocarbons (PFC/HFC) and to a lesser extent methane (CH_4) and sulfur hexafluoride (SF_6).

The non-CO_2 GHG emissions originate from processes including the following:

- **N_2O:** Adipic acid, nitric acid, caprolactam, glyoxal, and glyoxylic acid production
- **HFCs/PFCs:** Used as substitutes for ozone-depleting substances in a variety of industrial applications including refrigeration and air conditioning equipment, aerosols, solvent cleaning, fire extinguishing, foam production, and sterilization

[47] Expressed as CO_2e.

- **CH_4:** Silicon carbide production and from other chemical processes (US EPA 2019; CEFIC 2020)

Forward options:

- A separate focus on the production of HFCs/PFCs and potentially SF_6 could be considered. As a first step, increasing the understanding of emissions during production in the chemicals sector, and on their downstream scope 3 emissions,[48] would be a priority.
- There could also be a logic for focusing on N_2O:
    - For nitric acid, this can best be done as part of an effort focusing on the production of fertilizers (as this also enables covering the trade-off between urea-based and nitrate-based fertilizers); and
    - For N_2O emissions during the production of the other chemicals, this could be a separate activity.
- Emissions reduction pathways for non-CO_2 greenhouse gases should be determined since these pathways are not part IEA modeling.[49]

Recommendations and Next Steps

During 2020, the SBT initiative surpassed its goal of 1,000 committed companies and financial institutions. To build on this positive momentum and maximize emissions mitigation impact, the initiative updates its target-setting criteria, is currently producing a net-zero targets standard, and continues to develop support emissions-intensive sectors. As discussed in this document, the chemicals sector is a priority sector for research and method development to facilitate broader company adoption of SBTs.

The forward-looking options outlined address specific scope 1 and 2, scope 3, and non-carbon GHG emissions issues identified by chemicals sector stakeholders during this project. Within scope 1 and 2, the options include linkage with SDA electricity pathways, elaboration of CHP accounting approaches, exploration of separate process emissions target setting, and resources to support more consistent quantification and inclusion of fugitive emissions in company base year inventories. The scope 3 options include development of hybrid primary and secondary data approaches to improve data quality and measure emissions performance, increased requirements on downstream emissions reporting and targets, and consistent treatment of end-of-life and purchased goods and services emissions for recycled materials. While carbon accounts for the vast majority of GHG emissions across the sector, non-carbon GHG mitigation options can be pursued in parallel with carbon abatement.

To catalyze greater chemicals sector mitigation action in the next phase of work, this document builds on these options to present three top-line recommendations:

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[48] The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI and WBCSD 2011) requires companies that produce and sell GHGs, including all Kyoto GHGs, and products that contain or form greenhouse gases that are emitted during use, to report these emissions in scope 3, category 11: Use of sold products.
[49] This includes a decision about whether to set targets for each non-CO_2 component separately, to have one "non-CO_2 GHG emission reduction target," or aggregate to the level of total carbon dioxide equivalent (CO_2e).

- **Develop a chemicals sector Sectoral Decarbonization Approach**. Unlike the SDA for steel or cement, the proposed chemicals sector SDA would include specific emissions intensity pathways for the largest product categories (ammonia, ethylene, propylene, BTX, methanol, and hydrogen). It would also include one or more residual physical intensity approach(es) for the thousands of other chemicals products, perhaps using a non-specified physical intensity contraction approach similar to SBTi's treatment of vehicle manufacturing.
- **Improve chemicals sector scope 3 resources**. To address the chemicals sector's high degree of fossil feedstock use, heterogeneity, and prevalence of intermediate product trade, additional accounting and target-setting resources should be developed for key upstream and downstream emissions sources (scope 3, categories 1 (purchased goods and services), 10 (processing of sold products), 11 (use of sold products), and 12 (end-of-life treatment of sold products)). These resources would include sector- or product-specific emissions factors for companies that lack primary emissions data.
- **Develop end-of-life accounting and target-setting approaches for chemicals**. While a growing number of companies across sectors are focusing on their category 1 (Purchased goods and services) emissions, chemical companies are uniquely positioned to increase the share of secondary materials. Consistent boundary and accounting approaches across categories 1 and 12 could facilitate inclusion of these new target formulations into chemical companies' SBTs.[50]

The scope and focus of the next phase of the SBTi chemicals sector project will depend on funding, external collaboration, initiative priorities, and capacity. A consortium approach to funding including a range of companies and perhaps interested financial institutions and industry associations would help to ensure relevance, applicability, and credibility of further chemicals sector research. Key external collaborators include chemical companies, data providers starting with the IEA, climate modeling groups, and value-chain counterparts such as feedstock producers upstream and intermediate goods users downstream. SBTi is prioritizing net-zero resources and support of GHG-intensive subsectors in its next phase of work. Updates to the climate science (e.g., in the Intergovernmental Panel on Climate Change's [IPCC's] upcoming Sixth Assessment Report), policy discussions, and company performance as revealed in SBTi monitoring and verification will also influence next phase work. The goal is that the next phase will help to transform of the chemicals sector from one of the largest and growing sources of GHG emissions into a mitigation success story firmly on the path to net zero through widespread SBT adoption.

[50] In their survey responses, chemical companies indicated their preference for circularity targets; see Appendix F for additional information.

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Appendix A: Detailed Survey Results

SBTi Chemicals Sector Survey Results and Synthesis

This section describes the result of a survey WRI ran between June 25 and August 26, 2020 and aims to inform SBTi thinking about the methodological set-up of a refined target-setting methodology specifically for the chemicals sector. The main body of the scoping document provides interpretation and refers to this appendix.

The survey consisted of 29 questions, distributed over seven categories, and was aimed at respondents with a background in the chemicals sector and/or a sustainability background.

YOUR COMPANY:

1: Who are you?

The survey was filled in by 59 respondents; individual identities are not reported here.[51]

2: Are you from a chemical company?

Among the 59 respondents, 40 reported that they worked for a chemical company.[52] Other respondents represented a wide diversity of organizations.[53]

3: Does your company have an SBT?

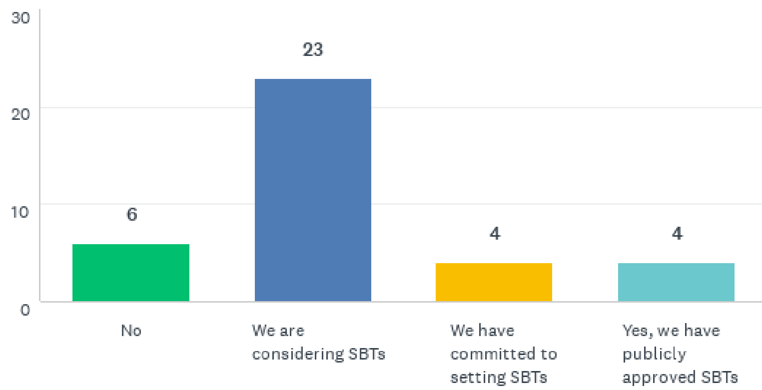
Thirty-seven respondents working for chemical companies answered this question, with 6 answering their company did not have SBTs, 23 that their company is considering SBTs, 4 that their company has committed to setting SBTs, and 4 answering that their company has publicly approved SBTs (see Figure A1 below).

[51] The total number was determined after eliminating double entries by the same person (including one case with different answers—when we took the latest answers). When multiple respondents from the same company gave answers (two respondents for four companies, and four respondents for one company), all respondents were considered after checking that their answers were not literally the same.

[52] Thirty-eight self-identified as working for a chemical company; two didn't answer this question but were treated as such based on their company name.

[53] Other respondents represented a nongovernmental organization (NGO), a member organization, a trade association, four broader companies with chemical divisions, a testing/inspection/certification organization, two companies producing consumer goods, two solution providers, three consultants, an environmental impact agency, an investor, a government-funded provider of sustainable development services, and one unknown.

Figure A1: Survey Results: Companies with Science-Based Targets



Source: SBTi Chemicals Sector Scoping Survey, 2020

4: Do your company's products release greenhouse gases at the end of their use-phase (e.g., hydrocarbons when they are incinerated)?

Among respondents working for chemical companies, 29 answered "Yes," and 8 answered "No." As most chemical companies produce hydrocarbons, the overwhelming positive answer to this question is in line with expectations. The answer to the question is used in some later questions, to distinguish between chemical companies for which these emissions are, or are not, relevant.

SCOPE:

5: Which sector classification (taxonomy) do you currently use (e.g., NACE, NAICS, GICS, CDP)?

Table A1 below summarizes how respondents answered this question for the options already mentioned in the question.

Table A1: Survey Results: Sector Classification

Sector classification	Respondents total[a]	Respondents working for chemical companies
NACE	8	6
NAICS	9	7
GICS	8	4
CDP	16	13
Other classifications	4	3
Answers only indicating the *actual* companies' classification	9	6
Not answered	18	10

Notes: NACE = Nomenclature generale des activitiés économiques dans la Communauté Européenne; NAICS = North American Industry Classification System; GICS = Global Industry Classification Standard; CDP = Carbon Disclosure Project.

a. Includes respondents working for chemical companies.

Source: SBTi Chemicals Sector Scoping Survey, 2020

One respondent from a chemical company remarked that while the company reports in Global Industry Classification Standard (GICS), due to the variety of applications of the company's product, the classification is not ideal. Another respondent also from a chemical company remarked that the company had its own system, including elements from Statistical Classification of Economic Activities in the European Community (Nomenclature statistique des activitiés économiques dans la Communauté Européenne, NACE) and GICS;[54] further, Sustainability Accounting Standards Board (SASB), US Environmentally-Extended Input-Output (US EEIO) 2002, and Standard Industrial Classification System (SIC) were mentioned.

No "other" classification has been mentioned more than once.

The number of respondents giving *actual* companies' classification suggests that the question was not clear to them. In total, 32 respondents answered the question by providing at least one sector classification methodology.

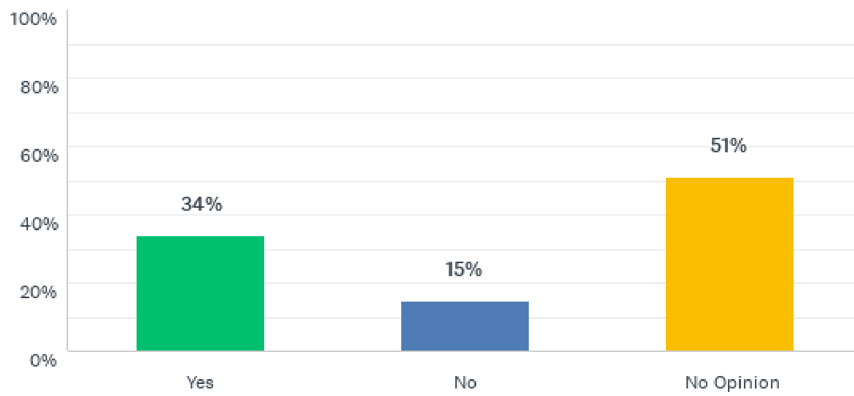
[54] These have also been included in the numbers for NAICS and GICS.

6: Should the SBTi chemicals methodology to be developed also apply to pharmaceuticals?

Sixteen respondents (of whom 13 work for a chemical company) responded “Yes,” 7 (of whom 5 work for a chemical company) responded “No,” and 24 respondents (of whom 16 work for a chemical company) indicated they did not have an opinion.

Figure A2 below shows the distribution of opinions from the 47 respondents (the result is not much different when including only respondents working for chemical companies).

Figure A2: Survey Results: Should SBTi Chemicals Methodology Apply to Pharmaceuticals?



Source: SBTi Chemicals Sector Scoping Survey, 2020

Reasons for voting “Yes”:

- Expected growth of the pharmaceuticals sector
- Chemicals are used in the production of pharmaceuticals
- Similarity in the challenge to map “purchased goods” emissions

Reasons for voting “No”:

- The big difference between produced quantities, yields, ancillary materials (such as solvents), footprint per ton, differences in regulatory oversight, and the different structure of the industry
- Pharmaceuticals are made from specialty materials that do not have known carbon footprints

Respondents have different views on the similarity of production processes, for some the existence of such similarities is the reason to vote “Yes”; for others, its absence is the reason to vote “No.” Two respondents pointed out that pharmaceuticals can be considered in the category of “Specialty chemical” by the nature of the process.

Respondents pointed out that pharmaceuticals can be produced through chemical routes (in which case inclusion in the chemicals sector might make sense) and through biotech/biological routes (in which case this might not make that much sense).

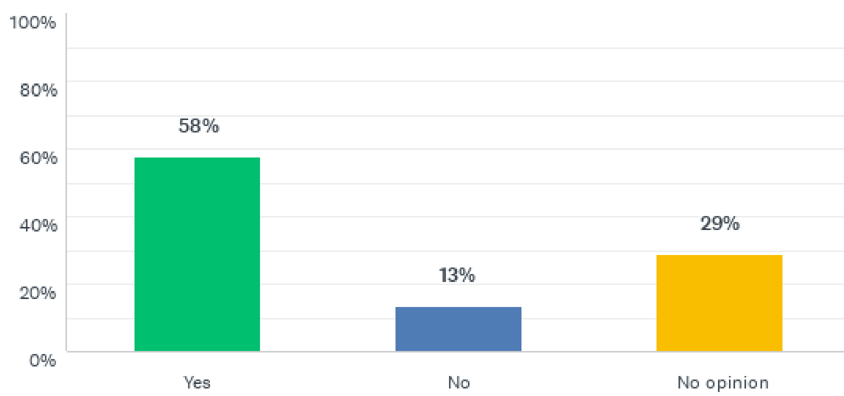
One respondent pointed out that scope 3 emissions are likely biggest, and another anticipated lack of commonly available data; yet another respondent specified that understanding scope 3's downstream emissions might be challenging for the pharmaceutical companies selling intermediates.

7: Should the SBTi chemicals methodology to be developed apply to the manufacture of biofuels as indicated above?

Twenty-six respondents (of whom 19 work for a chemical company) responded "Yes," 6 (of whom 4 work for a chemical company) responded "No," and 13 (of whom 9 work for a chemical company) indicated "No opinion."

Figure A3 below shows the distribution of opinions from the 45 respondents (the result is not much different when only respondents working for chemical companies are included).

Figure A3: Survey Results: Should SBTi Chemicals Methodology Apply to Biofuels?



Source: SBTi Chemicals Sector Scoping Survey, 2020

The main reason to vote "Yes" is that biofuels are produced chemically, and in similar processes as petrochemicals/linked to chemical businesses and chemical production; just the feedstock is different. Furthermore, the GHG emission abatement levers are similar to bioplastics and biochemicals.

The main reasons to vote "No" are that biofuels should be covered under energy, oil and gas, or fuel sectors and that biofuels and biomaterials bring up many issues around land-use change and biogenic CO_2 uptakes and emissions that are not common for chemicals.

Some respondents distinguish between the different scopes by suggesting the following:

- Apply the methodology to the scope 1 and 2 impacts of biofuels, not to the use-phase (scope 3).
- If the methodology focuses on production, coverage under the chemicals sector would be logical; if on use, coverage under the energy sector would be logical.

Others express doubt due to the following:

- Biofuels can reduce emissions in many ways—100 percent renewable energy can offer the potential to easily capture biogenic CO_2—leading to negative emissions.
- Biorefineries processing various feedstocks to produce products flexibly into fuel and chemicals will benefit from a consistent methodology for target setting in these two industries.
- The approach should be inclusive throughout the value chain for all types of fuels.
- Many chemicals are increasingly being synthesized from natural/agricultural materials as an alternative to, for example, petroleum-based materials. Accounting for biogenic carbon/sequestration during growth must be similarly considered for the chemicals industry and for the biofuels industry, to avoid companies claiming carbon neutrality simply off the back of using natural material, which sequesters carbon at beginning of life.

Respondents note that the methodology could clarify how to deal with CO_2 formed during bio-processes (excluding combustion).

8: Other remarks about this methodology to be developed and the scope of chemical products to which it should apply.

Respondents' comments on the scope of the methodology:

- Clarify that this also applies to food additives, biochemicals, etc., which are part of specialty chemicals.
- We question the fact that today industrial gases are included in this sector. A dedicated methodology to be developed with our peers would be welcome.
- It must apply to the plastics industry. No significant progress can be made in decarbonizing the chemicals sector without guidance for plastics production as it uses hydrocarbon feedstocks.
- Polymers
- Ammonia and ammonium nitrate
- Broadly it must encompass all key chemical processes such as crackers, ammonia, urea, basic chemicals, and chemical intermediates (e.g., methanol, syngas, basic polymers, specialty polymers, fine chemicals). Ideally the scope should include all chemicals.
- In general, I would prefer to set a broader scope so that companies with a broader portfolio do not run into the risk that a part of their portfolio is not covered by the SBT method.

- SBTi chemicals sector methodology should include specific guidance for specialty chemicals vs. commodity chemicals. The added value for specialties is greater, and the supply chains tend to be more complex.
- Should consider polyolefins, hydrocarbons, and fertilizers.

Respondents' comments on the methodology in general:

- Needs to be of sufficient detail to provide the level of guidance needed. If that means subdivision (e.g., biofuels), then this should be applied.
- Downstream scope 3 emissions in the use-phase of chemicals are very difficult to quantify because we do not track the processes of our customers. This especially applies to scope 3, category 10—Processing of sold products.
- Methodology must take complex companies into account.
- I think many of the principles developed through this work will apply to other intermediate "heavy" industries. However, I do not believe that these other industries necessarily need to be considered.
- The methodology should incentivize and drive the transition from fossil-based chemicals to bio-based materials, given that the bio-based chemicals have (from a cradle-to-grave perspective) lower specific GHG emissions than the fossil-based counterpart. However, at the moment, at company level this impact is not captured. For example, a bio-based chemical company with high growth will see its emissions increasing while at sector level this can contribute to a decrease in overall sector emissions.
- It should avoid the double accounting of emissions, which happens if not appropriately considered. SBT should be applicable to scope 1 and 2 for manufacturing companies to avoid double accounting of emissions. Moreover, if companies' operations are more on the supply chain side, such as assembling units, then SBT should be applicable to scope 3.

9: Scope 3 categories for which a methodology needs to be developed specifically for the chemicals sector.

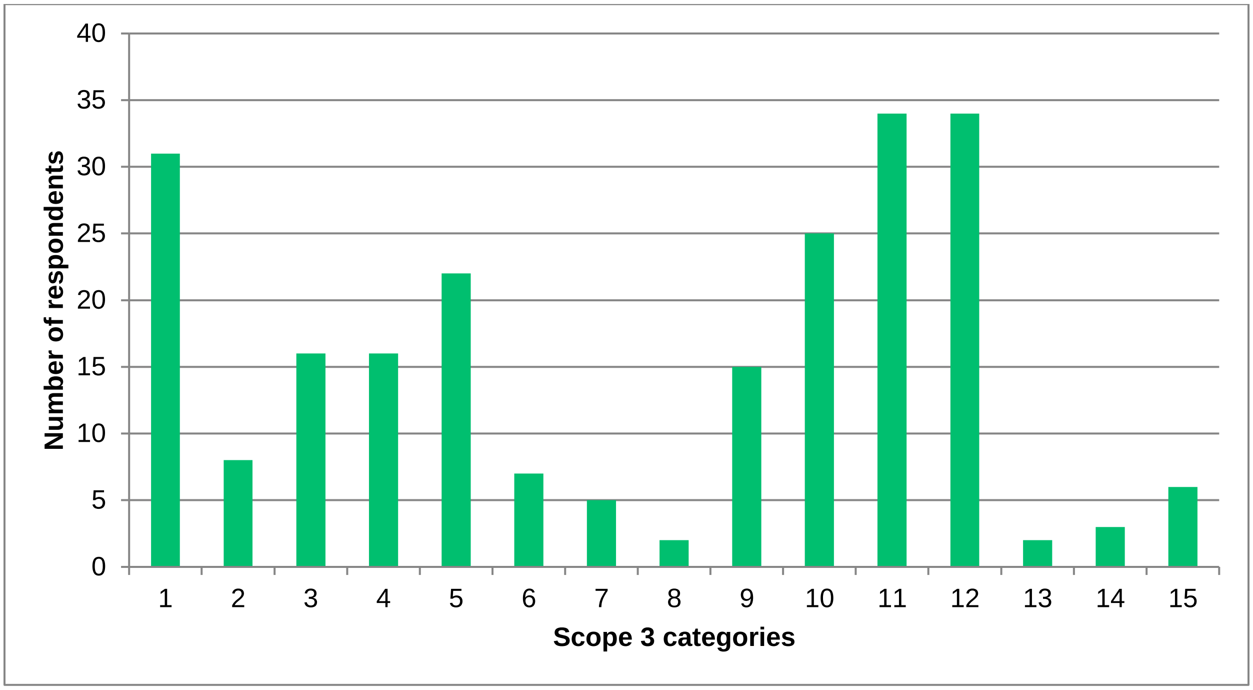
Table A2: Survey Results: Scope 3 Categories That Require a Methodology Specifically for the Chemicals Sector

#	Category	Respondents (%)	Respondents, chemicals sector (%)	Respondents, chemical company with end-of-life emissions (%)
UPSTREAM				
1	Purchased goods and services	69	63	68
2	Capital goods	18	16	20
3	Fuel- and energy-related activities (not included in scope 1 or 2)	36	34	40
4	Upstream transportation and distribution	36	41	36
5	Waste generated in operations	49	50	56
6	Business travel	16	16	16
7	Employee commuting	11	16	16
8	Upstream leased assets	4	3	4
DOWNSTREAM				
9	Downstream transportation and distribution	33	34	32
10	Processing of sold products	56	47	48
11	Use of sold products	76	66	68
12	End-of-life treatment of sold products	76	72	72
13	Downstream leased assets	4	3	0
14	Franchises	7	3	0
15	Investments	13	13	16
	Number of respondents	45	32	25

Source: SBTi Chemicals Sector Scoping Survey, 2020

Table A2 above does not show material differences when respondents working for chemical companies are singled out; also, focusing on respondents working for chemical companies with end-of-life GHG emissions does not change the picture at all.

Figure A4: Survey Results: Scope 3 Categories That Require a Methodology Specifically for the Chemicals Sector



Note: Total number of respondents = 45.
Source: SBTi Chemicals Sector Scoping Survey, 2020

Respondents' comments:

- General:
    - In the case of, for example, fertilizers, the use of the product leads to emissions of CO_2 and N_2O. These need to be taken into account, either in scope 1 or in scope 3 downstream.
    - A current challenge for upstream is lack of adequate quality data. Typically, databases like ecoinvent are used for purchased chemicals, but these may only be updated once per decade.
    - Emissions from processing of basic chemicals at the customers' end are scope 1 and 2 emissions of the customers. Emissions of purchased goods are the suppliers' scope 1 and 2 emissions. Including those would lead to double counting.
    - The biggest chemicals sector contributors to scope 3 (at a minimum the top five categories) should be part of the scope of the methodology. Those categories for which chemicals sector contributions are similar to those of any other industry can be excluded.
    - Important: How can we handle growth?
- Upstream categories:

- The chemicals sector is a large consumer of fossil fuels. The upstream CO_2 and CH_4 emissions that are released in the exploration, production, and transportation of these should be considered.
- Category 1 – Purchased goods and services:
  - Guidance in particular due to the broad range of goods necessary to produce chemicals, standardization of emission factors, guidance on how to account for emissions reduction activities from suppliers/raw materials.
  - We have an enormous number of suppliers (55,000+) and raw materials for very specific processes. We do not have a specific group of suppliers that covers a large percentage of our raw materials (all supply in low percentages relative to total supply chain), so it is extremely difficult to manage this number of suppliers and raw materials.

- Downstream categories:
  - Downstream processes are specifically challenging because reliable figures are difficult to obtain due to the diverse application and customer structure.
  - Product fate will be difficult to address due to the wide range of applications and processes they may be used in (very difficult to build a complete product trail).
  - It is important that certain categories, such as End-of-life, where producers do not have full control, are handled carefully for target setting. Standardization of approaches to accounting as well as further clarity on what is included and how to properly account for certain categories, such as category 10: Processing of sold products (which could include all downstream conversions of a chemical intermediate), require guidance.
  - Products are intermediates with many potential end uses. According to the GHG Protocol Technical Guidance for Calculating Scope 3 Emissions (WRI and WBCSD 2013), a company that produces intermediate products with many potential downstream applications, each with a potentially different GHG emissions profile, cannot reasonably estimate the downstream emissions associated with the various end uses of the intermediate products.
  - I imagine the inclusion of categories 1, 10, 11, and 12 will be fairly expected. However, I wonder if it is also worthwhile considering the unique waste streams within the chemicals sector. It is also the case that many “waste” streams in the chemicals sector can go on to be used by other companies as an input. Now, these are not considered sold products; however, if there are going to be used by another business, do those emissions fall into category 5 or 11?
  - Categories 10 and 11:
    - Most chemicals are intermediates to other products, as such, I believe there are unique characteristics applicable to the processing and use of sold products. Typically, the chemical producers do not define how their products are used by their customers.
    - The big challenges downstream are that many chemicals go into a myriad of varied products and applications and undergo chemical

transformations. Tracking, or even defining, what the downstream processing or use is can be complex, uncertain, and in many cases unknown to the chemical producer. In some circumstances, the use of a sold product could also be reduction or avoidance of emissions by others.

- Categories 10, 11, and 12:
  - We provide materials (300,000+ specialty products) for business-to-business (B2B), and as a result, the use-phase of chemicals is very difficult to quantify. Each customer has a different use for our products, and we have no way to track the processes of our 1,000,000+ customers.
  - Residual waste from explosives manufacture is generally classified as hazardous and cannot be sent to landfill; onsite burning and detonation is common. Similarly, detonation of explosives in the use-phase will warrant more sophisticated emissions estimation methodologies.
- Category 11: Can be complex and opaque and with limited control of the company, itself. Hard to interpret current methodology guidance, more specific examples for chemicals industry would be helpful as a minimum. Use of category (11) can also depend on the feedstocks the customers themselves choose to implement (e.g., bio or fossil)—the sold product does the same task irrespective of the embedded carbon in the feedstock.
- Category 15: Guidance if the company where investment is made does not report its own emissions.

CHEMICAL COMPANIES' OBSTACLES TO AND BENEFITS OF SETTING A SCIENCE-BASED TARGET:

10: Describe briefly how you have organized reducing your companies' (scope 1, 2, and 3) greenhouse gas emissions.

Out of 29 respondents, 28 working for a chemical company provided input on at least one of the categories, an illustrative selection is given here for each of the categories provided in the question:

- **Governance (24 inputs):**[55] Many respondents from chemical companies report how the efforts to set and deliver on greenhouse gas emissions reduction target(s) are structured:
  - Twelve report a high-level body overseeing the strategy, target setting, and/or progress, of whom 2 report the chief executive officer (CEO) to be the executive sponsor.

[55] Any input has been included here, apart from inputs such as "N/A" or "Not yet" (inputs such as "Planned" have been included).

    - Ten report to have one or more dedicated team(s) (e.g., including sustainability, environment, health and safety, operations, procurement) to drive the greenhouse gas emissions reduction program, progress, and reporting.

- **Involvement/Endorsement top management (24 inputs):** CEO/Board (of directors)/Top management involvement is secured in 24 chemical companies (from 28 respondents to this question) by, for example, endorsing targets, strategies, or action plans; sponsoring or driving greenhouse gas emissions reduction initiatives; or overseeing progress. Other input:
    - A yearly capital expenditures (capex) budget is secured for GHG reduction measures; scope 2 improvement is supported by a special sourcing mandate.

- **Internal carbon pricing (21 inputs):** Eleven respondents from chemical companies report their company has internal carbon pricing in place (for strategic, research, and investment decisions), seven are considering, planning, piloting, or implementing this.

- **Strategy process (21 inputs)**: Four respondents from a chemical company mention SBT as a significant element in their strategy.
    - "The strategy takes both a bottom-up and top-down approach to seek feedback from the sites, businesses, and relevant functions to inform the overall strategy. All targets are set at corporate level and cascaded throughout the business."
    - "Integrated into strategic risk analysis, business strategy, and financial planning; early-stage scenario analysis; embedded emissions reduction programs."
    - "We have introduced sustainability assessment in various processes such as technology development, design phase of mega projects, qualification of products, etc., low hurdle rates for sustainability projects."
    - Other respondents from a chemical company indicate that strategic greenhouse gas emissions goals are currently being developed, or regularly updated (Plan Do Check Act).
- **Targets for managers year-end performance evaluation (18 inputs):** Twelve respondents from chemical companies report their companies have greenhouse gas emissions reduction/sustainability targets in place for (some) (high-level) managers; four are considering or planning this.
- Five respondents provided "other" inputs.

11: What is holding you back from setting an SBT right now?

Table A3: Survey Results: Barriers to Setting Science-Based Targets

Barrier	Respondents (%)	Respondents, chemicals sector (%)	Respondents, chemical company with end-of-life emissions (%)
Strategic			
No pressure from investors	24	22	28
Lack of clients with upstream scope 3 supplier targets	18	19	24
Clients are not willing to pay more for products with a lower greenhouse gas footprint	39	38	40
No management support[a]	11	9	8
Feasibility			
Even after innovation, there are no ways to meet a science-based target	16	9	8
Technology readiness for some of the high-CO_2 abatement projects is too low ("innovation is needed")	42	41	44
Infrastructure will not be ready in time	24	16	16
It is economically not achievable to meet a science-based target	29	22	24
We cannot procure sufficient renewable electricity from the electricity grid	18	13	12
Amount of sustainable biomass available will not be sufficient	18	13	12
Amount of waste available for recycling will not be sufficient	8	6	4
Process of involving our suppliers or other new partners in the reduction of the scope 3 emissions will be too challenging	39	34	36
Process of involving other new partners in the reduction of the scope 3 emissions will be too challenging	18	19	20
Policies			
Policymakers need to introduce policies (i.e., a carbon tax)	0	0	0
Lack of sufficiently strict CO_2 regulations to include externalities	24	19	20
Uncertainty about future CO_2 prices and hence the correct timing of investments in CO_2 abatement	32	25	24
Policies typically exclude scope 3 reduction targets	37	34	40
Knowledge			

We do not know our current scope 1 and 2 emissions	0	0	0
We do not know our current emissions of greenhouse gases other than CO_2	3	3	4
We do not know our current scope 3 emissions at all	8	3	4
We do not know our current scope 3 emissions with sufficient accuracy	47	44	48
We do not know the long-term costs to reduce our emissions	32	28	36
Methodology			
Current methodologies have limitations	34	25	38
Methodology for the chemicals sector will be updated; we are waiting for the update and will then seriously consider setting a science-based target	39	38	44
We have so many mergers/acquisitions in our sector that we cannot meaningfully set a baseline	13	6	8
We have already set a science- based target, so this question does not apply to us[b]	18	19	12
Other	61	50	48
Number of respondents	38	32	25

Notes: CO_2 = Carbon dioxide.

a. Including one entry under "Other": Getting management on board.
b. Four of these respondents did not indicate any other barrier in this question.

Source: SBTi Chemicals Sector Scoping Survey, 2020

Under "Other" in Table A3 above, the following barriers were mentioned:

- Major barrier is to explain that an SBT needs to include scope 3—aversion due to scope 3 emissions targets being perceived internally as not credible/achievable because it is outside our control (two responses).
- Inadequate accommodation of companies that require hydrocarbons as feedstock.
- Senior management is not fully informed of how an SBT is set and managed. With the lack of the methodology for the chemicals sector, this has been some of the difficulty.
- The rate of change of what constitutes an SBT is high. Yes, the global situation is changing rapidly, but it is quite challenging to develop goals on targets that seem to change yearly.

The following arguments were given (the following is a selection):

- “We believe that it is hard for the chemicals sector to set a science-based target according to the general nonsectoral approach (e.g., 30 percent reduction of absolute CO_2 emissions over a 10 to 15–year time frame). For many chemicals, fossil fuels are an input material, and CO_2 is released during production. A substantial innovation is therefore needed to develop new low-carbon processes for those chemical products, for example, via carbon capture (large scale) or electrification of processes, with sufficient renewable energy being available. Even if new solutions exist, these need to become commercially available and economically viable (competitive) compared to existing solutions/processes. This either requires a strong policy push (e.g., via increased carbon prices) or strong renewable energy prices reduction to achieve similar production costs when processes are electrified. Still, there is a long timeframe needed to develop such new large-scale solutions and for those to be brought to the market (duration until new production plants/plant designs are developed, tested, built, etc.). This technology limitation needs to be considered when developing specific SBTs for the chemicals sector, at least with regard to specific products (e.g., hydrogen).”
- “Required innovative technologies are mostly long-term investments or R&D projects that take longer times to be developed. Thus, their emissions reductions would only take place after the 15 years cut-off criterion. There also has to be a way to account for part of the reduction measures after the initiation of such projects.”
- “The absolute and intensity contraction methods require emissions cuts at a rate that, especially in the short term, are economically just not feasible for us. We'd like to use the SDA method, but there isn't one yet for our (sub)sector(s).”
- “We need practical, abundant, and competitively priced renewable thermal energy sources to replace natural gas. We need practical and affordable carbon capture.”
- “We need an SBT methodology for the industrial gas sector combined with a clear methodology for our chemical customers that involves scope 3 for us to leverage our contribution to the GHG emissions reduction.”
- “Ability to influence through the value chain can be limited for speciality chemical companies like us. We are often a small part of our suppliers’ business and have limited influence. We also expect that shifts in product mix mean that primary materials (especially inorganic metals) needed will change significantly over the life of an SBT, without the corresponding increase in end of life to provide recycled materials of sufficient quantity in the SBT time frame. Additional guidance on in-use category would be helpful.”
- “Appropriate technology and levers that can help us achieve are a challenge.”
- We produce many tens of thousands of products in many countries, and we currently estimate scope 3 data uncertainty is ±50 percent, despite starting early. We took on the formidable task of calculating our downstream scope 3 impact for categories 9 through 12, determining the quantity of each product, the product category it was in (and whether greenhouse gas emissions were material). Then we determined emissions factors for each product category.

- “The reduction path to be considered does not reflect the diversity, complexity, and limited feasibility within the chemicals sector (see checks under ‘Feasibility’).”
- Many of our chemicals industry clients do want to set an SBT. However, there are multiple concerns:
    - The key concern is that the bulk of scope 3 emissions are either in raw material purchase or downstream processing/use, where it is felt that there is not much influence; so they could be setting an unachievable target. In particular, considerations would be as follows:
        - The chemicals industry is not that big, so there may only be a few companies that supply the required raw material. With such a scarce commodity, businesses do not have the level of influence over their supply chain as if it were a large, competitive market.
        - Many chemicals businesses produce >100s of different chemicals each, with multiple potential applications. How do you feasibly assess the downstream processing or use of all of them without making significant assumptions?
        - More guidance is required on attribution of downstream emissions. Is it expected that every partner in the supply chain set targets on effectively the same set of emissions? For example, if company A supplies to company B (which produces the end product), category 11 will be the same for both companies. Do they both set targets to reduce, and if so, how is this captured/accounted for within the global carbon budget?
    - Guidance on how to manage mergers and acquisitions is key, else they would be re-baselining every year. News of this guidance has also caused businesses to pause as they consider, “Why are we doing the work now when we might need to redo it next year anyway.

12: What benefits do you see toward setting SBTs for your chemical company?

We are not reporting on this question here, as we see that some respondents misunderstood how this question should have been answered.

STATISTICS FROM THE CHEMICALS SECTOR:

13: Do you have suggestions for credible, publicly available literature sources with current greenhouse gas emissions of the global chemicals sector, ideally split up per key chemical or production processes (steps)?

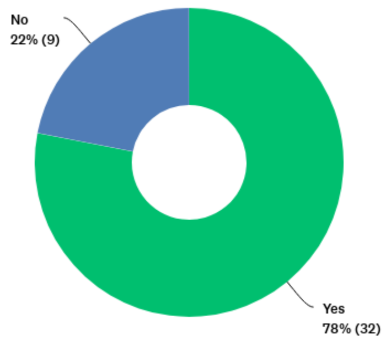
Respondents provided the suggestions listed below:

- IEA Energy Technology Perspectives 2017 paper
- Carbon Disclosure Project
- GHG Protocol
- Sustainability reports
- Sector studies
- CEFIC Mid-Century Vision Report: https://cefic.org/thought-leadership/mid-century-vision/
- https://ec.europa.eu/eurostat/home
- https://www.iea.org/reports/the-future-of-petrochemicals
- https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/gd9_sector_specific_guidance_en.pdf
- US Environmentally-Extended Input-Output (EEIO) is the best we have found, but it is quite dated
- Environmental Product Disclosures
- We use ecoinvent in LCA work. It is a good starting point and well-documented, but many datasets are old or of low quality (but that is known, due to good documentation)
- The National Greenhouse and Energy Reporting (Safeguard Mechanism) Amendment (Prescribed Production Variables) Rule 2020
- Fertiliser Canada, Fertiliser Europe, ammoniaindustry.com
- The Nova Institut GmbH has market reports on bio-based chemicals: http://nova-institute.eu
- Possible avenues will include combinations of reports from entities such as PlasticsEurope, Best Available Techniques Reference (BAT BREF) reports, (International Council of Chemical Associations (ICCA), European Chemical Industry Council (CEFIC).
- The key issue in both of these seems to be public access. IHS Chemical has a GHG Handbook for many chemical processes that would probably be useful, but it is not available to the public. There is the US Life Cycle Inventory database that is publicly accessible although sometimes difficult to extract data from. Whether it is credible or not is a matter of debate, but it is probably better than nothing.
- The current SBT-related literature on this topic is the best available so far. However, it is very European focused.
- The eco-profiles developed by Plastics Europe, though a little old, have some quite good GHG emissions splits for key plastics. Some of these are split by production process.

14: For a given fossil energy carrier input, do you track and report the share that is burnt vs. the share that is used as feedstock?

Forty-one respondents answered this question, of which 78 percent answered “Yes” (and 22 percent, “No”) (see Figure A5 below); the result is not materially different for the 30 respondents working for a chemical company (83 percent, “Yes”; 17 percent, “No”).

Figure A5: Survey Results: Tracking and Reporting Share Burnt vs. Used in Feedstock

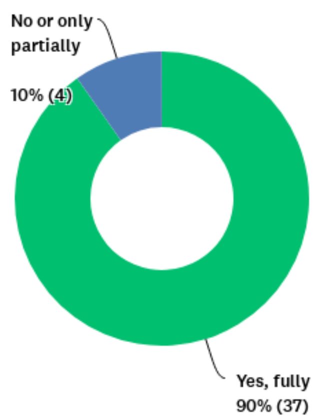


Source: SBTi Chemicals Sector Scoping Survey, 2020

15: Do you know what share of your scope 2 emissions originates from electricity, heat, steam, and cooling?

Forty-one respondents answered this question, of which 90 percent answered “Yes” (and 10 percent, “No”) (see Figure A6); the result is identical for the 30 respondents working for a chemical company. Reasons to answer “No” were that no distinction was made either between steam and heat, or between heating and cooling, and that there was the need to improve the management system.

Figure A6: Survey Results: Knowledge of origins of Scope 2 Emissions



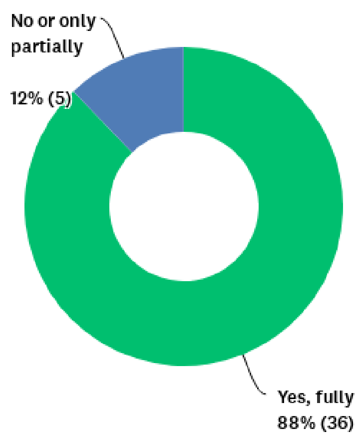
Source: SBTi Chemicals Sector Scoping Survey, 2020

16: Do you know how much electricity your company produces?

Forty-one respondents answered this question, of whom 88 percent answered "Yes" (and 12 percent, "No") (see Figure A7); the result is not materially different for the 30 respondents working for a chemical company (87 percent, "Yes"; 13 percent, "No"). Reasons to answer "No" were that part of the electricity that is generated in-house is not collected/controlled, and that not all CHPs are uniquely tracked for their electricity generation.

One respondent remarked that while the introduction to the question notes that electricity from CHP belongs to scope 1, this also holds true for heat. Thus, if the CHP is company-owned, all emissions from that plant will be scope 1.

Figure A7: Survey Results: Knowledge of Amount of Electricity Produced by Company



Source: SBTi Chemicals Sector Scoping Survey, 2020

17: Can you suggest credible, publicly accessible literature sources with long-term projections of the global chemicals sector's growth, ideally per key chemical/production process, and ideally with transparency about assumptions?

Twelve respondents provided input:

- Sectors associations (Associação Brasileira da Indústria Química (ABIQUIM), Asociación Nacional de la Industria Química (ANIQ), ICCA, CEFIC)
- "We believe the reports of agencies and industry consortiums such as PlasticsEurope, ICCA, CEFIC, as well as statistics and forecasts available from paid services such as those provided by expert consultancies (ICIS, Nexant, etc)."
- "We use nonpublic sources. IEA has had some simple models, at a high level."
- "We leverage global market analyst insights and reports (Wood McKenzie, Bloomberg)."
- "IHS Chemical also has some growth projections for many chemicals but not very long term and certainly not publicly available."

- The Nova-Institut GmbH has market reports on bio-based chemicals growth—http://nova-institute.eu.
- *Chemical Week News*
- "This is a key topic and we suggest looking at various sources with subsectoral trajectories. For example, a review we did earlier indicated that subsectoral data (one with highest correlation with historical growth) for the global chemicals sector from American Chemical Council (ACC) could be acknowledged as a reasonable proxy for determining market growth."

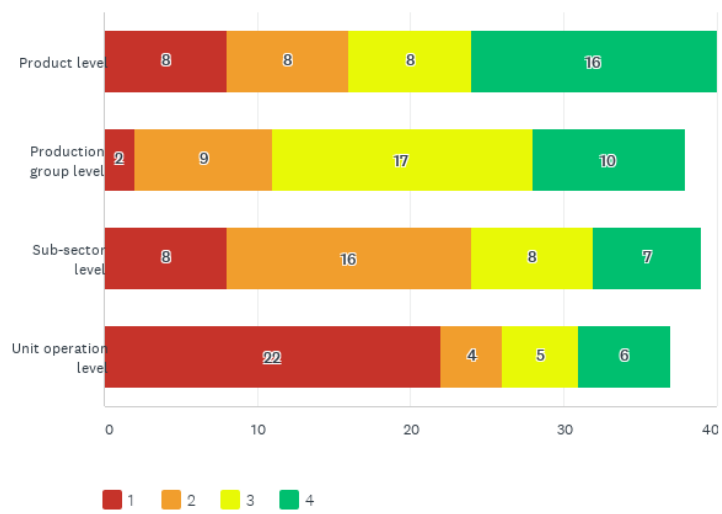
METHODOLOGICAL CHALLENGES:

18: How adequate (1 = Not adequate at all; 4 = Very adequate) do you consider the following subdivisions of the chemicals sector?

Thirty-six respondents answered this question (of whom 28 work for chemical companies).[56] They ranked the four possible subdivisions of the chemicals sector as follows:

- Production group level (e.g., plastics, surfactants, solvents): 2.9
- Product level (limited amount of key products, such as ethylene and ammonia): 2.8
- Subsector level (e.g., base organics, base inorganics, polymers, consumer chemicals, specialty chemicals): 2.4
- Unit operation level (reaction, separation, etc.): 1.9

Figure A8: Survey Results: Adequacy of Disaggregation Approaches to Subdivide the Chemicals Sector



Notes: 1 = Not adequate at all; 4 = Very adequate
Source: SBTi Chemicals Sector Scoping Survey, 2020

[56] The order of the ranking is the same when considering just the respondents working for chemical companies, with somewhat more preference for a subdivision by production group and even less preference for a unit operation level–based subdivision.

19: What other criteria should we consider (if any)?

Respondents were asked to assume we would split up per product (such as ethylene, ammonia) and then take the global emissions associated with producing the products into consideration (and focus on those whose production generates the highest scope 1, 2, and 3 emissions); they were then asked what other criteria should be considered. Twenty-two respondents provided input:

- “There will probably be much debate about the topic of subdividing. Each level has benefits and challenges. For example, subdividing by production group level may be easier for companies in terms of their accounting systems (like SAP). Subdividing by unit operation may be most helpful in terms of enabling the industry to address common issues. To the extent that the entire chemicals sector needs the same type of help (regardless of what products each company makes), the common issues we face are aligned around unit operations. That’s also how technical expertise is commonly subdivided.”
- On the use of products:
    - “We believe that the impact of a product, for example, to avoid global GHG emissions, needs to be considered somehow. The global warming of the planet depends on the total level of emissions; therefore, if certain products cause a higher emission avoidance than emissions created during production, this needs to be considered for the full GHG balance. The impact of products and their use must not be neglected.”
    - The use of nitrogen products must also take into consideration crop yield management, the overall food supply and impacts production, our impact on SDGs—specifically #2, Zero Hunger.
- On the production process, value chain and products:
    - “There are likely different ways to produce those products, and so the specific processes used should be considered.“
    - “Supplier-specific process technologies used”
    - “Region-specific energy composition/type”
    - “Variations in quality level (specification)”
    - “Which process is used for production; what is the source of raw materials (e.g., in the case of methanol as raw material, it is based on coal or natural gas)” + “Alternative technology routes for production.”
    - “Products that make up the majority of impacts. We have 300,000 products, most of which are sold in small quantities.”
    - “Chemical companies are typically diversified and may include a number of different subsector levels and/or production group levels.”
    - Focus can be on the products generating the highest emissions, but alternatively also on the products generating the highest economic value.
    - Prioritize products with high growth projections.
    - “Each company should have its own product-by-product analysis to reference the global number to help drive innovation/efficiency/decarbonization.”

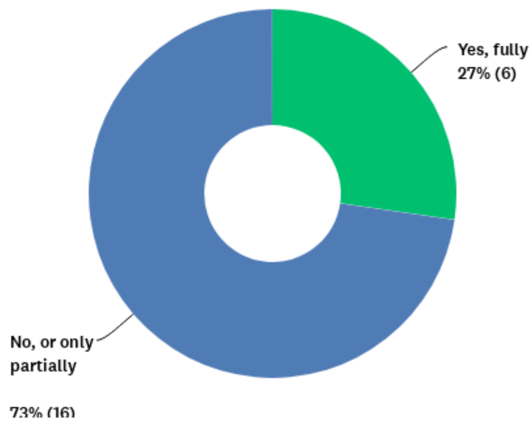
  - Assumption around level of existing abatement (Business As Usual (BAU), where the technology is proven and commercially available); for example, secondary abatement catalyst for nitrous oxide emissions in nitric acid production.
  - "Product composition and use of each product and product fate, including fugitive emissions."
  - Prioritize products for which solutions such as bio-based chemicals are available.
  - There may be a need to subgroup the chemicals sector companies as we have a wide range of products including by-products and different end uses.
  - "A key challenge, particularly with upstream 'data' is that many processes make multiple products with unequal economic value but must still be allocated in some way, usually by mass. If suppliers or databases use different allocation methods, the reported burdens can be vastly different."
- On scope 3 emissions:
  - With regard to scope 3 emissions, it is important to consider how products interact and volatize in soil and air, and how temperatures and moisture impact emissions. A global perspective is too general, and regional clarity is needed to provide meaningful targets.
  - It is key to consider a practical way of assessing scope 3 emissions of chemical intermediates as they flow into several possible value chains, each mapping to a different end of life and other considerations, which also vary by geography. Hence reliable market statistics are required. Also, at ethylene level, there may be feedstock differences that should be taken into consideration.
  - "Product life cycle in relation to recycle"
  - "Circular economy"
- Various other points:
  - "Ease and scope of obtaining the data"
  - Point of attention: Reductions of emissions over the value chain related to outsourcing part of the process to a specialist, thus transferring the emissions from one subsegment to another
  - Regional aspects
  - "This would be a huge leap forward"
  - Company revenue, geography, years of operation (history)

20: Do you know what happens with your hydrocarbon products at the end of their life?

Twenty-two respondents working for chemical companies producing products with end-of-life emissions (Question 4) answered this question, of which 16 (73 percent) indicated they do not, or only partially, know what happens with their hydrocarbon products at the end of their life (see Figure A9).[57]

[57] The percentage remains almost the same when including all respondents (37) or all respondents working for a chemical company (28).

Figure A9: Survey Results: Knowledge of Companies' Hydrocarbon Products End of Life Fate



Source: SBTi Chemicals Sector Scoping Survey, 2020

Respondents to Question 20 were asked to substantiate in case they only partially know these emissions, answers include the following:

- "There is no full traceability for scope 3."
- "Not "knowing" but some sources, for example, PlasticsEurope or Conversio surveys indicate at least a little bit how the real picture could look. Here, it is key to have reasonably reliable, regularly updated waste management distribution studies per chemical product disposed per country or at least region."
- We do not have detailed visibility, but most of our products are eaten.
- "Our products are bio-based; they only emit biogenic CO_2 so they are not contributing to downstream emissions. This benefit of using bio-based products needs to be addressed in the guidance."
- "Little line of sight of full chain of custody and use of chemical products after initial sale and distribution."
- "Unknown for products with hydrocarbons. Assume refrigerants released to atmosphere."
- "A global chemical company has typically diverse application and customer structure, delivering to all regions in the world. It is very challenging to know fully what happens with hydrocarbon products at the end of life. There are only few cases where we recycle back the product, or in particular applications where the end of life is combustion."
- "Yes, we agree, this is a very complex topic, and it is one of our challenges as well. For now we assume all of our products are incinerated, and we calculate the CO_2 emissions by amounts of the coal content of all our products."
- "Limited literature on end-of-life (EOL) for our products. Likely to increase in future with more circularity introduced."
- "Partially, we have no way of knowing exactly the method of disposal for all customers; how they are used, etc. Each customer is unique."

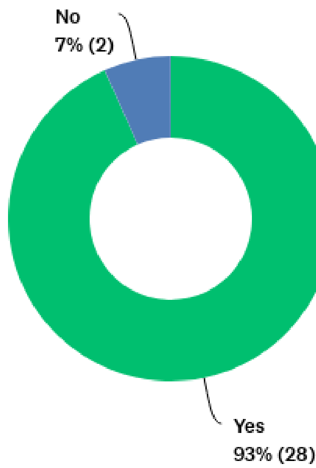
- "The end of life of our products vary significantly based on what products they are used in, since we produce intermediates."
- "Specialty chemicals and materials go into a highly diverse set of end uses, some of which are consumptive."
- We have made estimates for most products, putting everything into broad categories of the likely fate—landfill, incineration, wastewater treatment. There is high uncertainty, no actual data, and no ability to track year-on-year.
- We produce carbon containing bio-monomers that are reacted into various polymers. We do not know end of life for these polymers, which are sold into a variety of fragmented end markets.
- "Some are incinerated; some end up in the environment; a small portion are recycled. Quantities are unknown."
- Some of our products are used in packaging for consumers, so very dependent on local waste treatment practices.
- As intermediate producers, we sell business-to-business (B2B) and don't trace the end of life. However, we know that our carbon content is biogenic to a large extent. End-of-life emissions can change dramatically.
- Reliable and consistent market data should be made available for all parties. It is required to substantiate precisely the end of life of hydrocarbon products. Some polymer products that have been produced 30 to 40 years back, such as plastic pipes, may be in active service life now and even for extended periods. How to account for such factors?
- Based on emissions factors and modelling, in some cases not based on actual test data at each phase. Emissions factors are too general or don't show reduction achievements.
- "We estimate end-of-life fate via regional statistics on waste streams. This is a very rough approximation only, starting with the assumption that products sold in a certain region remain in this region."
- "We don't have visibility into every end-application in which our products are used, so cannot reasonably answer 'Yes' to this question without making a lot of assumptions."
- "We know most of the end-of-life fate, but cannot guarantee their use for nonintended purposes."
- We only have this information on a theoretical basis.

21: Do you track and report your process emissions?

Among respondents working for a chemical company, 93 percent indicate they track and report their process emissions (Figure A10).[58]

[58] 83 percent, if based on all respondents.

Figure A10: Survey Results: Tracking and Reporting of Process Emissions



Source: SBTi Chemicals Sector Scoping Survey, 2020

22: Should process emissions be treated differently from energy-related emissions?

Of total respondents (41), 61 percent indicate process emissions should be treated differently from energy-related emissions.[59] Reasons include the following:

- Emission sources and mitigation measures are different, so we need to treat them differently (four responses).
- No easy replacements or technology solutions to address process emissions. Much harder to decarbonize than energy (two responses).
- Given the heterogeneous nature of abatement potential, process and energy-related emissions should be treated differently:
    - Note that nitric acid production–related process emissions can more easily be abated than ammonia production–related process emissions.
- Tracking process emissions can be very challenging, it may be necessary to adjust thresholds for exclusion, or develop sector-specific estimation methods.
- Some process emissions such as purges are inevitable elements, sometimes for safety considerations of the plant. In such cases, if process purges up to a permissible level; for example, 5 percent or less of the total are allowed to be excluded, it makes the target aspirations more realistic.
- They can be an order of magnitude different.

Reasons not to treat process emissions differently include the following:

- "All these emissions contribute to global warming so all need to be addressed and included; no reason to treat this differently."
- "They should be treated the same, if they are both scope 1."

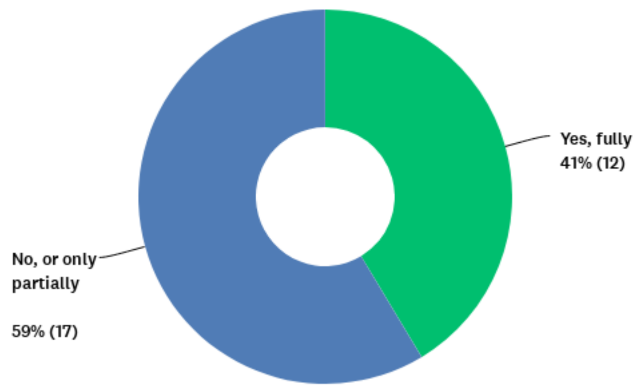
[59] 53 percent for the 30 respondents indicating they work for a chemical company.

- “GHG is GHG. It is helpful to disclose process GHG separately to energy-related GHG to help drive removal/alternatives.”
- “They are all emissions contributing to global warming potential (GWP), so they should be treated similarly. We also report biogenic process emissions.”

23: Do you know the amount of fugitive emissions in your chemical plants?

Of respondents working for a chemical company, 41 percent indicated they know the amount of fugitive emissions in their chemical plants (Figure A11).[60]

Figure A11: Survey Results: Knowledge of Amount of Fugitive Emissions from Company Operations



Source: SBTi Chemicals Sector Scoping Survey, 2020

24: Which share of your scope 1 emissions is formed by fugitive emissions?

Eighteen out of 39 respondents were able to provide a percentage, which was the following:

- 70 percent
- 25 percent
- Approximately <10 percent

Most respondents (15) provided percentages (well) below 5 percent:

- <5.0 percent (two responses)
- 4.0 percent
- <3.0 percent
- <2.0 percent
- <1.0 percent (seven responses)
- <0.5 percent (two responses)
- Almost nil

[60] 38 percent based on all respondents.

WHAT YOUR COMPANY CAN ACHIEVE:

The last four questions (25–28) aimed at understanding what GHG emissions reduction trajectory respondents would consider "feasible" for their chemical company. The questions asked for the technically feasible (not considering economics and assuming sufficient availability of sustainable resources) potential and for the most ambitious plausible pathway (including anticipated policy development, innovation, and infrastructure development and any other limitations the respondent chose to include or not to include) and aimed at sight years 2025 and 2035. These questions were difficult to answer, as some of the respondents indicated in the last general question (Question 29), remarking, the following:

- "Our estimates on technically feasible or realistic reductions of scope 1 and 2 emissions for 2025 and 2035 are based on an assumed annual growth of our business/production output. It is unrealistic to assume that there is no business growth, and we think that business growth (as well as speed of innovation and economics) needs to be factored in when determining absolute targets for the industry."
- "Responses to Questions 25–28 consider company growth, while Questions 27–28 also consider certain limitations of technology shifts (e.g., availability of low-carbon energy alternative in remote site locations, unfeasible projects in economic terms, etc.) as well as company preferences (e.g., prefer use of power purchase agreements [PPAs] for renewable electricity rather than environmental attribute certificates [EACs] only). Excluding these assumptions, the emissions reduction levels can be increased."
- "Providing data on potential GHG emissions reductions based on limited data is currently unrealistic, in my view. As an example, if carbon capture storage or use is feasible and cost effective, and there is a market for the CO_2 captured, this would have a tremendous effect on reducing our GHG footprint—today, that is not the case. Furthermore, technical advances being investigated are not currently available. These questions need to be better framed to allow for a reasoned response. Eliminating all roadblocks should result in zero GHG emissions—but that is not the case."

Consequently, the response rate was relatively low, and apart from that, respondents used different starting points when answering these questions:

- Some answered with absolute reductions, others with intensity reductions, and most did not specify whether growth was included.[61]
- One respondent provided combined scope 1 and 2 emissions reduction numbers.
- Some respondents used different base years—others did not specify the base year.[62]
- Six respondents[63] provided more ambitious realistic numbers than technically feasible numbers.

[61] Unfortunately, the survey did not specify this.
[62] It is expected that most other respondents had the current situation in mind, but this has not been made explicit.
[63] These have not been taken into consideration in the evaluation below.

It can thus be concluded that Questions 25–28 were not phrased sharply enough to enable firm conclusions to be drawn.

Nevertheless, some conclusions can still be drawn,[64] with some care:

- More respondents were able to provide emissions reduction numbers for scope 1 and 2 (17 and 16, respectively) than for scope 3 (9).
- Respondents provided a wide scatter of numbers, with the technical potential for scope 1 emissions reductions by 2025 ranging from 5 to 80 percent,[65] and for scope 2 emissions from 2 to 100 percent.
- In all sight years (2025 and 2035) and for both scopes (technical emissions reduction potential and most ambitious realistic potential), the scope 2 reduction potential is highest, and the scope 3 reduction potential is lowest.
- The technical emissions reduction potential is ~50 percent (scope 1), ~30 percent (scope 2), and >100 percent (scope 3) higher for 2035 than for 2025.
- The most ambitious realistic emissions reduction potential is ~50 percent (scope 1), ~90 percent (scope 2), and >100 percent (scope 3) higher for 2035 than for 2025.

FINISH:

29: Is there anything else you would want to comment on?

Below are a selection of comments:[66]

- "The calculation basis could be more clear and traceable."[67]
- It is important to consider bio-based materials as an alternative to fossil-based chemicals. The methodology should incentivize and drive this transition, given that the bio-based chemicals have lower specific GHG emissions than their fossil-based counterparts, from a cradle-to-grave perspective (companies should provide evidence that this is indeed the case to prevent misuse). However, at the moment at company level, this impact is not captured. For example, a bio-based chemical company with high growth will see its emissions increasing while at sector level this can contribute to decreasing the overall sector emissions.
- "Achieving significant reductions is dependent upon technology developments for scalable, cost-effective carbon capture storage (CCS) or carbon capture storage and utilization (CCSU). Without that, SBTs for scope 1 and 2 are unreachable for our company. Also, we do not think mandating a scope 3 target is appropriate to set a SBT for scope 1 and 2. There should be options to set SBTs for scope 1 and 2 independent of scope 3. The accounting for scope 3 is far too imprecise for us to manage a meaningful reduction target, let alone secure management support."

[64] In view of the relatively low response rate, no distinction has been made between respondents working for a chemical company, (not) producing products emitting greenhouse gases at the end of their life.
[65] This number has been provided by a respondent working for a chemical company.
[66] Some comments have been moved to the question they relate to.
[67] We assume this relates to Questions 25–28.

- Our specific production group will need a longer runway/timeline to obtain suggested targets as a result of several factors:
    - Turnaround schedules—our industry has annual turnaround schedules for weeks at a time, which impact emissions.
    - Supply/demand for our products—it is tied to an ever-growing world that needs our product, and demand for our products grows at 2 percent annually, so is hard to baseline production as we are continually adding new production to meet demand.
    - Technology—there is currently no new technology that can help to reduce emissions enough to hit current 2030 targets.
    - Renewable energy—A significant amount of renewable energy would be required, and without a larger and more economical supply of renewable energy this is not viable.
    - Economics—The economics of current and future technology is challenging.
- "We need some significant technical breakthroughs. We are limited by affordable renewable thermal energy sources and affordable carbon capture."
- "SBTi chemicals sector–specific guidance would be valuable for our company and industry, to ensure consistency and broad industry adoption."
- "We can only reinforce the message that industrial gases need to be in a different sector."
- "This is a really difficult survey to complete as the questions are not obvious and require a high degree of sustainability understanding. It might be worth checking comprehension with segments of the sector who are not yet fully engaged on sustainability and climate change."
- "The ability to offset should also be considered."
- "How does this framework address issues linked to mergers and acquisitions, especially as we see a lot of consolidations in this industry? What challenges are foreseen in progressing on climate and coupling growth (e.g., growth may happen in countries without strong CO_2 regulations or market pull, in which case, new assets have to be designed for low-carbon without any economic advantages or even at an economic disadvantage of an expensive design, asset, etc.). How do companies see the duality of growth investments in countries where limits on availability of feedstock also limits availability for other infrastructure for carbon mitigation, such as renewables, technology, etc."
- "When considering methodology development, trade-offs with other environmental impacts need to be taken into consideration."
- Many chemical companies require low and medium temperature process heat to drive chemical reactions and separations. We have and will continue to actively drive energy efficiency, but ultimate decarbonization will require net-zero GHG sources of heat. This has, thus far, made deep decarbonization of industry more difficult than power, transportation, and other industries tied to electricity.
- "Eagerly anticipating publication of chemicals sector methodology."

- “We are internally working out how a CO_2 roadmap and ambition can help us. We think that the chemical sector guidance will support us in defining the pathway.”

Appendix B: Scope 3 Category Priorities

Table B1: Rationale for Developing and Prioritizing Chemical Sector–Specific Resources and Guidance for Each Scope 3 Category

Category	Reasons	Percentage of respondents	Priority to develop specific guidance
UPSTREAM			
Category 1 Purchased goods and services	As a broad range of different goods from a high number of suppliers is necessary to produce chemicals, sector-specific guidance should include the following: • Standardization of emissions factors, guidance on how to account for emissions reduction activities from suppliers/raw materials. • WBCSD guidance (2013) suggests that companies should calculate emissions from at least 80 percent (by volume or weight) of their emissions of purchased goods and services, after which results can be extrapolated to estimate 100 percent of emissions. • How to deal with a potential “renewable/circular” target for purchased feedstocks (in coherence with categories 3, 5, and 12).	69	HIGH
Category 2 Capital goods	N/A	18	N/A
Category 3 Fuel- and energy-related activities (not included in scope 1 or 2)	N/A	36	N/A

Category 4 Upstream transportation and distribution	N/A	36	N/A
Category 5 Waste generated in operations	Chemicals sector–specific guidance should appropriately define waste. By definition, by-products from one process are considered waste; however, in the chemicals sector these by-products are often used as feedstock for another process. The approach for this category should align with the method chosen for end-of-life treatment of sold products.	49	N/A
Category 6 Business travel	N/A	16	N/A
Category 7 Employee commuting	N/A	11	N/A
Category 8 Upstream leased assets	N/A	3	N/A
DOWNSTREAM			
Category 9 Downstream transportation and distribution	N/A	33	N/A

Category 10 Processing of sold products	Chemicals sector–specific guidance should explore whether, and in which cases, non-CO_2 GHGs such as HFCs should be included/excluded from this category. It should also cover how chemical companies producing non-CO_2 GHGs should account and report emissions in this category. The Scope 3 GHG Protocol states that companies may disclose and justify the exclusion of downstream emissions from categories 9, 10, 11, and 12 (but should not selectively exclude a subset of those categories). “In certain cases, the eventual end use of sold intermediate products may be unknown. For example, a company may produce an intermediate product with many potential downstream applications, each of which has a different GHG emissions profile, and be unable to reasonably estimate the downstream emissions associated with the various end uses of the intermediate product” (WRI and WBCSD 2004). Not deemed required by WBCSD (2013) guidance for the chemicals sector, as “the diversity of applications generally cannot be reasonably tracked. Therefore, at this time category 10 is not required; however, if companies can account for these emissions, they should include them in their inventory.”	56	MEDIUM
Category 11 Use of sold products	Direct use-phase emissions of sold products can originate from the following: • Products that directly consume energy (fuels or electricity) during use • Fuels and feedstocks • Greenhouse gases and products that contain or form greenhouse gases that are emitted during use (WRI and WBCSD 2011) Chemicals sector–specific guidance should address how to deal with the following: • The large number of end products that intermediate products produced by chemical companies end up in • Specific product groups, including fertilizers (N_2O / CO_2 emissions) and HFCs The SBTi manual (2020d) specifies that inclusion of indirect use-phase emissions (e.g., emissions from washing apparel for a manufacturer of washing powder) is not mandatory in target setting. The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2011) states that companies may disclose and justify the exclusion of downstream emissions from categories 9, 10, 11, and 12 (but should not selectively exclude a subset of those categories).	76	MEDIUM

Category 12 End-of-life treatment of sold products	Chemicals sector–specific guidance should be provided for this category, as the sold products, differently than for most other sectors, generate emissions when they would be/are incinerated or sent to landfill. This should be done in coherence with the guidance for categories 1 and 5. The Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2011) states that companies may disclose and justify the exclusion of downstream emissions from categories 9, 10, 11, and 12 (but should not selectively exclude a subset of those categories).	76	HIGH
Category 13 Downstream leased assets	Not deemed relevant by WBCSD (2013) for chemicals sector—but needs checking every three years.	4	N/A
Category 14 Franchises	Not deemed relevant by WBCSD (2013) for chemicals sector—but needs checking every three years	7	N/A
Category 15 Investments	N/A	13	N/A

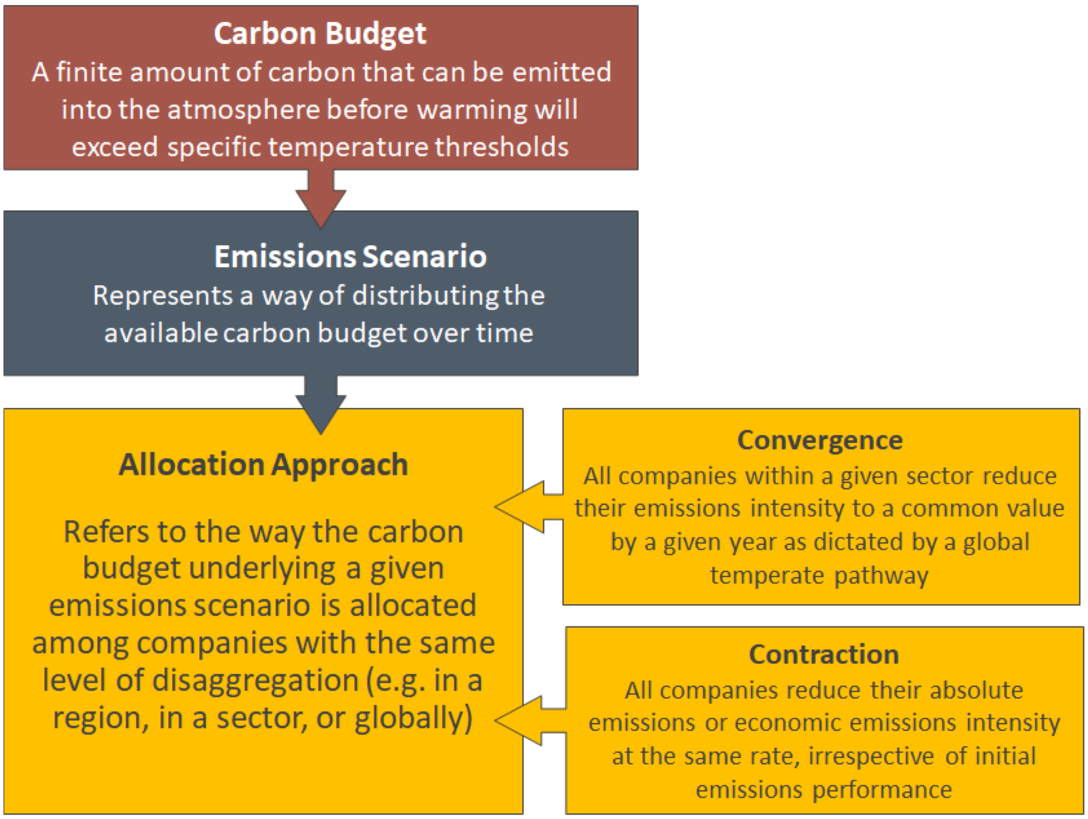
Notes: N/A = Not applicable **(**categories without any relevant chemicals sector–specific development); GHG = Greenhouse gas; HFCs = Hydrofluorocarbons; CO_2 = Carbon dioxide; N_2O = Nitrous oxide.

Source: Authors' assessment; "percentage of respondents" is based on the survey described in Appendix A.

Appendix C: SBTi Target-Setting Methods

In general, an SBT method comprises three components: an emissions budget, an emissions scenario, and an allocation approach (convergence or contraction). Methods can vary in terms of each of these components.

Figure C1: Elements of SBTi Methods



Source: SBTi 2020d

Carbon Budget

A carbon(-equivalent) budget is an estimate of the cumulative amount of greenhouse gases that can be emitted over a period while limiting temperature rise to a specific amount. The science-based target-setting methods apply to all seven greenhouse gases included in the Kyoto Protocol,[68] and temperature goals have been defined based on the Paris Agreement to limit the average global temperature rise to well-below 2°C (WB2D) above preindustrial levels and pursue efforts to limit this increase to 1.5°C.

[68] The seven GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

The SBTi uses the transient climate response to emissions (TCRE)[69] budget, which is estimated with earth system models of varying levels of complexity, aggregated by the Intergovernmental Panel on Climate Change (IPCC) in the Special Report on Global Warming of 1.5˚C (SR15), and assigned probabilistic bins for each level of warming (IPCC 2018, Table 2.2). The SBTi uses the 50th percentile TCRE CO_2 budget associated with 1.5˚C, 770 Gt CO_2 adds the approximate projected impact of non-CO_2 emissions (320 Gt CO_2e), and subtracts 100 Gt, which reflects the approximate impact of noninstantaneous earth system feedbacks.[70] Thus, the SBTi budget for a 1.5˚C scenario evaluates to 990 Gt CO_2e (670 GtCO_2). Likewise, the SBTi uses the 66th percentile TCRE CO_2 budget associated with 2˚C warming as a WB2D budget, 1,320 Gt CO_2, which evaluates to 1,540 Gt CO_2e (1,220 Gt CO_2). For more details, refer to SBTi's (2019) "Foundations of Science-Based Target Setting" publication.

Thus far SBTi has used aggregate global GHG budgets for scenario analysis. One potential future development would be to develop sector- or subsector-level budgets for well-below 2°C and for 1.5°C. This is contingent on IPCC Sixth Assessment Report publications and data, as well as resource availability and stakeholder engagement.

Scenarios Used for Setting SBTs

While it is not possible to predict future GHG emissions, scenarios provide trajectories for how emissions reductions *could be achieved* based on assumptions made about population, policy trajectories, economic growth, and technological advances and their cost effectiveness, while conserving a net GHG budget. The SBTi scenarios are drawn primarily from the Integrated Assessment Modeling Consortium (IAMC) and the International Energy Agency (IEA). The IAMC hosts an ensemble of more than 400 peer-reviewed emissions pathways, which have been compiled and assessed by the authors of the IPCC SR15 (Huppmann et al. 2019); and the IEA publishes its own scenarios regularly, which provide a greater amount of sectoral granularity. "Energy Technology Perspectives 2020" by the IEA (2020) explores a Stated Policies Scenario (STEPS) and Sustainable Development Scenario (SDS) from the present day to 2070 for the chemicals sector and has been taken into consideration during this phase of the SBTi chemicals sector scoping project.

Allocation Approach

SBTi translates the resulting carbon budget underlying a given emissions scenario into practical requirements that align company emissions with the same emissions reduction pathway using an allocation approach.

[69] The most commonly used emissions budget is the TCRE, which estimates the instantaneous global temperature response to cumulative emissions.
[70] The IPCC SR15 also includes adjustment amounts for different uncertainties and use-cases of the TCRE, such as an estimate of the impact of noninstantaneous earth system feedbacks (e.g., permafrost thawing), if evaluated to 2100.

The science-based target-setting methods use two main approaches to allocate emissions at a company level:

1. Convergence, where all companies within a given sector reduce their emissions intensity ***to a common value*** by some future year as dictated by a global emissions pathway (e.g., the emissions intensity of all electric power companies converges to a maximum of 29 g CO_2/kWh of electricity in 2050, which can also be expressed as a percentage). The reduction responsibilities allocated to a company vary depending on its initial carbon intensity and growth rate relative to those of the sector, as well as the sector-wide emissions intensity compatible with the global emissions pathway. The convergence approach can only be used with sector-specific emissions scenarios and physical intensity metrics (e.g., tons GHG per ton product or megawatt-hour [MWh] generated). While SBTi understands that companies face varying energy and emissions systems across geographies, the convergence approach reflects the initiative's exclusive global orientation, that is, SBTi does not provide for regionally differentiated targets.

2. Contraction, where all companies reduce their absolute emissions or economic emissions intensity (e.g., tons GHG per unit value added) ***at the same rate***, irrespective of initial emissions performance, and do not have to converge upon a common emissions value. The contraction approach can be used with sector-specific or global emissions scenarios.

This section also describes data inputs and outputs for each method. Because the methods are sensitive to the inputs used, and because errors can propagate throughout the methods, company data should be as accurate as possible (see also SBTi [2020d] Target Setting Manual, Chapter 3.3). Beyond currently available methods, it is expected that new scenarios and methods will be developed for a range of specific sectors, including components of the chemicals sector. Information on these will be posted to the SBTi's website as the methods are made publicly available and/or validated by the initiative.

Absolute Emissions Contraction

Absolute Emissions Contraction is a method for setting absolute targets that uses contraction of absolute emissions. Through this approach, all companies reduce their absolute emissions at the same rate, irrespective of initial emissions performance. Consequently, an absolute emissions reduction target is defined in terms of an overall reduction in the amount of GHGs emitted to the atmosphere by the target year, relative to the base year (e.g., reduce annual CO_2e emissions 35 percent by 2025, from 2018 levels).

The minimum reduction required for targets in line with well-below 2°C scenarios is 2.5 percent in annual linear terms. Companies, particularly those in developed countries, are strongly encouraged to adopt targets with a 4.2 percent annual linear reduction to be aligned with limiting warming to 1.5°C.

This method is a simple, straightforward approach to set and track progress toward targets that is applicable to most sectors. In the absence of sector-specific methods, chemical companies may use the absolute contraction method to set SBTs.

The absolute contraction approach can be applied to individual chemicals sector products and product-groups/subsectors (see Table C1).

Table C1: Absolute Emissions Contraction Approach

Method	Company input	Method output
Absolute emissions contraction	• Base year • Target year • Base year emissions, disaggregated by scope 1, 2, and 3	Overall reduction in the amount of absolute GHGs emitted into the atmosphere by the target year, relative to the base year

Note: GHG = Greenhouse gas.
Source: SBTi 2020d

Sectoral Decarbonization Approach

The Sectoral Decarbonization Approach (SDA) is a method for setting physical intensity targets that uses convergence of emissions intensity. An intensity target is defined by a reduction in emissions relative to a specific business metric, such as production output of the company (e.g., ton CO_2e per ton of product produced). The SDA assumes global convergence of key sectors' emissions intensity by 2060. For example, the emissions intensity of steel production in China, the United States, and Brazil is assumed to reach the same level by 2060, regardless of its current diversity. The existing fifteen regional pathways have not been incorporated into this method to maintain global convergence.

The SDA uses the Beyond 2°C Celsius Scenario (B2DS) from the IEA's (2017) "Energy Technology Perspectives 2017," which comprises emissions and activity projections used to compute sectoral pathways aligned with limiting warming to well-below 2°C. Due to the lack of 1.5°C scenario data from IEA, SBTi currently does not provide an SDA option for 1.5°C targets, with the exception of the electricity generation sector, for which SBTi has developed its own 1.5°C pathway and tool.

Due to unavailable subsector and product group emissions data, the SDA does not presently cover the chemicals sector. The renewed publication of the ETP in 2020 has raised the possibility of updating the SDA and perhaps including additional sectors, such as chemicals. As of December 2020, the IEA has made the ETP 2020 dataset available for purchase. It includes projections at the global level for the Sustainable Development Scenario (SDS), which corresponds with well-below 2°C; it does not include a 1.5°C scenario.

Targeted emissions intensity varies by company base year emissions intensity, projected activity growth, and sectoral budgets. Companies can use the relevant SDA pathways to calculate intensity in the target year. The SDA covers scopes 1 and 2. It has limited applicability to scope 3 categories.

The SDA (see Table C2) is not applicable to individual chemicals sector products or product groups/subsectors. However, disaggregation of specific products or product groups/subsectors has been considered during this phase of the SBTi chemicals sector scoping project.

Table C2: Sectoral Decarbonization Approach

Method	Company input	Method output
Sectoral Decarbonization Approach (SDA)	• Base year • Target year • Base year emissions, disaggregated by scope 1, 2, and 3 • Activity level in the base year (e.g., building floor area, distance traveled, etc.) • Projected change in activity by target year	A reduction in emissions relative to a specific production output of the company (e.g., ton CO_2e/MWh)

Note: CO_2e/MWh = Carbon dioxide equivalent per megawatt-hours.
Source: SBTi 2020d

Economic Intensity Contraction

Greenhouse Gas Emissions per Value Added (GEVA) is a method for setting economic intensity targets using the contraction of economic intensity. Targets set using the GEVA method are formulated by an intensity reduction of tons of carbon dioxide equivalent per value added (tCO_2e/$). Under the GEVA method, companies are required to reduce their GEVA by 7 percent per year (compounded). The 7 percent year-on-year reduction rate is based on an absolute emissions reduction of about 75 percent by 2050 from 2010 levels. Based on recent economic projections and estimates of historic emissions, the 7 percent rate is broadly compatible with high-confidence IPCC (RCP2.6) pathways, and its ambition is intermediate between the IEA 2DS and B2DS pathways, under idealized conditions that are expounded below (IEA 2017; SBTi 2019).

Unlike the Absolute Contraction and SDA methods, GEVA only maintains a global emissions budget to the extent that the growth in value added of individual companies is equal to or smaller than the underlying economic projection. The differentiated growth of companies and sectors is not balanced by GEVA (and other economic intensity target-setting methods); thus, the currently accepted GEVA value depends on idealized conditions where all companies are growing at the same rate, equal to that of GDP, and GDP growth is precisely known. For these reasons, and due to the volatility of economic metrics, economic intensity target-setting methods are considered less robust than absolute and physical intensity methods.

Note that per current SBTi criteria, scope 1 and 2 targets using GEVA are only acceptable when they lead to a reduction in absolute emissions in line with well-below 2°C and 1.5°C scenarios. GEVA as such is more applicable for scope 3 target setting (See Table C3).

Table C3: Greenhouse Gas Emissions per Value Added Approach

Method	Company input	Method output
GHG Emissions per Value Added (GEVA)	• Base year • Target year • Base year emissions, disaggregated by scope • Value added in the base year • Projected change in value added by target year • Possible metrics for calculating value added: ○ Value added = Sales revenue – the cost of goods and services purchased from external suppliers ○ Value added = Gross profit (in US accounting, often available in the annual financial statement) ○ Value added = Operating profit = Earnings before interest and depreciation (EBITDA) + all personnel costs	A reduction in emissions relative to financial performance of the company (e.g., ton CO_2e per value added)

Notes: Personnel costs should include payment to management and board members.
Source: SBTi 2020d; Randers 2012

Existing scope 1 and 2 SBTi methods provide a foundation for chemical company target development. However, the lack of chemicals sector–specific physical intensity pathways, emissions budgets, and sector guidance have been an impediment for some companies to set targets. Before reviewing the targets set thus far by chemical companies, it is helpful to understand the criteria in Section 2 used to assess SBTs.

Appendix D: Overview of Chemical Company SBTs and Distribution of Emissions

As of December 2020, the SBTi recognizes 29 chemical companies that have publicly committed to setting science-based targets, of which 11 have approved targets that meet all the current target-setting criteria.

Table D1: Overview of Selected Approved Chemical Company Science-Based Targets

Company	Temperature Alignment	Scope 1 and 2	Scope 3	Target Language
Novozymes A/S	1.5°C	Absolute	Absolute	Absolute: Global biotechnology company Novozymes commits to reduce absolute scope 1 and 2 GHG emissions 50% by 2030 from a 2018 base year. Renewable energy: Novozymes commits to increase annual sourcing of renewable electricity from 37% in 2018 to 100% by 2030. Absolute: Novozymes also commits to reduce absolute scope 3 GHG emissions from purchased goods and services 15% by 2030 from a 2018 base year.
Ecolab	1.5°C	Absolute	Supplier engagement	Absolute: Ecolab commits to reduce absolute scope 1 and 2 GHG emissions 50% by 2030 from a 2018 base year. Supplier engagement: Ecolab also commits that 70% of its suppliers by emissions covering purchased goods and services, capital goods, upstream transportation and distribution, business travel, and downstream transportation and distribution will set science-based targets by 2024. *The target boundary includes biogenic emissions and removals from bioenergy feedstocks.
Polygenta Technologies Limited	1.5°C	Absolute	N/A	Absolute: Polygenta Technologies Ltd. commits to reduce absolute scope 1 and scope 2 GHG emissions 50% by 2030 from a 2018 base year, and to measure and reduce its scope 3 emissions.

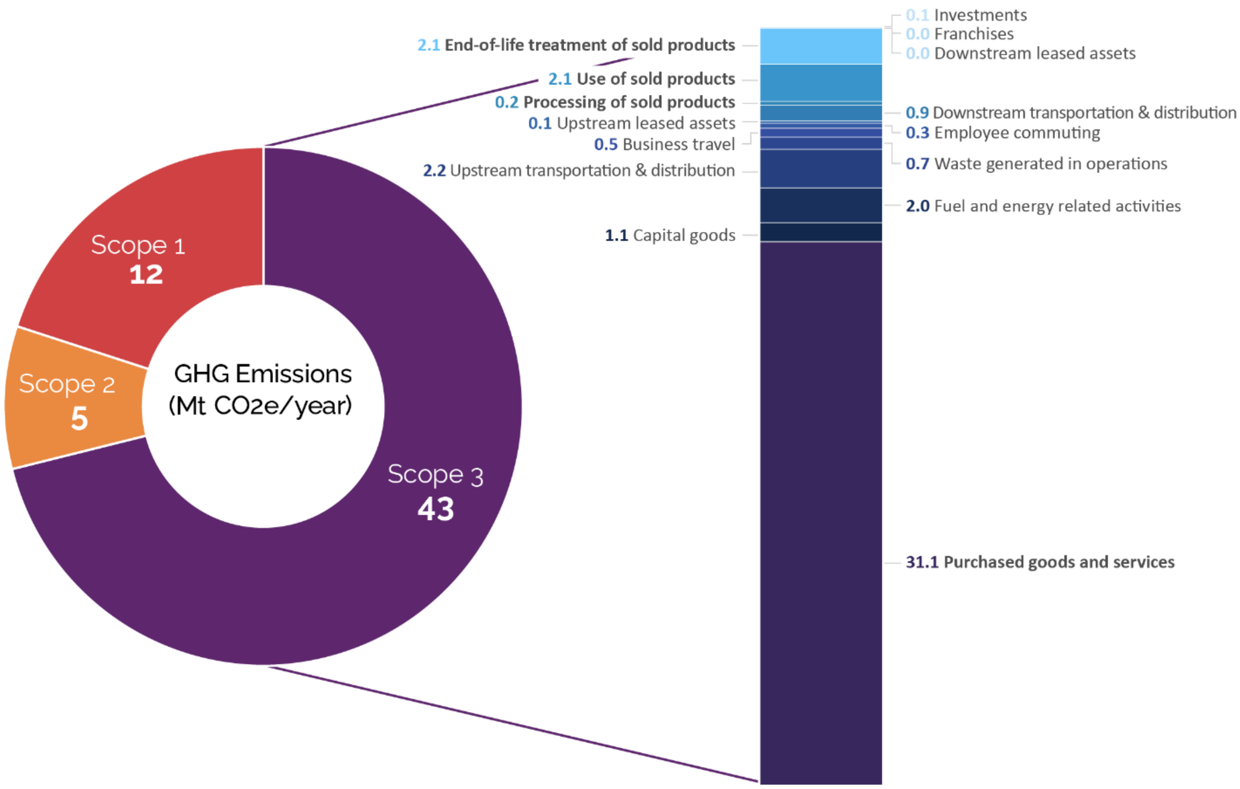
				*This target was approved using a streamlined target validation route exclusive to small and medium-sized enterprises (SMEs).
Borregaard A/S	WB2D	Absolute	Absolute	Absolute: Norwegian biorefinery Borregaard commits to reduce absolute scope 1 and 2 GHG emissions 53% by 2030 and 100% by 2050 from a 2009 base year. Absolute: Borregaard also commits to reduce absolute scope 3 GHG emissions by 30% by 2030 and 75% by 2050 from a 2017 base year *The target boundary includes biogenic emissions and removals associated with the use of bioenergy.
International Flavors & Fragrances, Inc.	WB2D	Absolute	Supplier engagement	Absolute: American producer of flavors and fragrances and cosmetic actives International Flavors & Fragrances, Inc. commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2025, from a 2015 base year. Supplier engagement: International Flavors & Fragrances, Inc., also commits to working with its suppliers (representing 70% of its supply chain emissions) so that they set their own science-based reduction targets and report annual emissions by 2025.
Sabará Participaçõesc	WB2D	Absolute	N/A	Absolute: Sabará Participaçõesc commits to reduce absolute scope 1 and scope 2 GHG emissions 30% by 2030 from a 2018 base year, and to measure and reduce its scope 3 emissions. *This target was approved using a streamlined target validation route exclusive to small and medium-sized enterprises (SMEs).
Syngenta AG	WB2D	GEVA	GEVA	Intensity: Agriculture company Syngenta commits to reduce scopes 1, 2, and 3 GHG emissions 68% per value added by 2030 from a 2016 base year.
Tata Chemicals Limited	WB2D	Absolute	N/A	Absolute: Tata Chemicals Limited commits to reduce absolute scope 1 and 2 GHG emissions 28% by 2030 from a 2019 base year.
Royal DSM	2°C	Absolute	Intensity	Absolute: Dutch multinational Royal DSM commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2030 from a 2016 base year.

				Intensity: DSM also commits to reduce scope 3 GHG emissions from purchased goods and services, upstream transportation and distribution, and waste generated in operations 28% per tonne of product produced by 2030 from a 2016 base year.
Sumitomo Chemical Co., Ltd.	2°C	Absolute	Supplier engagement	Absolute: Japanese multinational chemical company Sumitomo Chemical commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2030 and 57% by 2050 from a 2013 base year. Supplier engagement: Sumitomo Chemical also commits that 90% of its suppliers by product weight will institute science-based GHG reduction targets by 2024.
Sekisui Chemical Co., Ltd.	2°C	Absolute	Absolute	Absolute: Sekisui Chemical commits to reduce absolute scope 1 and 2 GHG emissions 26% by 2030 from a 2013 base year. Absolute: The company also commits to reduce absolute scope 3 GHG emissions 27% by 2030 from a 2016 base year.

Notes: N/A = Not applicable; GHG = Greenhouse gas; WB2D = Well-below 2°C; GEVA = Greenhouse Gas Emissions per Value Added.
Source: SBTi 2020a

The eleven chemical-company SBTs described in Table D1 above illustrate emerging best practices for climate action in the sector. As with other sectors, the first wave of chemical companies with approved SBTs predominantly operate downstream in the value chain. Figure D1 below illustrates the aggregated distribution of SBT chemical companies' base year GHG emissions across scope 1, 2, and 3 categories.

Figure D1: Aggregated Distribution of Self-Reported Base Year Greenhouse Gas Emissions for Chemical Companies with Approved Science-Based Targets



Notes: GHG = Greenhouse gas; Mt CO_2e/year = Megatons of carbon dioxide equivalent/year.
The number of companies reporting emissions in each scope 3 category (out of 9 companies in total) is as follows:

- 9 in categories 1, 2, 3, 4, and 6
- 8 in categories 5 and 7
- 7 in categories 9 and 12
- 4 in category 10
- 3 in categories 8 and 11

Source: SBTi.

Figure D1 demonstrates the significance of scope 3 emissions in the sector's overall emissions. As companies improve their scope 3 data collection practices, the distribution of scope 3 category emissions may shift. The extent to which downstream emissions from scope 3, categories 9, 10, 11, and 12 is appropriately and consistently included in companies' inventories is an open question since companies may disclose and justify the exclusion from these categories when its products have many potential downstream applications, each with a different GHG emissions profile (WRI and WBCSD 2011, 61).

Appendix E: Top Seven Chemicals Based on Global Production Volumes

Table E1: Top Seven Chemicals based on Global Production Volumes

Category	Chemical	Global production (Mt/year)
High-value chemicals	Ethylene	255
	Propylene	
	Benzene	110
	Toluene	
	Xylene	
Ammonia	Ammonia	185
Methanol	Methanol	100

Note: Mt = Million tonnes.
Source: IEA 2018.

The IEA estimates that these chemicals account for two-thirds of total chemicals sector energy use—that is, there are numerous smaller product categories that account for a third of the sector in energy terms. Product heterogeneity combined with varying growth rates and volume uncertainty underscores the importance of maintaining a broad perspective to ensure sector-wide decarbonization.

Appendix F: Target Setting for Category 12, End-of-Life Emissions

Due to the complexity of the sector and the enormous number of different end products/applications, chemical companies know their scope 1 and 2 emissions significantly better than their scope 3 emissions. This means that, to remain practical, the guidance on scope 3 should be balanced between accuracy (using real data from the value chain partners where relevant) and practicality from a data point of view (using typical data). Scope 3 resources should also enable quantitative tracking of emissions performance and achievement of targets.

Dealing with end-of-life (EOL) treatment of sold products adequately in target setting is relevant, as many of the chemicals sector's products cause greenhouse gas emissions when they are/would be incinerated at the end of their life. If all products were to be incinerated at the end of their life, scope 3, category 12 emissions of the chemicals sector would be higher than its scope 1 and 2 emissions combined (Stork and Lintmeijer 2018; Geres et al. 2019).[71] However, the WBCSD (2013) guidance indicates that, in case no data are known, default assumptions can be used.

Reducing EOL emissions requires additional consideration around abatement measures. Below, we summarize key abatement measures and factors in measuring and reporting EOL emissions, after which we describe potential options.

Key abatement measures and factors in measuring and reporting EOL emissions

i. Bio-Based Chemicals

End-of-life emissions of bio-based and fossil-based products are quantified based on their carbon content. The SBTi Criteria V4.1 (2020), in line with the GHG Protocol, requires all direct emissions of CO_2, CH_4, and N_2O from bioenergy[72] combustion that occur in the value chain to be included in a company's GHG inventory, with CO_2 emissions reported separately alongside scopes 1, 2, and 3. The SBTi Criteria (2020) also requires companies to provide information about biogenic emissions and removals associated with bioenergy, and to include these in their target boundary. These requirements transparently acknowledge the emissions from bioenergy use while providing an opportunity for target-setting companies to publish their understanding of removals.

Current practice could account for emissions reductions in scope 3 categories 1 and 3 if a chemical company purchases fossil to bio-based feedstocks. It is important to note that a company cannot attribute the reduction in categories 1 and 3 to category 12. The SBTi chemicals scoping project could consider engaging with a range of stakeholders on elaborating

[71] In the Netherlands: ~70 percent of aggregate scope 1,2, and 3 emissions in 2012, and in Germany ~50 percent in 2020.

[72] Bioenergy is energy generated from the conversion of solid, liquid, and gaseous products derived from biomass. Biomass is any organic matter, that is, biological material, available on a renewable basis. This includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.

the treatment of bio-feedstocks and bioenergy use in the chemicals sector and a review of studies estimating the extent to which sustainable biomass would be available for the chemicals sector.

While the GHG Protocol Corporate Standard provides limited guidance on how to account for removals from biogenic sources, there is no consensus method yet on how to account for these removals. The GHG Protocol is developing additional guidance on how to treat other biogenic emissions and carbon removals in 2021, which will be adopted by the SBTi.

ii. Recycling

In case of recycling, the emissions impact can be distributed as follows over the various players in the recycling value chain:

- WBCSD's (2013) guidance for the chemicals sector indicates that emissions from the recycling processes shall be included in upstream scope 3 emissions (purchased goods and services) of the company purchasing the recycled product.
- Two approaches can be taken:
    - In an End-of-Life (EOL) Recycling Approach (also known as avoided burden), environmental benefits are only granted for the fraction of material that is recovered and recycled after the use-phase. This means that the chemical company whose plastic is recycled at the end of its lifetime receives the credit, while the company deciding to process recycled products (like pyrolysis oil in a naphtha cracker) sees the emissions from the recycling process in its scope 3, category 1 emissions. The WBCSD's (2013) guidance for the chemicals sector could be interpreted to favor/prescribe this approach, and this approach could be chosen when there is no quality loss in the recycling process, sufficient demand for the secondary materials, the lifetime of products is short (so that there is a relatively high certainty that the materials will become available for recycling), and/or when aiming to stimulate design-for-recycling.
    - In a Recycled Content (RC) Approach (also known as the Cut-off Approach), environmental benefits are only granted for the actual fraction of secondary material in a product.

  A 50/50 distribution between the two approaches could be explored. Alternatively, the EU has published an EU Circular Footprint formula (Wolf et al. 2019), distributing the scope 3 benefits of recycling between the company producing the recycled plastic and the company processing it.

Mechanical recycling loops currently typically stay outside the chemicals sector; its only effect is that the demand for virgin chemicals decreases. Still mechanical recycling is part of a circular solution, and it is thus worthwhile exploring the accounting principles, for example, for mechanically recycled plastics. In the future chemical companies might also undertake mechanical recycling activities, the impact of which needs to be included in the further development of the methodology.

iii. Carbon capture and utilization

Key questions to consider for carbon capture and utilization (CCU) abatement measures:

- How to properly account and report captured CO_2 emissions? Possible routes could include the following:
  - The company whose CO_2 emissions are captured reduces its scope 1 emissions, and the company that is using the captured CO_2 as a feedstock reduces its scope 3, category 12: End-of-life treatment of sold products emissions; or
  - The company whose CO_2 emissions are captured reduces its scope 1 emissions, and the company that is using the captured CO_2 as a feedstock reduces its scope 3, category 1: Purchased goods and services emissions.
- How to deal with CCU for short-lived applications (CO_2 built in a product that is incinerated within weeks/months/years), in the case of fossil CO_2, biogenic CO_2, and Direct Air Capture (CO_2 captured from the air specifically for the CCU application)?

iv. Electrification

Electrification plays an important role in decarbonizing of the chemicals sector. This lever can, in combination with CCU (see above) lead to a shift of scope 3 end-of-life emissions/a "carbon removal effect" early in the value chain, at the expense of a significant increase of the electricity consumption (and thus, in case not 100 percent renewable electricity would be used, of the scope 2 emissions).

- **Hydrogen** plays a role in many of the abatement routes, especially in case green hydrogen (hydrogen produced by electrolysis) is used in combination with CCU (see above).

v. Other Factors to Consider in End-of-life Accounting

Furthermore, end-of-life accounting takes the following factors into consideration; the impact on them should be considered when developing the SBT methodology for the chemicals sector:

- Impact on energy recovery; and
- Chemical products that are assumed not to degrade for at least 100 years—for which no emissions need to be reported (WBCSD 2013). Table F1 shows that the difference between attributing the status of "durable plastics" or not is **more than a factor 50**, either leading to a reduction of the calculated GHG emissions with a factor 5, or an increase with a factor 10 in comparison with just assuming 100 percent incineration.

Table F1: Impact of Waste's "Durable Plastic" Status on End-of-Life Emissions

		Durable plastics		Nondurable plastics	
	GWP[a]	Default value[b] (%)	Default value x GWP (%)	Default value[b] (%)	Default value x GWP (%)
Share to **landfill**—converted to CO_2[c]	1	0	0	40 (80% x 50%)	40
Share to **landfill**—converted to CH_4[d]	25	0	0	40 (80% x 50%)	1,000
Share to **incineration** —converted to CO_2[e]	1	20	20	20	20
Calculated GHG emissions relative to just assuming 100% incineration[f]	N/A	N/A	20	N/A	1,065

Notes: N/A = Not applicable: GWP = Global warming potential; CO_2 = Carbon dioxide; CH_4 = Methane; GHG = Greenhouse gas.

a. GWP = Global warming potential, relative to CO_2.
b. Assumed share of the plastic converted with this route.
c. GWP = 1.
d. GWP = 25.
e. In case of energy recovery, part of the emissions can be allocated there.
f. Excluding the beneficial impact of allocating GHG emissions to energy recovery.

Source: Based on WBCSD 2013.

Options to Account for End-of-Life Emissions

Two options to deal with EOL emissions have been explored:

- Setting a target to reduce EOL emissions with a certain rate; and
- Target to have an increasing share of circular feedstock.

The feasibility of both could be explored in Phase II of the SBTi chemicals sector project.

1. Target to Reduce End-of-Life Emissions by a Certain Rate

In this case the end-of-life emissions of the products of chemical companies would need to decrease over time. Further guidance on their calculation would need to be developed.[73] The target should be based on a GHG emissions reduction pathway of the waste processing sector, which should be informed by a target reduction of the current share of landfilling.

These emissions are not within the direct control of chemical companies producing the intermediates that go into these and producing bio-based chemicals or chemicals from recycled

[73] This guidance could include the following:

- Which plastics should be considered as durable, and which should not (and are thus assumed to degrade during landfilling to CO_2 and/or to CH_4)?
- How to deal with targets aimed at reducing landfilling (zero landfilling)?
- Which share of end-of-life emissions can be allocated to energy recovery (now, and in a future with increasing shares of renewable electricity and heat)?

materials does not always reduce these emissions according to current calculation guidelines (see above). Nevertheless, chemical companies could engage with the value chain to meet these targets, by for example:

- Cooperating with clients and companies further downstream in the value chain (e.g., companies producing packaging)/waste sorting/processing to stimulate recycling [or CCS]), for example, by engaging with them to set a science-based target to reduce their emissions; this engagement could include chemical companies purchasing recycled flows (e.g., pyrolysis oil) for reuse.
- Participating in Extended Producer Responsibility schemes, in which products are, for example, designed-for-recycling

In case the option to reduce EOL emissions by a certain rate would be chosen, the options chemical companies would have to deliver on the scope 3 end-of-life target would need to be further defined.

Advantages:

- In line with the usual approach for SBT
- Close to the EOL approach (see above)
- Target can be determined relatively straightforwardly
- For scope 3 category of end-of-life emissions, this is unexplored grounds within SBTi; as this category is important for many of the chemicals, EOL emissions reduction targets could stimulate chemical companies to explore—for them—new ways to cooperate over the value chain to reduce emissions (including mechanical recycling and design-for-recycling).

Disadvantages:

- Chemical companies do not control the EOL fate of their products (many steps down the value chain, multiple applications, diverse customers, exporting).
- Difficult to prove that the material is recycled.
- Data limitations, as the chemical products (intermediates) will be converted over several steps in the value chain, into numerous applications sold in many markets across countries.
- Chemical intermediates and the products made from them are traded globally, and chemical companies would thus need to cooperate with a large number of waste processors to cover a significant share of their EOL emissions in their approach; this could potentially be prevented by working on a mass-balance basis.
- Chemical companies in the Expert Advisory Group (EAG) indicated overwhelmingly not to be in favor of this option for the reasons mentioned above.

2. Target to Use an Increasing Share of Circular Feedstock

A circular feedstock target would set a target on the share of bio-based, recycled, and CCU feedstock. This target could be expressed on an energy and GHG emissions mitigation basis and would need to include renewable hydrogen, electricity, biomass, and recycling.[74] Setting such a target would be new for the SBTi; the hydrocarbon nature of most products produced by

[74] The alternative, to set such a target on a mass basis would not make sense: For example, it would give a low weight to the use of green hydrogen and would not be able to deal with the use of renewable electricity, while giving much weight to reuse of CO_2.

the chemicals sector and the resulting GHG emissions when they are incinerated *might potentially* justify such a new approach.

Advantages:
- Close to the Recycled Content Approach (see above)
- Chemical companies control the feedstocks they purchase and the processes they operate, so they can control delivery on this target
- Data generally available
- The second meeting of the Expert Advisory Group revealed that the participants (representatives from the chemicals sector) had a clear preference for this option

Disadvantages:
- This would be a new and potentially inconsistent approach for SBTi
- Could stimulate improper recycling[75]
- Does not stimulate mechanical recycling, design-for-recycling, and product durability, and companies would still need to be stimulated to engage in consumer and customer behavior improvement and recycling engagement.

How could a circular/renewable target be determined?

The text below is to be interpreted as a first start of a methodological exercise to determine a circular/renewable target for SBTi. The following approach could be considered:

Step 1: Determine the end-of-life emissions each individual product, each product group, and/or subsectors currently generates (potentially excluding emissions only generated after >100 years). This would need to be based on typical data and should track the current use of renewable/circular feedstocks.

Step 2: Determine the growth rate of the production for each of the products, product groups, and/or subsectors. The growth rate of the production of products like high value chemicals (HVCs) is impacted by assumptions on, for example, recycling, bio-based production, and CCU-based production. As these growth rates thus include projections on an increase of the share of circular/renewable feedstocks, they should be made explicit.

Step 3: Determine the pathway for the chemicals sector's scope 3 category EOL (including waste) emissions. This would need to be determined in a separate modeling exercise.

Step 4: Determine for each product (group) or subsector the options to reduce value chain emissions related to each of the key circular/renewable feedstock options.

[75] This could, for example, stimulate companies to convert waste streams that could be used for less energy-intensive mechanical recycling to pyrolysis oil (cracker feedstocks). Improper use of waste streams (or biomass) could be discouraged by putting limits on qualifying streams. A balance between practicality and perfect use of each feedstock will need to be found.

Step 5: Determine the required rate of increase of the use of circular/renewable feedstocks over each of the product (groups) and/or subsectors to stay within the overall pathway.