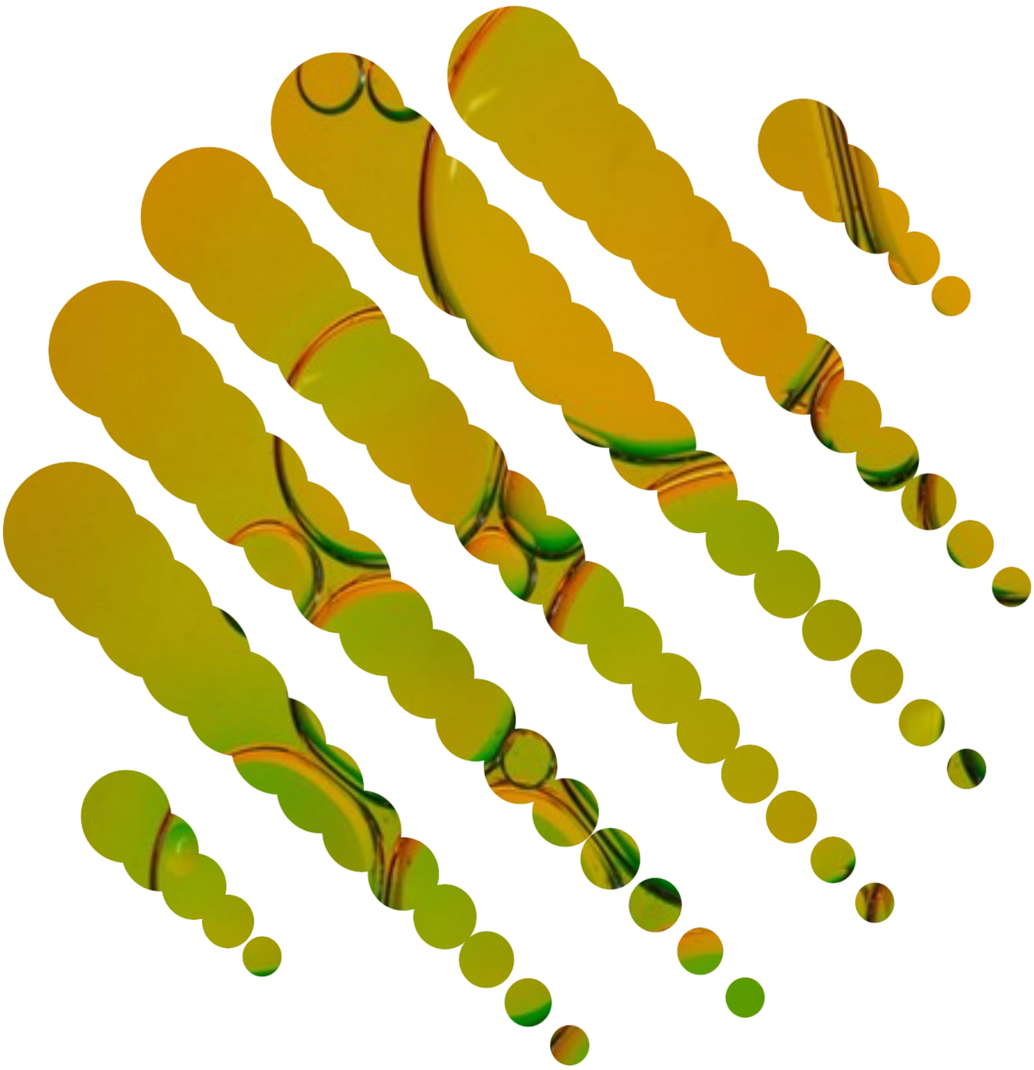
TPI Global Climate Transition Centre
Research and Data at LSE

LSE Global School of Sustainability

Carbon Performance assessment of chemical producers: methodology note

June 2026



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Transition Pathway Initiative

About the TPI Global Climate Transition Centre at LSE

The TPI Global Climate Transition Centre (TPI Centre) is an independent, authoritative source of research and data on the progress of corporate and sovereign entities in transitioning to a low-carbon economy. It is part of the Global School of Sustainability at the London School of Economics and Political Science (LSE). The TPI Centre is the academic partner of the Transition Pathway Initiative (TPI), a global initiative led by asset owners and supported by asset managers, aimed at helping investors and other stakeholders assess company, bank and sovereign preparedness for the transition to a low-carbon economy and supporting efforts to address climate change. More than 155 investors globally, representing approximately US$90 trillion[1] combined Assets Under Management and Advice have pledged support for TPI. The TPI Centre provides data on publicly listed equities, corporate bond issuers, banks and sovereign bond issuers. The TPI Centre's company data:

- Assess the quality of companies' governance and management of their carbon emissions and of risks and opportunities related to the low-carbon transition.
- Evaluate whether companies' current and planned future emissions are aligned with international climate targets and national climate pledges, including those made as part of the Paris Agreement.
- Form the basis for the Climate Action 100+ Net Zero Company Benchmark Disclosure Framework assessments.
- Are published alongside the methods online. They are public and free to use for non-commercial purposes and available at www.transitionpathwayinitiative.org.

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[1] This figure is subject to market-price and foreign-exchange fluctuations and, as the sum of self-reported data by TPI supporters, may double-count some assets.

Contents

1. The TPI Centre's use of the Sectoral Decarbonisation Approach (SDA)

The TPI Centre's Carbon Performance assessments have been predominantly based on the Sectoral Decarbonisation Approach (SDA).[2] The SDA translates emissions reduction targets made at the international level (e.g. under the 2015 UN Paris Agreement) into benchmarks, against which the performance of individual companies can be compared [1].

The SDA recognises that different sectors of the economy (e.g. oil and gas production, electricity generation and automobile manufacturing) face different challenges arising from the low-carbon transition, including where emissions are concentrated in the value chain and how costly they are to reduce. Other approaches to translating international emissions targets into company benchmarks have applied the same decarbonisation pathway to all sectors, regardless of these differences [2]. Such approaches would likely make climate action expensive, as not all sectors have the same emissions profiles or face the same challenges: some sectors may be capable of faster decarbonisation, while others require more time and resources.

Therefore, the SDA takes a sector-by-sector approach, comparing companies within the same sector against each other and against sector-specific benchmarks, which establish the performance of an average company aligned with international emissions targets.

The SDA can be applied by taking the following steps:

- A global carbon budget is established, which is consistent with international emissions targets, for example, keeping global warming below 2°C. To do this rigorously, some input from a climate model is required.
- The global carbon budget is allocated across time and to different regions and industrial sectors. This typically requires an Integrated Assessment Model (IAM), and these models usually allocate emissions reductions by region and by sector according to where it is cheapest to reduce emissions and when. Cost-effectiveness is, however, subject to some constraints, such as political and societal preferences, and the availability of capital. This step is therefore driven primarily by economic and engineering considerations, but with some awareness of political and social factors.
- To compare companies of different sizes, sectoral emissions are normalised by a relevant measure of sectoral activity (e.g. physical production or economic activity). This results in a benchmark pathway for emissions intensity in each sector:

$$\text{Emissions intensity} = \frac{\text{Emissions}}{\text{Activity}}$$

- Assumptions about sectoral activity need to be consistent with the emissions modelled and therefore should be taken from the same economy–energy modelling where possible.

[2] The Sectoral Decarbonisation Approach (SDA) was created by CDP, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF) in 2015. See https://sciencebasedtargets.org/resources/files/Sectoral-Decarbonization-Approach-Report.pdf

- Companies' recent and current emissions intensity is calculated, and their future emissions intensity is based on emissions targets they have set (this assumes companies meet their targets).[3] Together, these establish emissions intensity pathways for companies.
- Companies' emissions intensity pathways are compared with each other and with the relevant sectoral benchmark pathway.

[3] Alternatively, companies' future emissions intensity could be calculated based on other data companies provide on their business strategy and capital expenditure plans.

2. Applying the SDA to the chemicals sector

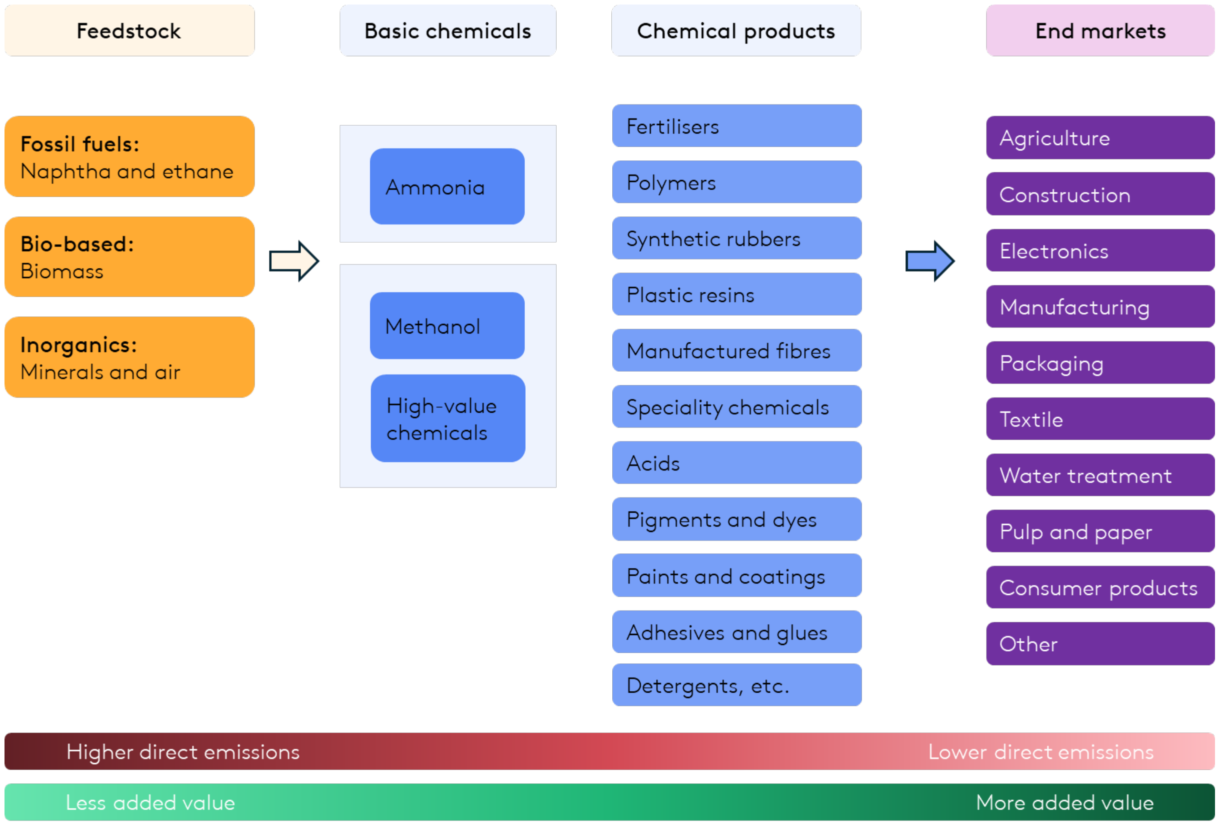
2.1. Introduction to the chemicals sector

The chemicals sector is a significant source of carbon dioxide (CO_2) emissions, accounting for 1.3 gigatonnes of direct CO_2 emissions annually or 3.6% of global CO_2 emissions [3]. The use of fossil fuels is the main contributor to the sector's emissions. When both energy-related fuel use and non-energy feedstock consumption are taken into account, the chemicals sector emerges as the largest industrial consumer of fossil fuels overall [4].

Beyond CO_2, the chemicals sector is a significant contributor to non-CO_2 greenhouse gas emissions, including some of the greenhouse gases with the highest global warming potential (GWP). Industrial nitrous oxide (N_2O) emissions arise directly from processes such as nitric acid production, while the application of synthetic fertilisers releases additional N_2O, responsible for approximately 6.2% of global agricultural emissions [5]. The sector is also the primary producer of products that release fluorinated gases (F-gases) during their use, making it the largest industrial contributor to F-gas emissions globally [6].

Figure 2.1 presents an overview of the chemicals sector. The diagram underscores the foundational importance of basic chemicals, which serve as essential building blocks for the production of all downstream chemical products. Within this figure, ammonia is identified separately, recognising its critical role as the principal input for fertiliser manufacturing. For the purposes of this illustration, the complex and highly interconnected process chains are not depicted; instead, the flows of materials from feedstocks to basic chemicals, and subsequently from chemical products to end-use markets, are presented in a simplified manner to enhance clarity and facilitate understanding.

Figure 2.1. Overview of the chemicals sector: from feedstock to selected end markets



2.2. Establishing the assessment boundary

Defining subsectors for the chemicals sector

The broad range of chemical products — in both their emissions profiles and economic value — presents a central challenge: establishing a meaningful and comparable Carbon Performance metric that reconciles the sector's diverse carbon intensities with its uneven distribution of value generation. Using one metric across companies of different profiles runs the risk of unfairly advantaging producers of chemicals products over producers of basic chemicals, as their emissions intensity is likely to be lower due to lower direct emissions and higher added value of products. **To address this challenge, we divide the sector into three distinct subsectors that exhibit similar emissions profiles and transition trajectories. This approach enables the creation of more homogeneous groupings, within which Carbon Performance can be compared more consistently and fairly.**

The first division within the chemicals sector is based on the economic value of products. We distinguish between primary and non-primary chemicals. We define primary chemicals as a subset of basic chemicals that includes methanol and high-value chemicals (HVCs). Ammonia is also commonly classified as a primary chemical, but here we treat it separately as an agricultural chemical (see below). Methanol and HVCs are produced through high-temperature, emissions-intensive processes and typically generate lower revenue per unit than downstream products. In contrast, non-primary chemicals — including plastics, speciality chemicals and consumer-facing products — tend to have lower emissions during production but higher economic value.

A second division addresses differences in greenhouse gas profiles, particularly emissions that occur beyond the production phase. Agricultural chemicals stand apart in this regard, as a significant portion of their emissions arises during the use phase. Accordingly, we define a dedicated agricultural chemicals subsector, which includes ammonia, the key input for nitrogen-based fertilisers.

Table 2.1 summarises our three subsectors of the chemicals sector and their definitions.

Table 2.1. Subsectors defined by the TPI Centre for the chemicals sector

Subsector	Definition
Agricultural chemicals	This subsector covers the value chain of agricultural chemicals, starting from the production of ammonia and urea through to the manufacture of nitrogen-based fertilisers. It also includes non-ammonia-based fertilisers, such as those derived from phosphorus and potassium. In addition, other applications of ammonia — including its use as an energy carrier, in explosives, and in various industrial processes — are also categorised within this subsector, as they are closely linked in terms of production processes.
Primary chemicals	With ammonia classified under agricultural chemicals, this subsector encompasses methanol and high-value chemicals (HVCs). HVCs typically include light olefins — such as ethylene and propylene — and primary aromatics, including benzene, toluene and xylenes. Sometimes referred to as basic organic or bulk chemicals, these substances serve as essential building blocks for a wide array of downstream chemical products and materials.
Non-primary chemicals	We define the non-primary subsector as including a broad array of products, including inorganic chemicals, plastic resins, synthetic rubbers, manufactured fibres, speciality chemicals, and consumer chemical products. Pharmaceuticals are excluded from this category due to their relatively low direct emissions intensity, which would otherwise distort benchmark comparisons within the subsector.

Emissions boundaries by subsector

Here, we set the assessment boundaries in terms of emissions. For all subsectors, we consider the following emissions scopes and categories material: direct fuel and process emissions (Scope 1), indirect emissions from electricity and steam generation (Scope 2), indirect emissions from upstream fossil fuel production (Scope 3, Category 1), and indirect emissions from the downstream processing of sold chemicals (Scope 3, Category 10).

Emissions from the use of sold chemical products (Scope 3, Category 11) can originate from various sources: the application of fertilisers and urea in agriculture, the use of industrial gases, and the leakage of F-gases during the use of products such as refrigerants, blowing agents and fire extinguishers [7]. However, among our three subsectors, we only include emissions from the use of sold agricultural chemicals. These primarily include N_2O emissions from fertiliser application and CO_2 emissions from the agricultural use of urea. All other sources of use-phase emissions are excluded on the grounds of (im)materiality and consistency. CO_2 emissions from non-agricultural uses of urea, such as in diesel exhaust fluids, are negligible [7], as are emissions from the use of industrial gases.

F-gases contribute disproportionately to overall emissions intensities due to their high GWP. However, we exclude them because otherwise they would distort the analysis too much. Limited modelling of F-gases in climate scenarios further hinders consistent benchmarking. This methodological choice does not imply that reductions in F-gases are unimportant; rather, investors should remain mindful of their significant warming impact and encourage companies to pursue dedicated mitigation measures.

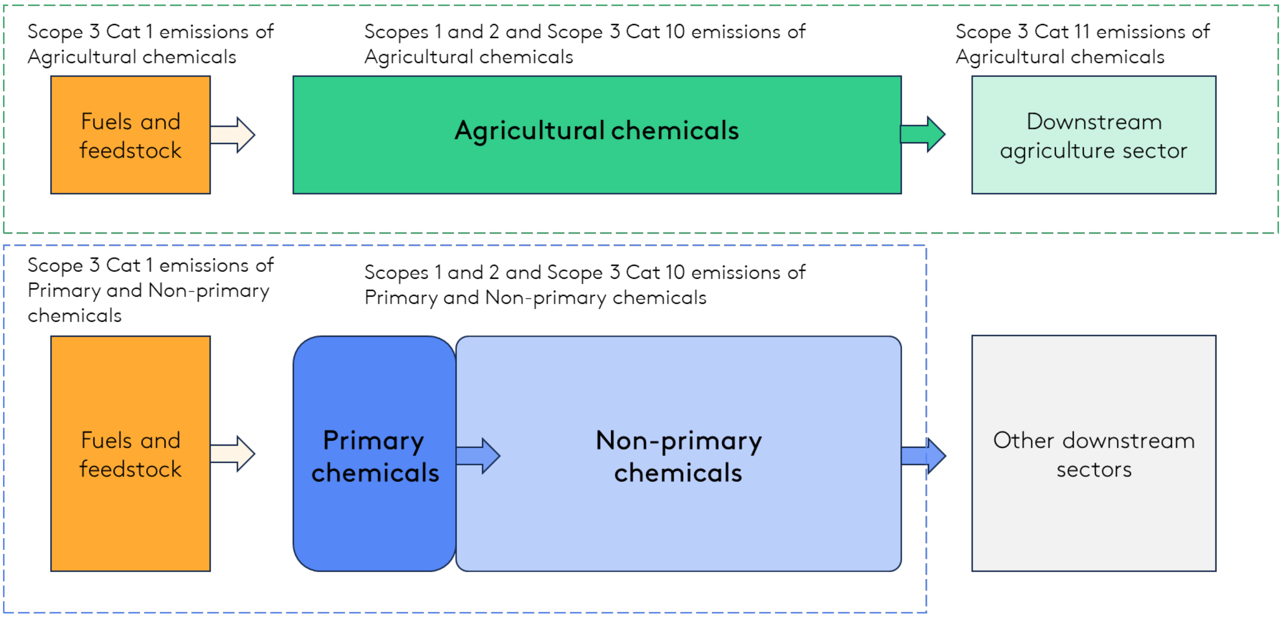
We also exclude Scope 3, Category 12 emissions from the end-of-life treatment of sold products. These emissions vary widely depending on the type of chemical, the treatment method, and the ultimate disposal or recycling pathway. This variation introduces greater uncertainty and reduces the accuracy of calculated emissions, both at the corporate reporting level and when estimating global totals.

Table 2.2 summarises the most relevant emissions scopes and categories for the three chemicals subsectors, along with their corresponding emissions sources. Figure 2.2 summarises the approach we take and illustrates the interlinkages between the three subsectors and their respective emission sources.

Table 2.2. The relevant emissions sources in the chemicals sector

Scopes	Categories	Emissions sources	Inclusion in the TPI Centre's subsectors		
			Agricultural chemicals	Primary chemicals	Non-primary chemicals
Scope 1		Direct fuel and process emissions			
Scope 2		Indirect electricity and steam generation emissions			
Scope 3	Category 1: purchased goods and services	Indirect emissions of upstream fossil fuel production			
		Indirect emissions of purchased chemicals			
	Category 10: processing of sold products	Indirect emissions from the processing of sold chemicals			
	Category 11: use of sold products	Emissions from the use of fertilisers and urea in agriculture			
		Emissions from the use of industrial gases			
		Leakage of fluorinated gas emissions during the use of products (e.g. refrigerants, blowing agents, fire extinguishers)			
	Category 12: end-of-life treatment of sold product	Emissions from landfilling, incineration, recycling, chemical degradation, or residual emissions			

Figure 2.2. Overview of the TPI Centre's defined chemicals subsectors, with allocated emission scopes and key emission sources



2.3. Deriving the benchmark pathways

The TPI Centre evaluates companies against benchmark pathways, which translate the emission reductions required by the Paris Agreement goals into a measurable trajectory at the sectoral level. For each sector benchmark pathway the key inputs are:

- A timeline for greenhouse gas emissions that is consistent with meeting a particular climate target (e.g. limiting global warming to 1.5°C) by keeping cumulative carbon emissions within the associated carbon budget.
- A breakdown of this economy-wide emissions pathway into emissions from key sectors (the numerator of sectoral emissions intensity), including the sector in focus.
- Consistent estimates of the timeline of physical production from, or economic activity in, these key sectors (the denominator of sectoral emissions intensity).

For the chemicals sector, we obtain the first two inputs mainly from the International Energy Agency (IEA), via its *World Energy Outlook 2024* [3], *The Future of Petrochemicals* [4], and *Ammonia Technology Roadmap* [7] reports. The IEA has established expertise in modelling the cost of achieving international emissions targets. It also provides access to the modelling inputs and outputs in a form suitable for applying the SDA.

The IEA's economy–energy model simulates the supply of energy and the path of emissions in different sectors burning fossil fuels, or consuming energy generated by burning fossil fuels, given assumptions about key inputs, such as economic and population growth.

In low-carbon scenarios, the IEA model minimises the cost of adhering to a carbon budget by always allocating emissions reductions to sectors where they can be made most cheaply, subject to some constraints, as mentioned above. These scenarios are therefore cost-effective, within some limits of economic, political, social and technological feasibility.

The IEA's work can be used to derive three benchmark emissions pathways, against which companies are evaluated:

1. A National Pledges scenario, which is consistent with the global aggregate of emissions reductions related to policies introduced or under development as of mid-2024. According to the IEA, this scenario does not take for granted that all government targets will be achieved. Instead, it takes a granular, sector-by-sector look at existing policies and measures. This scenario gives a probability of 50% of holding the global temperature increase to 2.4°C by 2100 [3].
2. A Below 2°C scenario, based on the IEA's Announced Pledges Scenario (APS),[4] which is consistent with the overall aim of the Paris Agreement to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" [8], albeit at the lower end of the range of ambition. This scenario gives a probability of 50% of holding the global temperature increase to 1.7°C by 2100 [3].
3. A 1.5°C scenario, based on the IEA's Net Zero Emissions (NZE) by 2050 scenario, which is consistent with the overall aim of the Paris Agreement at the high end of the range of ambition. This scenario gives a probability of 50% of limiting long-term global warming to 1.5°C with limited overshoot [3].

Estimating emissions

The definition of distinct subsectors for the chemicals sector, as outlined in Section 2.2, necessitates the calculation of emissions trajectories at the subsector level. This requires disaggregating overall sectoral emissions into separate trajectories for each subsector, reflecting their differing emissions sources and profiles.

The agricultural chemicals subsector has a distinct emissions trajectory and portfolio because of the inclusion of use-phase emissions associated with the application of fertilisers and urea in agriculture. These emissions contribute significantly to global greenhouse gas totals and are consistently identified in climate models as among the most challenging to abate in net zero scenarios [9]. This is due to their diffuse nature arising from millions of small-scale sources, and the limited availability of scalable mitigation options beyond behavioural and agronomic changes in farming practices.

In contrast, emissions from the primary and non-primary chemicals subsectors are interlinked. Producers of primary chemicals (methanol and HVCs) typically report downstream emissions under Scope 3, Category 10 (processing of sold products), reflecting the transformation of their product by downstream users. Meanwhile, non-primary chemical producers, who purchase and further process these inputs, account for upstream emissions under Scope 3, Category 1 (purchased goods and services), representing the embedded emissions of the primary chemicals they acquire. As a result, the benchmark numerator for both subsectors reflects their overlapping life cycle emissions.

To calculate the carbon emissions of each subsector under each warming scenario, we:

1. Estimate the total emissions of the chemicals sector across Scope 1, Scope 2 and Scope 3, Categories 1 and 10;
2. Estimate the emissions associated with agricultural chemicals specifically for Scope 1, Scope 2 and Scope 3, Categories 1, 10 and 11;
3. Allocate the emissions calculated under (1) and (2) to each of our three subsectors.

A detailed overview of the methodology, assumptions and data sources used to estimate benchmark emissions by scope and category is provided in Appendix 1. Following the calculation of emissions for all warming scenarios across the relevant scopes and categories, we allocate these emissions to the agricultural, primary and non-primary subsectors. This allocation is summarised in Table 2.3.

[4] Additional data has been taken from the IEA's Sustainable Development Scenario (SDS). This scenario is also aligned with the goals of the Paris Agreement, with global temperature rise peaking at just under 1.7°C. The IEA phased out the SDS in the *World Energy Outlook 2022* as the outcomes of the APS came close to the SDS in terms of temperature outcome [15], [20].

Table 2.3. Allocation of estimated emissions across the agricultural, primary and non-primary subsector benchmarks

Subsector	Scope 1 and 2	Scope 3, Category 1	Scope 3, Category 10	Scope 3, Category 11
Agricultural	Scope 1 and 2 agricultural chemicals	Scope 3, Category 1 agricultural chemicals	(Included in Scope 1)	Scope 3, Category 11 agricultural chemicals
Primary	Scope 1 chemicals sector + Scope 2 chemicals sector − Scope 1 and 2 agricultural chemicals	Scope 3, Category 1 chemicals sector − Scope 3, Category 1 agricultural chemicals	(Included in Scope 1)	Not applicable
Non-primary	Scope 1 chemicals sector + Scope 2 chemicals sector − Scope 1 and 2 agricultural chemicals	Scope 3, Category 1 chemicals sector − Scope 3, Category 1 agricultural chemicals	(Included in Scope 1)	Not applicable

Establishing a common denominator for emissions intensity: sales revenue

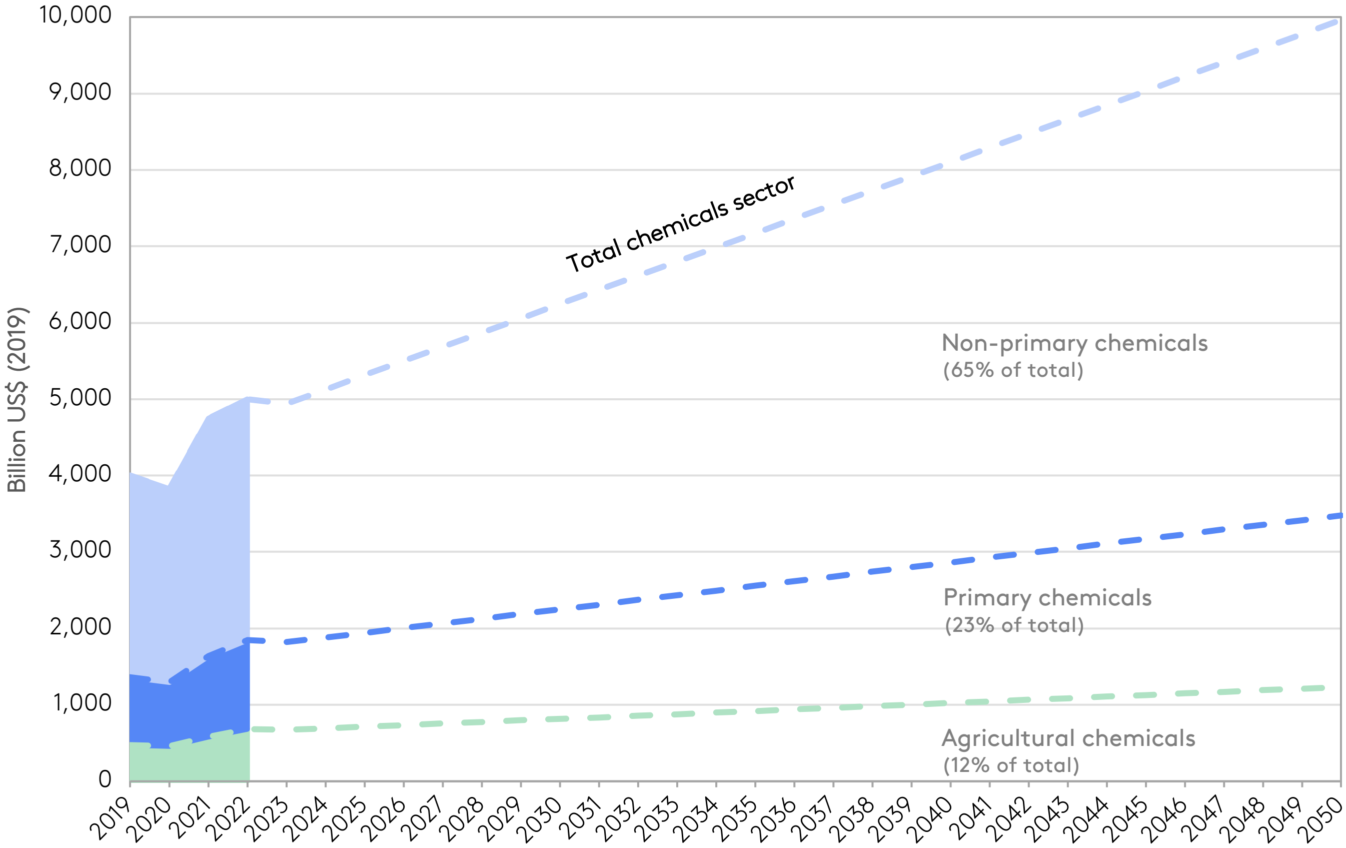
In the SDA, an ideal denominator for emissions intensity should meet two key criteria. First, it should be closely correlated with the company's core activities that drive greenhouse gas emissions. Second, it should be supported by company disclosures, meaning it is regularly and publicly reported by a significant share of companies in the sector. For the chemicals sector, sales revenue was preferred over physical output as the denominator for emissions intensity, as it is more consistently disclosed across the chemicals sector and better reflects the diversity of products, while physical metrics are both inconsistently reported and not comparable across heterogeneous outputs.

Total global sales revenues of the chemicals sector (excluding pharmaceuticals) increased from US$4.1 trillion in 2018 to US$5.7 trillion in 2022 [10] and should continue to grow in the future. To project sales revenues up to 2050, we assume that the chemicals sector will grow at the same real rate as global GDP, as modelled by the IEA's *World Energy Outlook* [3]. To maintain consistency across the benchmark period, we adjust sales values to constant 2019 US$ using historical global inflation data reported by the World Bank [11]. Under this approach, global chemical sales (excluding pharmaceuticals) are projected to reach approximately US$10.0 trillion (constant 2019 prices) by 2050.

Between 2018 and 2022, agricultural chemicals accounted for 12% of total revenues, primary chemicals for 23%, and non-primary chemicals for 65% [10]. In our benchmark analysis, we assume these proportions remain constant through 2050 across all scenarios. Accordingly, these subsectors are projected to generate revenues of US$1.2 trillion, US$2.2 trillion and US$6.5 trillion (2019 constant), respectively, by mid-century.

Figure 2.3 illustrates the historical trends and projected sales trajectories by subsector of the chemicals sector through 2050.

Figure 2.3. Historical and projected sales revenues of the chemicals sector by subsector



Benchmark emissions reduction pathways for chemicals subsectors

Emissions intensity benchmarks for the three chemicals subsectors — agricultural, primary chemicals and non-primary chemicals — are presented in Figure 2.4 across three warming scenarios. The underlying emissions intensity data, expressed in tonnes of carbon dioxide equivalent (tCO_2e) per US$1,000 (2019), are summarised in Table 2.4.

In establishing three distinct subsectors for the chemicals sector, we recognise that several companies operate integrated businesses spanning more than one subsector, making a single benchmark assignment inappropriate. For such companies, we derive a weighted average benchmark based on each company's revenue exposure to the relevant subsectors, as detailed in Section 4.2.

Figure 2.4. Benchmark global emissions intensity pathways for the chemicals subsectors

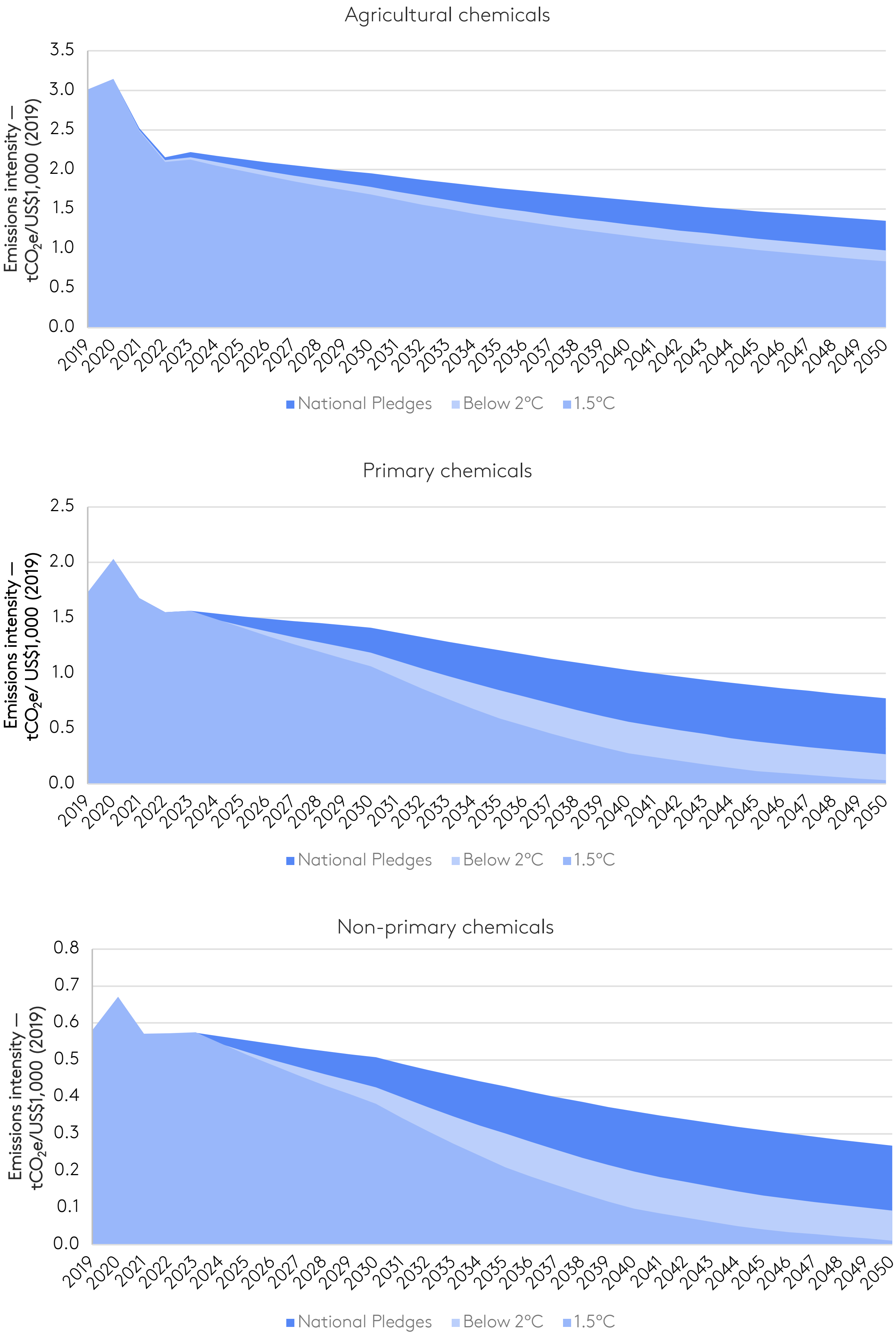


Table 2.4. Projections of emissions and sales revenues used to calculate intensity pathways for chemicals subsectors

		2019	2030	2040	2050
Agricultural chemicals					
	Sales revenue billion US$ (2019)	473	817	1,024	1,231
National Pledges	Emissions $MtCO_2e$	1,424	1,593	1,655	1,668
	Emission intensity tCO_2e/US$1,000 (2019)	3.01	1.95	1.62	1.35
Below 2°C	Emissions $MtCO_2e$	1,424	1,455	1,337	1,207
	Emission intensity tCO_2e/US$1,000 (2019)	3.01	1.78	1.31	0.98
1.5°C	Emissions $MtCO_2e$	1,424	1,375	1,187	1,034
	Emission intensity tCO_2e/US$1000 (2019)	3.01	1.68	1.16	0.84
Primary chemicals					
	Sales revenue billion US$ (2019)	886	1,434	1,840	2,247
National Pledges	Emissions $MtCO_2e$	1,530	2,024	1,891	1,736
	Emission intensity tCO_2e/US$1,000 (2019)	1.73	1.41	1.03	0.77
Below 2°C	Emissions $MtCO_2e$	1,530	1,702	1,035	601
	Emission intensity tCO_2e/US$1,000 (2019)	1.73	1.19	0.56	0.27
1.5°C	Emissions $MtCO_2e$	1,530	1,524	508	75
	Emission intensity tCO_2e/US$1,000 (2019)	1.73	1.06	0.28	0.03
Non-primary chemicals					
	Sales revenue billion US$ (2019)	2,641	3,993	5,239	6,484
National Pledges	Emissions $MtCO_2e$	1,530	2,024	1,891	1,736
	Emission intensity tCO_2e/US$1,000 (2019)	0.58	0.51	0.36	0.27
Below 2°C	Emissions $MtCO_2e$	1,530	1,702	1,035	602
	Emission intensity tCO_2e/US$1,000 (2019)	0.58	0.43	0.20	0.09
1.5°C	Emissions $MtCO_2e$	1,530	1,524	508	75
	Emission intensity tCO_2e/US$1,000 (2019)	0.58	0.38	0.10	0.01

3. Carbon Performance assessment of chemical producers

3.1. Calculating company emissions intensities

The TPI Centre's Carbon Performance assessments are based on public disclosures by companies. In any given sector, disclosures that are useful to our assessments tend to come in one of three forms:

1. Emissions intensity. Some companies disclose their emissions intensity and some companies have also set future emissions targets in intensity terms. Provided these are measured in a way that can be compared with the benchmark scenarios and with other companies (e.g. in terms of scope of emissions covered and measure of activity chosen), these disclosures can be used directly. In some cases, adjustments need to be made to obtain consistent estimates of emissions intensity. The necessary adjustments generally involve sector-specific issues (see below).
2. Absolute emissions. Some companies disclose their emissions on an absolute (i.e. un-normalised) basis. Provided emissions are appropriately measured, and an accompanying disclosure of the company's activity can be found that is also in the appropriate metric, historical emissions intensities can be calculated.
3. Absolute emissions targets. Some companies set future emissions targets in terms of absolute emissions. This raises the question of what can be assumed about these companies' future activity levels. The approach taken by the TPI Centre is to assume company activity increases at the same rate as the sector as a whole (i.e. this amounts to an assumption of constant market share), using sectoral growth rates from the same model that is used to derive the benchmark pathways, for consistency. While companies' market shares are unlikely to remain constant, there is no obvious alternative assumption that can be made which treats all companies consistently. Subsector growth rates are calculated, and a weighted growth rate is used for each company based on its product mix (see Section 4.2).

The length of companies' emissions intensity pathways will vary depending on how much information companies provide on their historical emissions, as well as the time horizon for their emissions reduction targets.

3.2. Emissions reporting boundaries

Companies disclose emissions using different organisational boundaries. There are two high-level approaches: (i) the equity share approach, and (ii) the control approach, within which control can be defined as financial or operational. Companies are free to choose which organisational boundary to set in their voluntary disclosures, and there is variation across the companies assessed by the TPI Centre.

The TPI Centre accepts emissions reported using any of the above approaches to setting organisational boundaries, as long as:

- The boundary that has been set appears to enable a representative assessment of the company's emissions intensity; and
- The same boundary is used for reporting company emissions and activity, to obtain a consistent estimate of emissions intensity.

Currently, limiting the assessment to one particular type of organisational boundary would severely restrict the breadth of companies that can be assessed.

When companies report historical emissions or emissions intensities using both equity share and control approaches, a reporting boundary is chosen based on which method provides the longest available time series of disclosures or is the most consistent with disclosure on activity and any targets.

3.3. Data sources and validation

The TPI Centre's data are based on companies' own disclosures. The sources for the Carbon Performance assessment include responses to the annual CDP questionnaire, as well as companies' own reports, e.g. sustainability reports.

Given that our Carbon Performance assessment is both comparative and quantitative, it is essential to understand exactly what the data in company disclosures refer to. Company reporting varies not only in terms of what is reported, but also in terms of the level of detail and explanation provided. The following cases can be distinguished:

- Companies that provide data in a suitable form and with enough detail for analysts to be confident that appropriate measures can be calculated or used.
- Companies that provide enough detail in their disclosures, but not in a form that is suitable for the assessment (e.g. they do not report the measure of company activity needed). These companies cannot be included in the assessment.
- Companies that do not provide enough detail on the data disclosed (e.g. the company reports an emissions intensity estimate but does not explain precisely what it refers to). These companies are also excluded from the assessment.
- Companies that do not disclose their carbon emissions or activity.

Once a preliminary Carbon Performance assessment has been made, it is subject to the following procedure to provide quality assurance:

- Internal review: the preliminary assessment is reviewed by an analyst who was not involved in the original assessment.
- Company review: the reviewed assessment is sent to the company, which has the opportunity to review it and confirm the accuracy of the disclosures used. This review includes all companies, including those that provide unsuitable or insufficiently detailed disclosures.
- Final assessment: feedback from the company is reviewed and incorporated if it is considered appropriate. Only information in the public domain can be accepted as a basis for any change.

3.4. Responding to companies

Giving companies the opportunity to review their Carbon Performance assessments is an integral part of the TPI Centre's quality assurance process. Each company receives its draft assessment and the data that underpins the assessment, offering them the opportunity to review and comment on the data and assessment. We also allow companies to contact us at any point to discuss their assessment.

If a company seeks to challenge its result or representation, our process is as follows:

- The TPI Centre reviews the information provided by the company. At this point, additional information may be requested.
- If it is concluded that the company's challenge has merit, the assessment is updated.
- If it is concluded that there are insufficient grounds to change the assessment, the original assessment is published.
- If the company requests an explanation regarding its feedback after the publication of its assessment, the TPI Centre explains the decisions taken.
- If a company requests an update of its assessment based on data publicly disclosed after the research cut-off date communicated to the company, the new disclosure is noted. For corrections, we take this into consideration immediately, whereas general assessment updates will be incorporated in the next assessment cycle.

If a company chooses to further contest the assessment and reverts to legal means to do so, the company's assessment is withheld from the TPI Centre website and the company is identified as having challenged its assessment.

3.5. Presentation of assessment on the TPI Centre website

The results of the Carbon Performance assessments are posted on the TPI Centre's online tool (https://www.transitionpathwayinitiative.org/tpi/sectors). On each company page, the company's emissions intensity pathway is plotted on the same chart as the benchmark pathways for the relevant sector.

4. Specific consideration in the assessment of chemical producers

4.1. Measure of emissions intensity

As discussed in Section 2.2, we divide the sector into three subsectors: agricultural chemicals, primary chemicals and non-primary chemicals. For each subsector we define specific emissions boundaries and derive emissions trajectories correspondingly.

Hence, in the chemicals sector, the specific measures of emissions intensity used by the TPI Centre are:

- For agricultural chemical producers: Scope 1, 2 and 3 (purchased goods and services, processing of sold products and use of sold products) emissions, per unit of revenue, in units of (metric) tonnes of CO_2 equivalent per US$1,000 (adjusted to constant 2019 US$).
- For primary and non-primary chemical producers: Scope 1, 2 and 3 (purchased goods and services and processing of sold products) emissions, per unit of revenue, in units of (metric) tonnes of CO_2 equivalent per US$1,000 (adjusted to constant 2019 US$).

Hydrofluorocarbon (HFC) emissions, both Scope 1 (e.g. arising from the production of F-gases) and Scope 3 (e.g. leakage during the use phase), are excluded from the assessment boundary. We also exclude pharmaceuticals and other non-chemical activities from both the emissions and sales revenue calculations.

4.2. Assessing integrated companies: deriving subsector-weighted benchmarks

While calculating subsector benchmarks enhances the granularity of emissions assessments across different product segments, companies often operate across multiple subsectors of the chemicals value chain. For these integrated companies, applying separate Carbon Performance assessments per subsector is not feasible, as it would require emissions data to be disaggregated by subsector — information that is typically not publicly available.

To address the lack of disaggregated emissions reporting for integrated companies, we use a subsector-weighted benchmarking approach that constructs a single, portfolio-oriented benchmark for each company. By combining relevant subsector benchmarks according to a company's product mix, this method captures the diversity of business models in the chemicals sector and supports a more accurate assessment of a chemical company's overall transition risk.

To map companies' operations across the defined subsectors, we use the sales segmentation reported in their financial statements. We first exclude revenues from non-chemical business segments, such as oil and gas refining and other commodities and services. Then, we calculate the five-year average shares of chemical sales revenues allocated to each subsector. These shares are subsequently used to derive each company's subsector-weighted average benchmark.

To calculate the intensity-based subsector-weighted benchmarks for each company in the chemicals sector based on the company's proportional involvement in agricultural chemicals (w_{Ag}), primary chemicals (w_P) and non-primary chemicals (w_{Np}), we use the formula presented in Equation 1:

$$EI_{company\ benchmark} = w_p \times EI_p + w_{np} \times EI_{np} + w_{Ag} \times EI_{Ag}$$ (Equation 1)

$$where{:}\ EI_x = \frac{E_x}{S_x}, and\ w_P + w_{Np} + w_{Ag} = 1$$

$$(EI = emissions\ intensity,\ E = emissions,\ S = sales)$$

4.3. Coverage of targets

There are often differences in the scope of companies' emissions targets. In the chemicals sector, some companies have set specific targets spanning Scope 1, 2 and 3 emissions that cover a broader set of categories than those included in our methodology. Where a target encompasses more Scope 3 categories than we included (as set out in Section 4.1), it is assumed — in the absence of any other specific information — that the percentage reduction in emissions is uniform across all Scope 3 categories, so the target percentage (e.g. a 20% cut) can be directly applied to the Scope 3 emissions from the relevant categories.

Some companies' targets cover only a subset of the scopes and categories included in our methodology (e.g. targeting Scope 1 and 2 emissions only). For the scopes and categories not covered by a target, we assume that emissions intensity remains constant through to the target year.

Some companies set targets that only apply to a subset of emissions in scope, e.g. 90% of Scope 1 and 2 emissions from chemicals production. The share of relevant emissions that are not covered by the target are assumed to be unchanged from the base year to the target year.

Some companies disclose net targets. Unlike gross targets, net targets include emissions offsets or negative emissions, either within company boundaries or outside them. Currently, the TPI Centre accepts both types of targets and does not make an explicit distinction between them. Although we recognise that there are additional risks related to relying heavily on offsetting, in principle, it is a cost-effective mechanism to reduce emissions. Moreover, companies rarely disclose the detailed contribution of offsets to their overall targets.

4.4. Worked examples

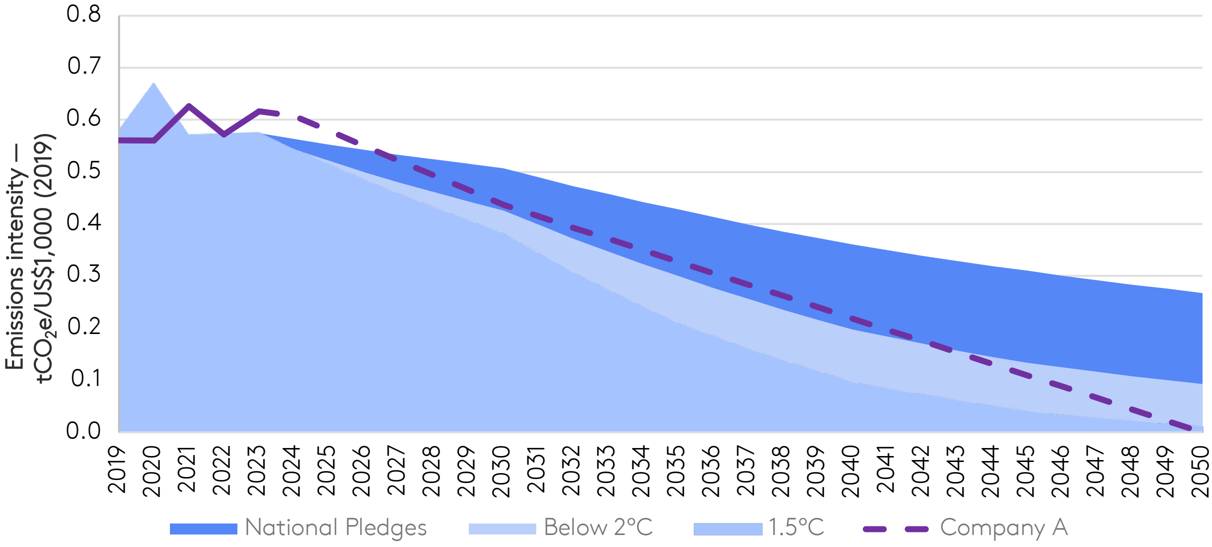
Company A: a straightforward calculation

Company A is a non-primary chemicals producer, mainly engaged in the production of industrial gases. The company reports Scope 1, 2 and 3 (Categories 1 and 10) emissions, which are used in conjunction with its revenue disclosure to calculate its emissions intensity.

Company A has set a target to reduce its Scope 1, 2 and 3 emissions by 20% by 2030 against a 2019 base year, and to achieve net zero emissions across all scopes by 2050. The company's target also covers Scope 3, Categories 4 and 9; however, as these fall outside our assessment boundary, the implied reduction rate is assumed to apply uniformly across all included scopes and categories.

Company A discloses its emissions disaggregated by scope and category for the 2019 base year. The 20% reduction is applied to base year absolute emissions, and the expected revenue growth rate for non-primary chemicals is applied to the company's most recently reported revenue to derive projected revenue in 2030. The resulting emissions intensity in 2030 is calculated at 0.44 tCO_2e per US$1,000 (2019). For the net zero target, emissions intensity is set to zero in 2050, with a linear reduction assumed from the 2030 target value to 2050 (see Figure 4.1).

Figure 4.1. Company A's emissions intensity pathway compared to the non-primary subsector benchmarks



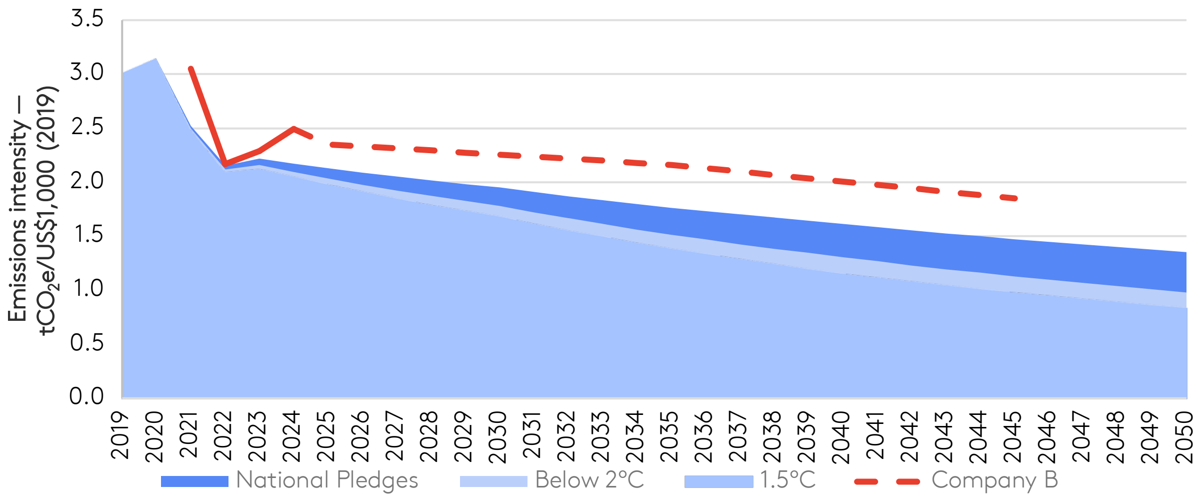
Company B: less than 100% target coverage

Company B is an agricultural chemicals producer primarily engaged in the production of ammonia and nitrogen-based fertilisers. Accordingly, Scope 1, 2 and 3 (Categories 1, 10 and 11) are all considered relevant for this company. Company B reports emissions disaggregated by scope and category for 2021–24.

Company B has set a target to reduce its Scope 1 and 2 emissions by 50% by 2035 against a 2021 base year, and to achieve net zero Scope 1 and 2 emissions by 2045. The target covers 90% of the company's Scope 1 and 2 emissions. No target has been set for Scope 3 emissions or the remaining 10% of Scope 1 and 2 emissions. For these, emissions intensity is assumed to remain constant through to the target years.

To construct the company's emissions pathway, the 50% reduction is applied to the covered 90% of Scope 1 and 2 emissions, and the expected revenue growth rate for agricultural chemicals is applied to derive projected revenue in 2035. The resulting Scope 1 and 2 target intensity is 0.31 tCO_2e/US$1,000 (2019) in 2035 and zero in 2045. The constant-intensity component, comprising Scope 3 emissions and the uncovered 10% of Scope 1 and 2 emissions, is calculated at 1.85 tCO_2e/US$1,000 (2019) based on 2024 reported emissions. Adding both components, the final emissions intensity is 2.16 tCO_2e/US$1,000 (2019) in 2035 and 1.85 tCO_2e/US$1,000 (2019) in 2045 (see Figure 4.2).

Figure 4.2. Company B's emissions intensity pathway compared to the agricultural subsector benchmarks



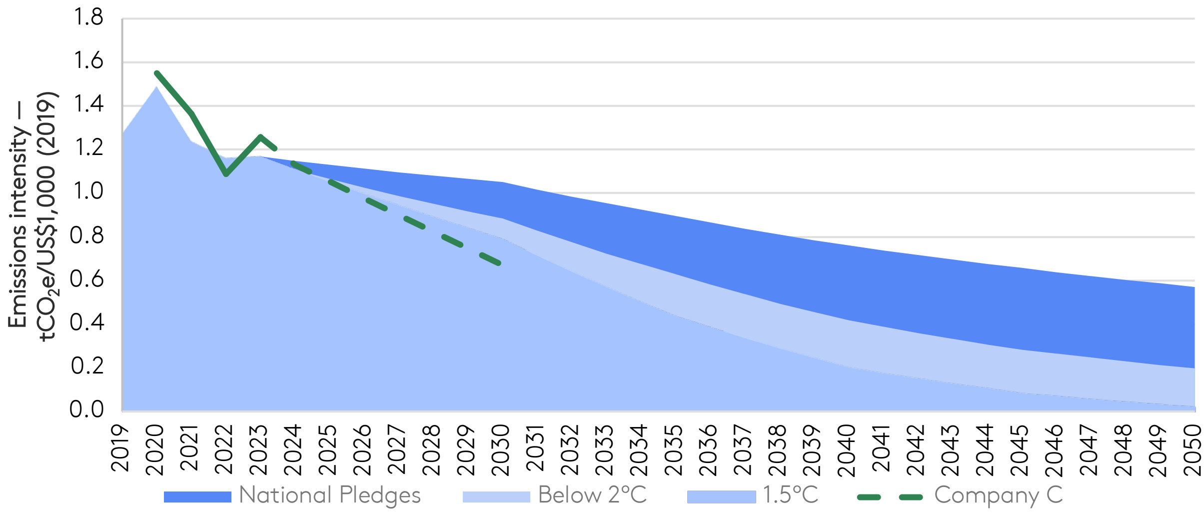
Company C: an integrated company

Company C is an integrated primary and non-primary chemicals producer with operations spanning speciality chemicals and methanol production. The company is also involved in oil refining. Emissions and revenues from external sales of refined oil are excluded from the assessment boundary.

Company C has set targets to reduce its Scope 1 and 2 emissions by 45% and its Scope 3 (Categories 1 and 10) emissions by 30% by 2030, both against a 2022 base year. The company has set no targets beyond 2030.

The company's revenue breakdown is used to derive subsector weights, calculated as a five-year average of annual revenue shares by subsector, excluding oil refining revenues. These weights are 40% primary chemicals and 60% non-primary chemicals and are used to construct the company-specific benchmark. To calculate the 2030 emissions intensity, the respective reduction targets are applied to the relevant emissions for each scope, and sales revenue for each subsector is projected to 2030 using the subsector's growth rate. The resulting emissions intensity in 2030 is 0.19 tCO_2e/US$1,000 (2019) for Scope 1 and 2 and 0.48 tCO_2e/US$1,000 (2019) for Scope 3, giving a combined intensity of 0.67 tCO_2e/US$1,000 (2019) (see Figure 4.3).

Figure 4.3. Company C's emissions intensity pathway compared to a company-specific benchmark constructed from the primary and non-primary subsector benchmarks



5. Discussion

This note has described the methodology followed by the TPI Centre in carrying out Carbon Performance assessment of chemical producers. The Carbon Performance assessment is designed to be robust yet easy to understand and use. There are inevitably many nuances surrounding each company's individual performance, how it relates to the benchmarks, and why. Investors may wish to dig deeper into companies' assessments in their engagements with them to better understand these.

5.1. General issues

The methodology builds on the SDA, which compares a company's emissions intensity with sector-specific benchmarks that are consistent with international targets (i.e. limiting global warming to 1.5°C, well below 2°C, and the sum of National Pledges).

The TPI Centre mainly uses the modelling of the IEA to calculate the benchmark pathways. Models have several advantages, but they are also subject to limitations. In particular, model projections often turn out to be wrong. This would impact the accuracy of the benchmark and potentially lead to investors drawing inaccurate conclusions about a company's alignment. Models tend to be regularly updated with the aim of improving their accuracy, and the TPI Centre updates its benchmark pathways accordingly. Nevertheless, in such a forward-looking exercise, there is no way to avoid the uncertainty created by projecting into the future.

We use companies' self-reported emissions and activity data to derive emissions intensity pathways. While much of this data is audited, the emissions intensity estimates can only be as accurate as the underlying disclosures.

Estimating the historical and especially the future emissions intensity of companies involves several assumptions. Therefore, it is important to bear in mind that, in some cases, the emissions pathway drawn for each company is an estimate made by the TPI Centre, based on information disclosed by companies, rather than the companies' own estimate or target. In other cases, the information disclosed by companies is sufficient on its own to completely characterise the emissions intensity pathway.

5.2. Issues specific to chemical producers

A central question is whether an absolute or intensity approach is more suitable for benchmarking performance against climate scenarios. The TPI Centre has historically assessed companies' emissions pathways on an intensity basis using the SDA. In the chemicals sector, however, this question carries more weight than usual. The sector's highly heterogeneous product mix means that no single physical activity metric captures output consistently across companies. Revenue is the only widely available common denominator, but it introduces sensitivity to price volatility and market fluctuations that can obscure underlying emissions trends. This raises the question of whether an absolute emissions contraction approach, which sidesteps the denominator problem entirely, might be preferable.

In the TPI Centre's *Carbon Performance Assessment of Chemical Producers: Discussion Paper*, both approaches were evaluated, and the decision was made to use the emissions intensity metric [12]. We continue to use the intensity approach for the following reasons:

I. **Recognition of current performance.** The intensity approach incorporates companies' starting Carbon Performance into their trajectory. High-intensity companies generate the same revenue with more emissions, while low-intensity companies reflect earlier mitigation progress. By contrast, the absolute approach indexes all companies to a common baseline, which does not take into account efficiency differences and past decarbonisation efforts.

II. **Differentiated expectations and efficiency.** In the intensity method, companies with higher starting intensities must adopt more ambitious reduction targets to become aligned, while those with lower intensities can follow a more gradual path. This design places the onus for action on the most carbon-intensive firms, where substantial and often lower-cost abatement opportunities are typically found, promoting overall economic efficiency. By contrast, the absolute method treats all companies equally and applies the same emissions reduction rates regardless of starting position, which does not reward efficient producers.

The chemicals sector also has a blurred boundary with the upstream oil and gas industry, largely due to the integration of refineries into petrochemical complexes. To enable a fair assessment of Carbon Performance, companies should clearly distinguish, both in their emissions disclosures and financial statements, between refined oil and gas products sold externally and those used internally to produce primary chemicals. Failure to make this distinction can result in an overestimation of emissions intensity.

Some chemical companies are planning to transition into the production of clean fuels. For the purposes of this methodology, clean fuels refer to low- or zero-carbon energy carriers. The production of biofuels and bio-based feedstocks should, in principle, be assessed within the oil and gas sector. However, if chemical companies do not separately disclose the emissions and sales revenues generated from these products it becomes difficult to allocate these activities to one of the defined subsectors. To date, this has been rare among assessed companies, and we take a conservative approach of excluding the relevant sales revenues from the calculations while retaining the associated emissions.

On the other hand, some clean fuel options are chemical products, such as methanol, hydrogen and ammonia. Hydrogen can also be used as a clean reducing agent in other industries, such as steelmaking. In principle, we do not account for the avoided emissions from using these fuels compared to their high-carbon alternatives. Use-phase emissions from these fuels are included in the calculation of emissions intensity only if the company is involved in the production of agricultural chemicals. The agricultural chemicals benchmarks explicitly incorporate the emerging use of ammonia as a clean fuel. Since hydrogen and ammonia do not emit greenhouse gases during use, this generally does not create boundary issues. The main challenge arises if a company produces methanol used as a clean fuel while also reporting Scope 3, Category 11 emissions associated with agricultural chemicals. In such cases, we estimate the CO_2 emissions from methanol combustion using global emissions factors and exclude them from the company's reported Scope 3, Category 11 emissions.

Some companies produce ammonia exclusively for non-fertiliser applications, such as explosives. For these companies, Scope 3, Category 11 emissions represent a negligible share of their total emissions inventory, and these use cases are not captured within our Scope 3, Category 11 methodology. Accordingly, while classified within the agricultural chemicals subsector, these companies are assessed against a specific benchmark excluding Category 11, covering Scope 1, 2 and 3 (Categories 1 and 10) emissions only.

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Appendix 1. Detailed methodology for estimating benchmark emissions

Emissions from the chemicals sector value chain

Estimating the Scope 1 emissions of the chemicals sector

The IEA's *World Energy Outlook 2024* provides historical CO_2 emissions data for the chemicals sector, along with projections under three emissions scenarios. These figures include both direct energy-related CO_2 emissions and process emissions within the sector [3]. To account for other non-CO_2 greenhouse gases (excluding hydroflourocarbons [HFCs]), we apply the ratio of these gases to CO_2 emissions observed in the US chemicals sector, adjusting the global CO_2 figures accordingly [13]. On that basis, the CO_2e/CO_2 ratio decreased from 1.10 in 2019 to 1.07 in 2023. This ratio is held constant at its 2023 value of 1.07 through to 2050, implying that all greenhouse gases are assumed to grow and decline at the same rate across the scenarios.

Estimating the Scope 2 emissions of the chemicals sector

To estimate the Scope 2 emissions from electricity and heat, we need to estimate the electricity and heat consumption of the chemicals sector. The IEA's *World Energy Outlook 2024* reports final energy consumption for the sector, but does not break it down by energy carrier [3]. We assume that the share of electricity and heat in total energy use is the same as that observed across the industrial sector more broadly. This share is then applied to the energy portion of the chemicals sector's total energy use, excluding feedstock, to estimate electricity and heat consumption. Based on data from the IEA's *Future of Petrochemicals* report, we use a ten-year average (2006–15) to split total energy use in the chemicals sector into 43% for energy and 57% for feedstock [4]. We then apply the global average CO_2 intensity for electricity and heat to estimate Scope 2 emissions.

While on-site power generation (Scope 1 from a corporate accounting perspective) is excluded from the IEA's Scope 1 emissions for the chemicals sector, both purchased and self-generated electricity are included in total 'electricity and heat' consumption. As a result, no adjustment is made for on-site generation.

Estimating the Scope 3, Category 1 emissions of the chemicals sector

From the corporate reporting perspective, Scope 3, Category 1 emissions encompass upstream emissions from purchased goods and services, including the extraction, processing and refining of fossil fuels, as well as emissions embedded in purchased chemical products. However, in constructing the sector-level benchmark, the latter is inherently accounted for in the Scope 1 emissions of the chemicals sector itself. Therefore, to avoid double-counting, the benchmark emissions calculation focuses solely on upstream emissions from fossil fuel extraction and processing.

To quantify these emissions under each warming scenario, two key inputs are required: (A) the emissions intensity of upstream oil, gas and coal production activities, and (B) the chemicals sector's total consumption of each fuel type, including both energy and feedstock use. Emissions are calculated by multiplying the fuel-specific emissions intensities by their respective consumption levels in each scenario and summing the results across all fuels.

To estimate the upstream emissions intensity of the oil and gas sector, we assume that the emissions intensities of upstream oil and gas activities follow the same growth and decline trends as the broader oil and gas sector. We apply a constant ratio of 0.217, which represents the share of emissions from upstream extraction and processing relative to the total value chain emissions of the oil and gas sector, based on 2022 data [14]. This ratio is then applied to scale the oil and gas benchmark emissions intensities across all scenarios. For coal, we use the emissions intensity of coal mining activities — specifically, extraction and processing — as estimated in the TPI Centre's coal mining methodology.

To project fossil fuel consumption in each warming scenario, we use data from the IEA's publicly available reports. For the **National Pledges** scenario, we rely on the *World Energy Outlook 2022*, which provides projections for total energy and feedstock consumption in the chemicals sector under the IEA's Stated Policies Scenario (STEPS) [15]. To estimate the share of each fuel type (coal, oil and gas), we use data from the IEA's *The Future of Petrochemicals* report, which presents disaggregated fuel consumption projections under the Reference Technology Scenario (RTS) [4].

For the **Below 2°C** scenario, where fuel-specific projections for chemicals are not directly available, we assume that coal, oil and gas consumption in the sector will grow at the same rate as in the global industrial sector. We derive these growth rates from the *World Energy Outlook 2024* industry energy consumption projections [3].

For the **1.5°C** scenario, we use the *World Energy Outlook 2022*, which provides detailed projections of energy and feedstock use in the chemicals sector under the NZE pathway, disaggregated by fuel type [15].

Estimating the Scope 3, Category 10 emissions of the chemicals sector

We assume that all emissions associated with the processing of sold chemical products occur within the chemicals sector itself. As a result, these emissions are captured within the sector's Scope 1 emissions.

Emissions from the agricultural chemicals value chain

Estimating the Scope 1 and 2 emissions of the agricultural chemicals subsector

The IEA's *Ammonia Technology Roadmap* reports both direct and indirect emissions from ammonia production, including emissions from power consumption, through 2050 across three emissions scenarios: STEPS, Sustainable Development Scenario (SDS) and NZE [7]. We adopt these figures as the Scope 1 and Scope 2 emissions of the agricultural chemicals subsector.

These figures exclude Scope 1 and 2 emissions from the production of ammonia for use as an energy carrier, in the NZE the IEA has modelled all growth of ammonia for these purposes will come from low-emissions hydrogen [16]. All low-emissions electrolysis hydrogen is assumed to have zero Scope 1 and 2 and Scope 3, Category 1 emissions. A proportion of the modelled low-emissions hydrogen will be from gas with carbon capture. The proportions of total low-carbon production from this route for 2030, 2035 and 2050 are taken from the *World Energy Outlook 2024* and applied to the energy carrier ammonia production figures [3]. Emissions intensity figures (covering Scope 1, 2 and Scope 3, Category 1) for ammonia from low-carbon CCS (carbon capture and storage) hydrogen are taken from the IEA [17].

Estimating the Scope 3, Category 1 emissions of the agricultural chemicals subsector

The IEA's *Ammonia Technology Roadmap* provides projections of energy consumption through 2050 across the three emissions scenarios, disaggregated by fuel type (i.e. coal, oil and natural gas) [7]. These figures encompass both process energy and feedstock use. To estimate total upstream emissions, we apply the same upstream emissions factors for oil and gas, as well as for coal mining, that are used in the broader chemicals sector benchmarks to these energy consumption figures. For ammonia for use as a fuel, the emissions are accounted for in the intensities used for ammonia from CCS hydrogen, as outlined in the above section.

Estimating the Scope 3, Category 10 emissions of the agricultural chemicals subsector

We assume that all emissions associated with the processing of sold agricultural chemical products occur within the agricultural chemicals subsector itself. As a result, these emissions are fully captured within the subsector's Scope 1 emissions.

Estimating the Scope 3, Category 11 emissions of the agricultural chemicals subsector

The IEA's *Ammonia Technology Roadmap* projects ammonia and urea production under three climate scenarios, along with ammonia use in 2050 [7]. Currently, around 70% of global ammonia production is allocated to the agricultural sector. For all three scenarios it was assumed that this proportion of ammonia production for existing uses (excluding production for use as an energy carrier) remains constant through 2050 [7].

To calculate N_2O emissions from fertiliser application, we adopt an emission factor of 1.325% of nitrogen content, based on empirical research [18]. We then use the conversion factor for N_2O–N to N_2O (molecular weight ratio 44/28) and a GWP of 273 tCO_2e per tonne of N_2O, in line with the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report [19]. For CO_2 emissions from urea hydrolysis, the figures were taken from the *Ammonia Technology Roadmap* for all three scenarios in 2030, 2040 and 2050; values in between were interpolated linearly [7].

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