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PRODUCT CARBON FOOTPRINT TRACKING AND TRACING

Review of the global status and a perspective for the chemical industry

SYSTEMIQ

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TABLE OF CONTENTS

ABOUT THIS REPORT

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As economies need to decarbonise rapidly, **product carbon footprint tracking and tracing (PCF)**, the assessment of a product's greenhouse gas (GHG) emissions over its lifetime, can help create the necessary transparency for companies and regulators alike to manage the transition.

This report, commissioned by the Center for Global Commons (University of Tokyo) and supported by Mitsubishi Chemical Corporation, set out to investigate the current landscape, potentials, challenges, and opportunities of PCF as well as make recommendations for regulators and company executives. The report addresses five key questions:

1. Why should and how could chemicals companies and policy makers develop PCF?
2. Which existing standards should be considered, and what are the remaining methodological gaps for developing wide-scaled PCF?
3. What can be learned from existing government initiatives and PCF labels?
4. What is the status of multilateral and private sector action?
5. What enablers as well as hurdles exist for PCF and how can they be overcome?

As part of a larger programme to assess transition pathways of the global chemicals sector, this analysis takes a particular focus on the chemicals sector.

For this study, Systemiq conducted over a dozen interviews with chemical sector experts, corporate and start-up software companies, standards bodies, and the European Commission to answer these questions. We further analysed and reviewed over ten product and corporate carbon footprint standards in-depth. Besides, we investigated four national and supra-national initiatives as well as six leading non-governmental collaborative initiatives. We also screened seven leading corporate PCF case studies. Please note that if we do not provide a source for a particular statement throughout this report, the statement is based on Systemiq analysis.

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EXECUTIVE SUMMARY

Product carbon footprint tracking and tracing can support the chemicals sector in getting ready for a decarbonised economy

This report sheds light on product carbon footprint tracking and tracing (PCF), its importance, and how it can be achieved. The report deep dives into PCF in the chemicals sector that plays a crucial role in global decarbonisation.

Given the need to decarbonise the global economy rapidly and until mid-century the latest, net-zero emissions **legislations are becoming mainstream**, especially in the EU. While all sectors will be affected by the transition to net-zero, for some – including the **chemicals sector** – the **transition** will be more dramatic: Chemicals are carbon-and energy-intensive. The majority of chemical companies produce chemicals for a vast amount of downstream products, creating a highly complex network. Therefore, capturing the footprint of chemical products is key to enabling supply chain transparency on environmental impacts more broadly. On the one hand, implementing PCF in the chemical sector is very challenging due to the highly complex supply chain network and processes that chemical products are part of. On the other hand, given the need to decarbonise entire supply chains and their upstream position, chemical companies can become key drivers in the transition. Seizing this opportunity by implementing PCF will not only allow them to become pioneers in PCF but also make sure that they prevail in a net-zero world.

In general, product carbon footprint tracking and tracing can create business value and support companies from various industries to decarbonise

In general, PCF can create business value and support companies from various industries to decarbonise by:

- differentiating pro-active from passive actors,
- satisfying product footprint information requests by B2B customers,
- enabling more active management of greenhouse gas emissions (GHG) by each individual company and across the value chain,
- creating scaled markets for low-carbon commodities with green premiums,
- enabling corporate carbon risk management, and
- establishing consumer carbon labels.

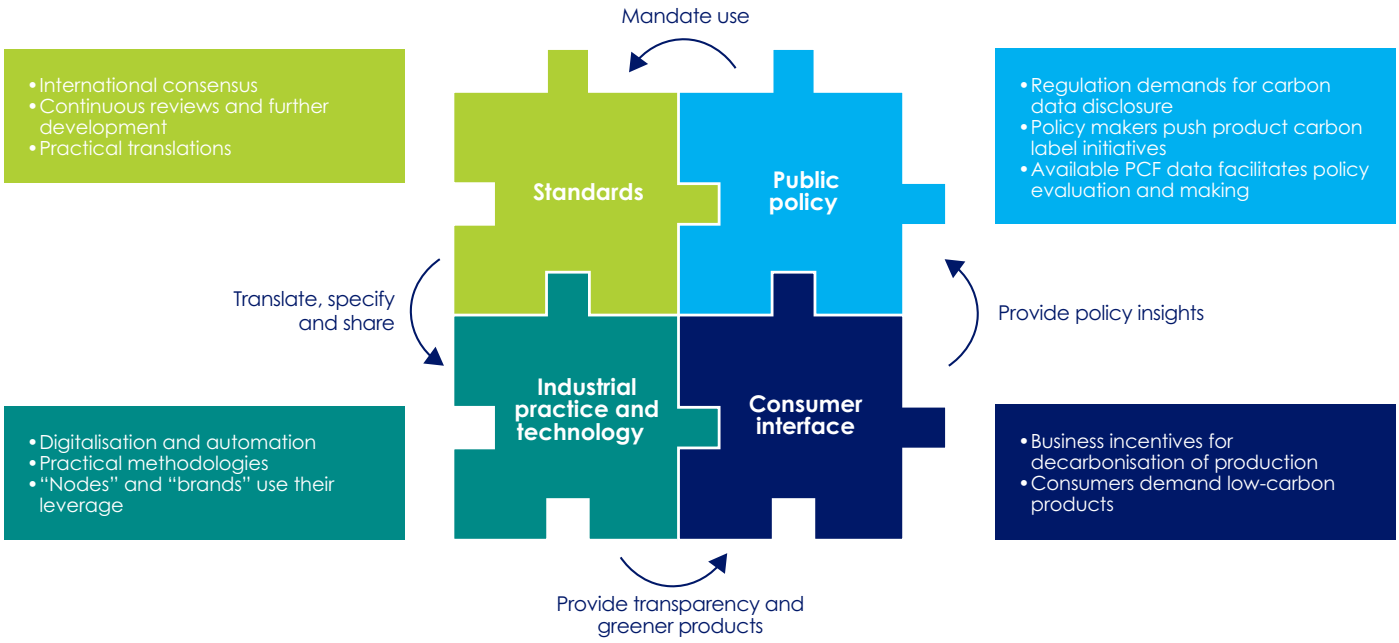
Decision makers from all industries (also beyond the chemical industry) as well as policy makers can **use the current momentum to scale** PCF by bringing together **coalitions** of pioneer companies, governments, and multilateral non-profit initiatives to collaboratively develop as well as adopt practical **PCF methodologies** and showcasing **PCF's business value.** In doing so, **international** and **cross-industry collaboration is key** since separate national approaches would lead to a tremendous increase in overall effort and cost, insufficient harmonisation, and PCF tools of lower quality. Therefore, even countries with a strong focus on the national rather than the international economy and respective guidelines should **build on existing standards, methodologies, and initiatives** as well as minimise customisation and work on standalone initiatives.

More specifically, successful and scalable PCF requires streamlined action along four critical building blocks: **standards, consumer interface, industrial practice and technology,** as well as **public policy.** We deep dive into the current status, challenges, and action needs of each of these four building blocks in the following and in the main part of this report.

Successful and scalable product carbon footprint tracking and tracing requires a collective and well-aligned effort along four key building blocks

Standards, consumer interface, industrial practice and technology, as well as public policy are the **four building blocks** that must **go hand in hand to implement and scale successful PCF practice.** To guide this development, the following lays out ideal characteristics of and synergies between these four building blocks (cf. Figure 1). Dedicated and collective efforts from policy makers and industry players (including chemical companies) are required to successfully advance and scale PCF.

Figure 1: The "North Star" for the four building blocks



Standards are the basis for harmonised product carbon footprint tracking and tracing throughout supply chains and industries

Standards ensure that footprint data collection, quality, quantification, reporting and sharing, as well as auditing are comparable and consistent throughout supply chains and industries. Generally speaking, standards can be structured into product-level, corporate-level, and generic standards. As of today, **no single international product-level gold standard has emerged** for harmonised PCF. Rather, several standards are used; especially the GHG Protocol Product Standard, PAS 2050, or ISO 14067.

However, some limitations remain. **Standards do not fully answer some practical questions on PCF,** such as the setting of scope and system boundaries. **Standards are also rather abstract** and not necessarily aligned with business realities, which hampers their application in practice. Hence, more detailed **methodologies that translate standards into practice are required** to ensure their broad and harmonised adoption. Ideally, these methodologies **provide product-specific PCF rules to ensure high consistency and accuracy,** and, when product-specific rules do not exist, less detailed sector-specific rules should be applied. Moreover, to obtain **comparability between different PCF,** harmonisation throughout standards and methodologies is crucial to obtain comparable PCF.

Consumer interfaces of product carbon footprint tracking and tracing can support greener products but have had limited success so far

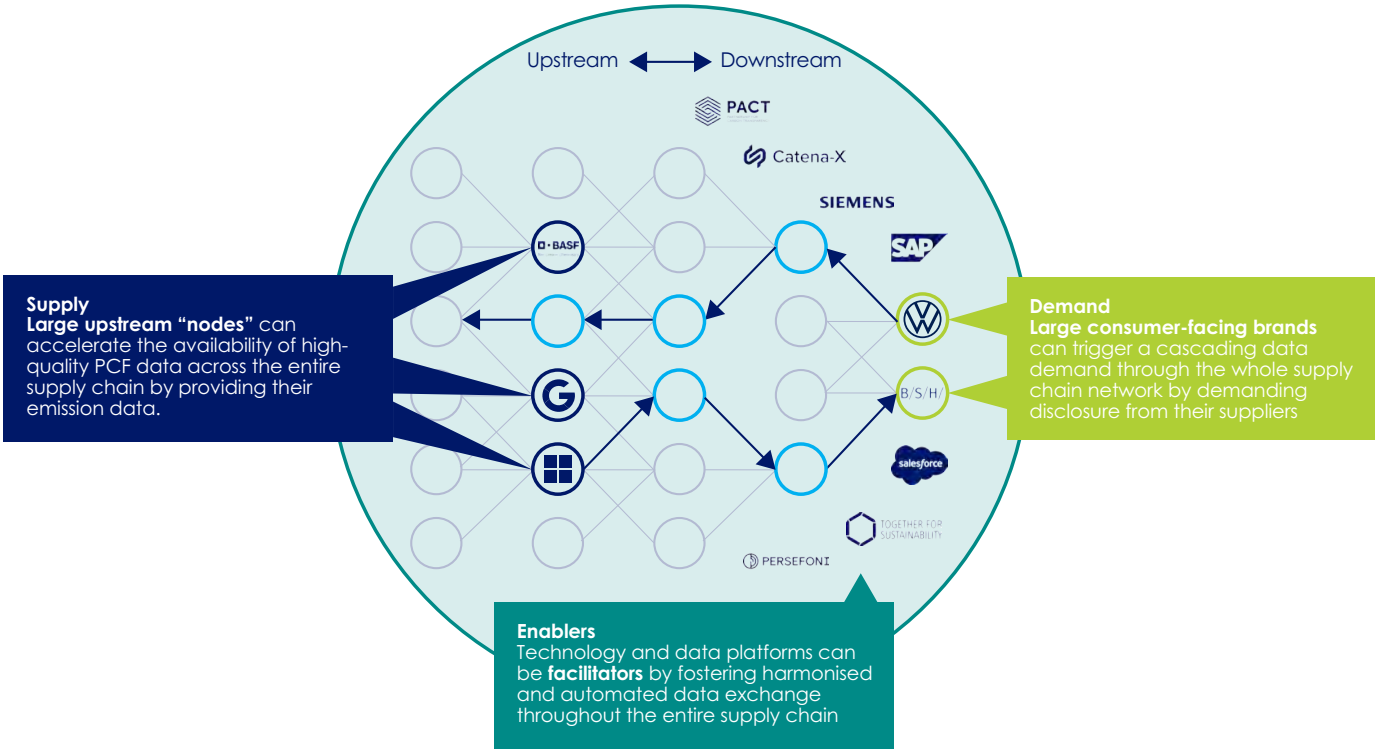
Many product labels of varying types exist (verified vs. trust-based, quantitative vs. qualitative, relative vs. categorical vs. absolute, etc.) that aim to **inform consumers about a product's sustainability performance.** On the one hand, product labels tend to be effective in incentivising companies to improve their products **('push' effect for greener products)** by creating reputational effects and giving them more data to manage their supply chain. On the other hand, in recent years, product labels have had very limited success in changing consumer behaviour (i.e., **creating a 'pull' effect for greener products).** Firstly, product labels are mostly available to consumer brands. Secondly, to change consumer behaviour, **consumers must notice, believe, understand, and be able to easily access as well as act according to the label information.** Thirdly, data collection and verification tend to create significant costs that have so far led many labels to fail in the long run. Hence, **balancing PCF accuracy vs. cost for data collection is key** and depends on the specific context. In conclusion, product labels should be developed with great care and only be considered **one of the above-mentioned reasons to implement PCF and leverage its potential to support decarbonisation.**

Industrial practice and technology pioneers are accelerating product carbon footprint tracking and tracing

Corporate (private sector) and collaborative (non-profit) initiatives have pushed PCF towards a tipping point on methodological consolidation and improvement of reporting. The generated momentum yields improved **carbon data availability** as well as quality throughout the supply chain and, therefore, reduces costs for PCF quantification and reporting. Various multilateral initiatives evolve PCF from multiple angles (sector-specific vs. sector-agnostic as well as corporate-level vs. product-level reporting focus). The **Partnership for Carbon Transparency (PACT)** by the World Business Council for Sustainable Development (WBCSD) can be considered the **emerging leading multilateral initiative,** providing an umbrella framework for PCF rules ("Pathfinder Framework") and ensuring comparability of different PCF. Moreover, the **Together for Sustainability (TfS) initiative** has published its **upstream scope 3 guidance** for the chemical sector.

Besides such multilateral initiatives, a few **fast-moving businesses unlock PCF from both downstream and upstream:** Large upstream actors ("nodes", e.g., BASF, Google) provide their emission data to huge downstream networks. On the other side, consumer-facing downstream actors ("brands", e.g., Volkswagen) accelerate the demand for upstream data along the whole value chain. Corporate **technology and data platforms** are starting to push into the space and could occupy it quickly by providing integrated solutions for PCF measurement and management (cf. Figure 2).

Figure 2: Dynamics between nodes, brands, as well as technology and data platforms



Policy is a key enabler for developing and establishing product carbon footprint tracking and tracing schemes

Policy is key to industry decarbonisation. And yet, **despite its potential, some attempts to implement policies that enable large-scale and effective PCF have not been successful so far.** In France, the PCF scheme BPX 30 – 323 combined 300 international organisations and aimed to establish a multi-criteria approach to calculate PCF. In Japan, the Environmental Labelling Programme (ELP) differentiates products with lower carbon footprints using labels that indicate the product's environmental impact to trigger more sustainable consumer behaviour as well as enable businesses to reduce their products' footprint. Both policy initiatives did not sufficiently create the intended impacts and are no longer pursued actively for several reasons. Firstly, **data collection caused high costs,** mainly due to a lack of primary data availability[1] as well as data exchange throughout the supply chains; and secondly, the impact on consumer decision making was lower than expected. However, the projects also revealed valuable learnings: It's crucial to establish methodologies that ensure as well as sustain the accuracy and reliability of PCF and avoid competitive disadvantages for reporting companies due to a lack of comparability. Furthermore, it is important to educate and engage consumers, because even if they are interested in carbon footprint information, moving from information to action is challenging. And lastly, **international collaboration is key for future success in harmonising PCF.**

More recently, the EU has started developing its promising Product Environmental Footprint (PEF)[2] programme. **EU PEF is a method for measuring and communicating the potential life cycle environmental impact of a product.** It aims to promote the demand and supply of environmentally friendly products in the EU as well as enable the transition to a circular economy and reduce the environmental impacts of products, considering the products' entire supply chains. Using the life cycle assessment (LCA) approach, it calculates environmental impacts in 16 environmental categories. To do so, PEF uses Product Environmental Footprint Category Rules (PEFCRs) which provide technical guidance on how to conduct a PEF study for a specific product category. **PEF also feeds into various other EU initiatives that are relevant to the chemical sector.** The project proved its comprehensive approach by initiating it in collaboration with more than 280 volunteering companies and organisations as well as its large scope of **16 impact categories.** As of 2023, PEF is still **entirely voluntary** but the EU is increasingly adopting legislation that will create a legal basis in the near future (e.g., the block's recently adopted battery regulation mandates PEF for batteries as of 2024[3]). On the downside, PEF's high level of detail makes its implementation costly for businesses which leads to a limited adoption in practice as of today. Also, PEF has limited global applicability as it is EU-specific. Nevertheless, EU PEF is expected to become an essential building block for the EU policy landscape. Beyond EU PEF, policy initiatives like Ecodesign for Sustainable Products Regulation (ESPR) or United States Securities and Exchange Commission (US SEC) climate disclosure requirements charter the way to more comprehensive, ambitious, and consistent carbon accounting and reporting.

1 Note that secondary data is largely available but not as accurate as primary data.
2 EC-DG Env 2021b
3 EC 2022

Achievements and barriers

Based on our analysis of the four building blocks, we summarise the main achievements and remaining barriers on the path to effective PCF in Table 1.

On that basis, we derive recommendations for chemical companies, governments, industrial manufacturing companies, and multilateral initiatives in the following.

Table 1: Achievements and remaining barriers along the four key building blocks

	Achievements so far	Remaining barriers
Standards	• Internationally and cross-industry applicable **standards have been developed** and are being continuously refined (e.g., GHG Protocol, ISO, EPDCR) • **First versions of methodologies** that translate standards into action exist and more are under development	• Applying **standards** in practice requires **expert translation and interpretation** into **actionable guidance** • **Methodologies** that translate standards into action are **insufficiently available, not broadly adopted in practice, and often not harmonised across industries**

Industrial practice and technology	• Early movers are working on or already **providing cradle-to-gate (C2Gate) PCF** data and pass on down-stream. Amongst them are **market leaders** ("nodes" and brands) with high leverage to advance PCF
	• First solutions that digitalise OEF and PCF using state of the art **(digital) technologies** already exist. More are under development by corporates and start-ups
	• **Capital markets'** demand for climate risk assessment and **B2B clients'** sourcing requirements **increase pressure** on businesses to disclose carbon data
		• **High cost** for businesses to implement PCF based on standards:
		  • **Lack of harmonisation and automation** of **primary data** collection and data exchange
		  • **Lack of** sufficiently accurate, decentralised, and open-source **databases** providing **secondary data**
		• **Assurance** (third-party audit) not applied broadly yet
		• Often **unclear business** value of PCF so far

Public Policy	**Several regulations are forming**, e.g., on sustainable products and supply chains, product environmental footprinting, as well as carbon disclosure and boarder adjustment, **especially covering the EU market.**	• **Policies** that include effective enforcing mechanisms and reach are **still lacking** • **Insufficient international consistency** so far
Consumer interface	**Consumers** are increasingly putting **pressure on businesses** by **demanding sustainable products** and thus influence corporate action (including product design and responsible supply chain management)	**Insufficient shift in consumer demand** yet, also due to: • consumers' lack of **understanding** of carbon labels • lack of **comparable** PCF information implies that **corporate PCF communication is ineffective**

Recommendations for governments, industrial manufacturing companies, and multilateral initiatives

Past efforts to create product carbon labels have been largely unsuccessful, mainly because the benefits did not justify the effort and cost. Therefore, to advance PCF, future efforts should **prioritise the development of effective PCF policies, methodologies, as well as technical infrastructure for data sharing. Labels should only be considered one additional side product of PCF.** We summarise how governments, industrial manufacturing companies[4], and multilateral initiatives can implement effective and scalable PCF in Table 2.

4 As opposed to upstream materials producers including chemicals sector

Table 2: Recommendations for government, industrial manufacturing companies and multilateral initiatives

	Governments	Industrial manufacturing companies	Multilateral initiatives
Standards	• Engage in the ongoing **development of methodologies** that translate standards into action (e.g., TfS, PACT, or EU PEF) to ensure their alignment with (future) legislation • Build on **IFRS ISSB standards** and upcoming **EU CSR Directive** to **demand more carbon disclosure**	**Engage in the ongoing development of methodologies** that translate standards into action (e.g., TfS, PACT, or EU PEF) to ensure their alignment with (future) legislation	**Standards/Industrial practice and technology** Based on recognised standards, co-develop practical and harmonised **methodologies and PCRs** that: • are **internationally applicable** and easy to use • identify and close **methodological gaps** to harmonise disclosure • **facilitate automated** data collection, secure and credible exchange, as well as efficient auditing • decrease the **cost burden** for businesses to report PCFs by bringing together and cooperating with industry players
Industrial practice and technology	• **Engage industry to take into account business needs for future policy frameworks** • Akin to financial company data, **phase in PCF assurance/ audit requirements** to ensure credibility • **Require businesses to report** their PCFs (or at least their scope 1 and 2 emissions) and/ or **introduce mechanisms** that link PCF reporting with business value (e.g., carbon boarder adjustment mechanism) • **Support businesses in implementing PCF**, e.g., through subsidies, trainings, or fostering collaboration and exchange (especially relevant for local governments)	• Pioneers: **Pro-actively comply** with emerging disclosure rules (e.g., TCFD, ISSB) and **showcase feasibility** of PCF • Second-movers: **Explore OEF and PCF** as ways to improve footprint and access premiums • **Instate low-CO2 purchasing rules and leverage consumer pressure** for decarbonisation to cascade carbon transparency upstream and manage own upstream scope 3 emissions • **Invest in (digital) technologies** that facilitate PCF • Contribute to the development of **open-source and decentralised data bases** • **Optimise product** design to decrease use phase emissions	
Public Policy	Invest significantly more into **policies that are internationally aligned** (e.g., EU – Japan, and later with USA and China), catering for international supply chains	Demand **ambitious climate policy** (not least as differentiator)	**Broadcast urgency** to amplify need for action; translate into options for business action and coordinate industry to act
Consumer interface	Use the **momentum that consumer pressure creates** to implement more sophisticated PCF und OCF policies	**Aggregate product lifecycle data** for consumer information, e.g. for consumer carbon labels based on best practice and targeting consumer understanding	• **Supply developed methodologies and data bases** to policy makers as proofs of concept and basis for regulation • **Offer policy makers the evidence of cost and benefits** of wide-scale adoption of harmonised disclosure rules at corporate- and product-level

The mounting pressure for decarbonisation of all value chains, together with a legislative push have the potential to **scale global PCF within the next years: Standards** have evolved and are now largely complete, but still require more sectoral and product-specific guidance. **Policy** plays a key role in driving PCF adoption and especially EU legislation has a high potential for success. In addition, **businesses** can benefit from PCF in various dimensions as well as overcome cost and technological hurdles through a balance between accuracy and pragmatism. The latest developments in **technology** and climate policy could enable PCF to scale.

Recommendations for chemical companies

Given the urgency to decarbonise chemical companies' energy- and carbon-intensive industry and their key position in global supply chains, they are well-positioned to lead the way in advancing PCF. Recommendations along the four building blocks include:

Standards: Even though standards for PCF already exist, it still requires expert knowledge to apply them in practice. Therefore, to advance PCF in their industry, chemical companies should **actively shape the development and refinement of methodologies that translate standards into practice.** In doing so, **leveraging and aligning with existing work** on advancing PCF is key to achieving maximum harmonisation. Since we consider them some of the globally leading initiatives, we advise chemical companies to use, as well as contribute to the further development of, the **TfS Product Carbon Footprint Guideline** for the chemical sector specifically and, in doing so, strongly align with **PACT and EU PEF.**

Industrial Practice and Technology: First, to ensure the commitment of the entire company, chemical companies should **make carbon accounting a strategic priority** by introducing environmental KPIs into C-level decision-making and risk management. Second, chemical companies should **invest in (digital) technologies** to increase efficiency and minimise costs of data collection, PCF calculation, data exchange across the supply chain, as well as auditing. Harmonised cradle-to-gate (C2Gate) PCF data can then be passed on downstream. **Quick wins** can be achieved when especially big "nodes" are amongst the first players exchanging their C2Gate data and are prioritising activities, production processes, and products that have the highest footprints.

Public Policy: Beyond implementing PCF today in anticipation of coming policy requirements, chemical companies should also make use of their economic importance: They are well-positioned to **put pressure on governments to enact policies** that enable carbon data exchange and contribute expertise to ensure the effectiveness and practical applicability of policies.

Consumer Interface: Chemical companies should also **make downstream consumer-facing supply chain partners aware of the business value of PCF and put pressure on them to implement PCF.** This will also allow these downstream actors to implement trusted, accurate, and broadly adopted product carbon labels that are easy to grasp and provide relative rather than absolute quantified footprint information to their customers.

Report Structure

This report starts by laying out the motivation for implementing PCF in chapter 1. In chapter 2, we analyse the characteristics of and synergies between the four building blocks to implement and scale successful PCF. Chapter 3 presents recommendations for action for chemical companies, governments, industrial manufacturing companies, and multilateral initiatives.

Chapter 1:

HOW PRODUCT CARBON FOOTPRINT TRACKING AND TRACING CAN HELP INDUSTRY DECARBONISE: THE CASE OF THE CHEMICAL SECTOR

We must reach net-zero globally by mid century to stay on a below 2°C pathway

Every fraction of temperature increase above 1.5°C has a major impact on the climate and exponentially worsens the consequences for life on earth. Therefore, pathways that limit global warming to 1.5°C should be the collective goal.[5] To maintain a 1.5°C pathway, the International Energy Agency (IEA) calls for an immediate cease of new fossil fuel exploration, which has significant impacts on the global economy.[6]

Net-zero legislations are becoming mainstream

More and more countries anchor net zero emissions by mid-century into legislation. By now, six of the G20 nations have "net zero" enshrined in law and nearly all other G20 members have formally declared that they will move to net zero. In general, with growing awareness, other countries are following the lead and are working on integrating the net zero goal into their legislation.[7]

EU standards in several sectors are on path to integrate lifecycle emissions (scope 1-3), both in the materials and use phase

In the past years, the EU has been working on establishing standards to integrate lifecycle emissions (scope 3) in several sectors. As an example, in March 2022, the EU adopted its Sustainable Product Initiative (SPI) with the Ecodesign for Sustainable Products Regulation (ESPR)[8] proposal , which is a milestone regulation setting minimum requirements for the sustainability of products. ESPR also includes extensive value chain due diligence requirements. Besides evaluating the possibility of taking into account lifecycle emissions from cars, vans and other heavy-duty vehicles for future CO2 regulations, the goal of the EU vehicle regulation is to introduce a full lifecycle emissions regulation and pricing for the automotive industry by 2028. For buildings, the EU promotes circularity principles and guides green investments as a part of the EU's Circular Economy Action Plan. Furthermore, the European Parliament has recently agreed on an EU Carbon Border Adjustment Mechanism (CBAM), which will compensate for differences in carbon footprints at EU borders to end 'carbon leakage' mainly in the materials sector. By 2026, priority materials (i.e., energy-intensive materials like steel and select chemicals) are planned to be taxed based on their carbon content.[9] The shift that the chemical sector will have to undergo is tremendous (esp. scope 3).

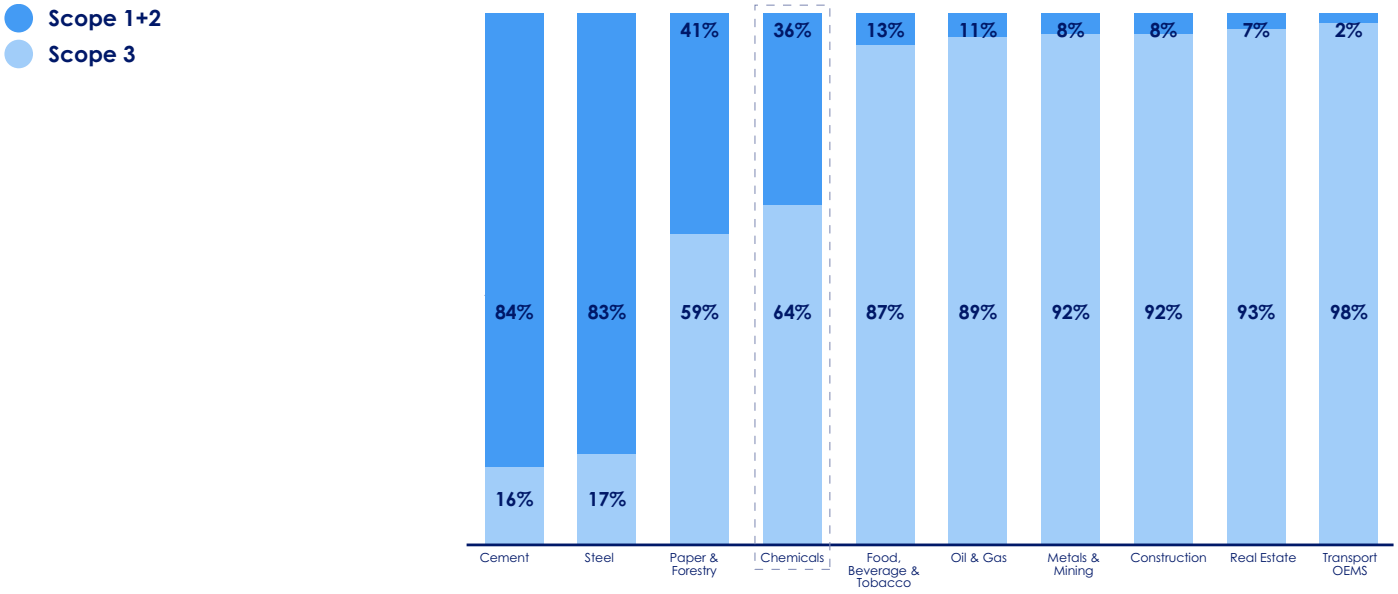
The carbon- and energy-intensive chemical sector will be particularly strongly affected by the EU standards as well as the need to emit no more emissions by 2050 and has to undergo tremendous changes. The chemical industry is recognised as a hard-to-abate sector alongside heavy-duty road transport, aviation, steel, shipping, aluminium and cement and concrete, which collectively account for around 32% of GHG emissions.

5 IPCC 2018
6 IEA 2021
7 https://netzeroclimate.org/sectors/law/
8 EC-DG Env 2022
9 https://taxation-customs.ec.europa.eu/green-taxation-0/carbon-border-adjustment-mechanism_en

Decarbonisation requires effective management of scope 3 emissions

Scope 3 carbon emissions account for the largest share of emissions in most sectors and, thus, play a substantial role in global decarbonisation (around 64% of carbon emissions in the chemical industry sector are scope 3 activities[10]). In general, scope 3 emissions are indirect emissions that are caused along a company's value chain (up- and downstream) and companies have different visibility on their upstream emissions, mostly depending on their position in the supply chain. Scope 3 emissions are structured into 15 emission categories that can be divided into upstream and downstream activities throughout a product's lifecycle. Amongst upstream activities, categories like the purchase of goods and services, fuel- and energy-related activities, and waste that is generated in operations affect the chemical industry's cradle-to-gate (C2Gate) cycle in particular. Downstream activities that affect the chemical industry's cradle-to-grave (C2Grave) cycle include the processing, use, as well as end-of-life treatment of sold products.

Figure 3:[11] Share of total scope 1+2 and scope 3 emissions in different sectors



Despite their key role, the interpretation of scope 3 categories and definition of boundaries differ among players. This results in emission measurements that are not harmonised and therefore lack comparability as well as hinder efficient carbon data exchange along the value chain. Moreover, the disclosure of scope 3 emissions is voluntary in multiple carbon reporting standards, and results are often unverified, which poses a significant risk. Eventually, given the large share and complexity of scope 3 emissions in many sectors, it is key to work on solutions to the above-mentioned issues by harmonising the measurement.[12]

Besides these issues, there is a variety of benefits that come with carbon tracking and tracing for value chain participants, as set out by the WBCSD[13] (see figure 5 on the following page).

10 This share refers to a chemical system with the following chemicals in scope: ammonia and derivatives urea and ammonium nitrate, methanol, ethylene, propylene, butadiene, benzene, toluene, xylene
11 CDP 2023, Chemicals values based on Systemiq & CGC 2022
12 GHG Protocol (2013), Team analysis
13 WBCSD 2021

Figure 4[14]: Benefits of carbon tracking and tracing, reproduced from WBCSD 2021

Example use cases for businesses resulting from emissions transparency

Sustainability
Support in achieving decarbonisation targets and increased accountability through transparency on real performance and gaps/ opportunities

Consumers
More eco-conscious choices based on Incentivization of purchasing and usage decisions

Procurement and Supply Chain
Reduced supply chain inefficiencies and risks through new supply chain relationships and improved visibility of supplier performance

M&A
More informed investment/divestment decisions based on decarbonisation potential and target's position in comparison to competitors

Marketing and Sales
Strong brand differentiation through product labelling

R&D and Innovation
Informed portfolio decisions with better insights into gaps/ opportunities in products and technologies

Corporate Reporting
Reduced need for cost-intensive LCAs and more accurate and streamlined reporting processes

HR and Employee Engagement
Enhanced employee engagement, retention and attractiveness due to measurable decarbonisation activities (purpose-driven organization)

How product carbon footprint tracking and tracing can enable decarbonising the chemical sector

To bring the chemical industry (as well as other industries) on a zero-carbon pathway, accurate footprint measurement is an essential tool. Product carbon footprints (PCF) are only one type of impact quantification (cf. Figure 6):

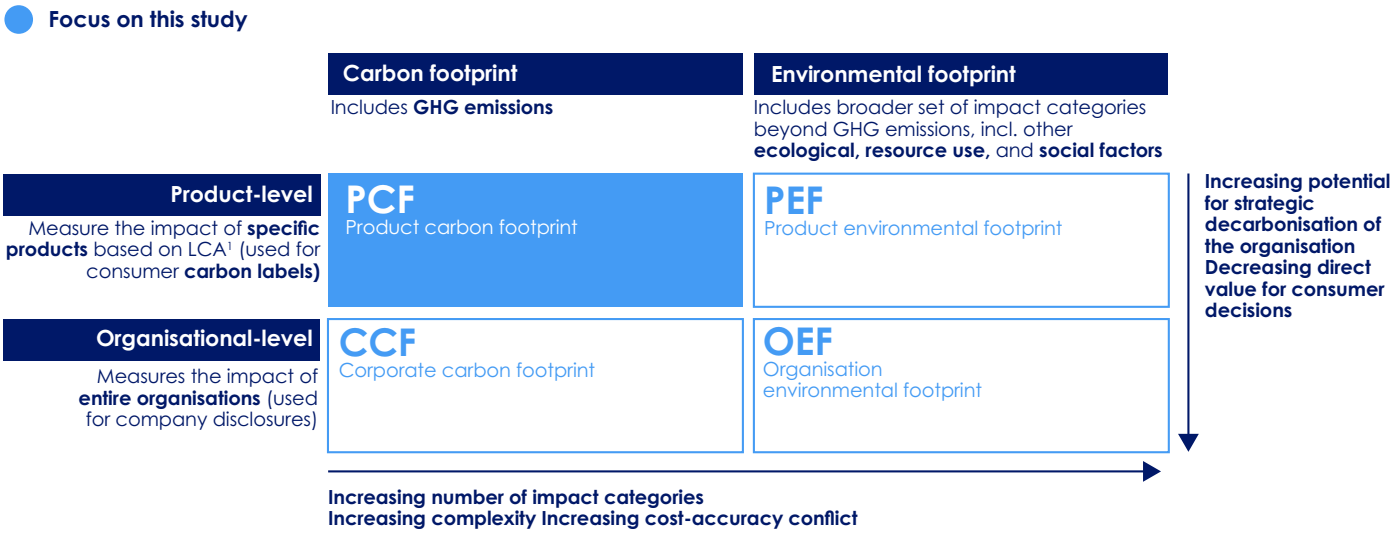
- The corporate carbon footprint (CCF) results in measurement at an organisational level. This approach allows for more aggregate and therefore strategic insights about decarbonisation options of the individual organisation but decreases the direct value for consumer decisions, as it does not allow product-related assessment of emissions in the use phase.
- The product environmental footprint (PEF) adds further environmental impact categories to GHG emissions.[15] This makes it comparatively more complex and increases trade-offs between accuracy and cost-efficiency.

14 WBCSD 2021
15 The PEF categories include: climate change, ozone depletion, human toxicity (cancer), human toxicity (non-cancer), particulate matter, ionizing radiation (human health), photochemical ozone formation (human health), acidification, eutrophication (terrestrial), eutrophication (freshwater), eutrophication (marine), ecotoxicity (freshwater), land use, water use, resource use (minerals and metals), resource use (fossils)

PCF can be referred to as carbon tracking and tracing at the product level that enables accurate measurement using full life cycle assessment (LCA). Even though by definition, PCF and PEF assess a product's impacts throughout its full life cycle (i.e., C2Grave), in practice, C2Gate assessments performed by each value chain actor and passed on to the next increase efficiency whilst yielding the same result if they are performed by all involved value chain actors. PCF's less extensive scope and complexity compared to PEF can enable a more sophisticated data collection approach, i.e., more use of primary rather than secondary data. The more primary data is used, the higher the accuracy and the more valuable is the PCF for managing GHG emissions along the supply chain.

From an impact perspective, product-level accounting should always be integrated with corporate-level accounting since the entire company must be decarbonised rather than only some of its products. Therefore, it is important to establish a corporate decarbonisation strategy with the right priorities.[16]

Figure 5: Overview of different carbon tracking and tracing approaches



1

There are several benefits of the PCF that help the chemical sector to decarbonise. In this study the benefits for companies unleashed by PCF are structured into four categories: green product and commodity markets, corporate carbon risk management, policy making, and consumer carbon labels (cf. Figure 6).

Figure 6: How companies can benefit from PCF

Green product and commodity markets	Corporate carbon risk management	Policy making	Consumer carbon labels
• Ability to capture a 'green' premium in markets' growing segment of sustainable products • Comply with legislative requirements for quota (e.g., EU Carbon Border Adjustment (CBAM), packaging law, batteries regulation etc.) • Join 'fast mover' group of corporates for differ-entiation through reputation as pioneer	• Optimize GHG footprint of own products (incl. supply chain) and monitor reduction progress • Comply with intensifying downstream low-carbon purchase requirements • Identify risks of stranded assets • Qualify for low-carbon investments • Support corporate decarbonisation strategies operationally	• Satisfy the increasing regulatory requirements on carbon accounting (e.g., EU CBAM, sectoral decarbonisation policies, etc.) • Support effective and efficient policy making by facilitating assessment of policies during policy making, and evaluation of their impacts over time	• Trusted carbon labels enable consumers to take responsible decisions and, therefore, support decarbonisation • Increased demand for low-carbon products enables businesses to further decrease their products' footprints • Differentiate consumer brands for growing conscious buyers market

In the following chapters, we go into more detail about why and how companies and policy makers could develop PCF labels. By analysing existing standards, we highlight methodological gaps for developing wide-scaled PCF. Furthermore, we evaluate learnings from existing government initiatives and labels. Hereby, we take a closer look into the status of multilateral and private sector actions. Lastly, we point out enablers and barriers that exist for PCF.

Chapter 2:

THE FOUR BUILDING BLOCKS

Standards, consumer interface, industrial practice and technology, as well as public policy are the four building blocks that must go hand in hand to implement and scale successful PCF. To guide this development, the following chapter lays out ideal characteristics of and synergies between these four building blocks.

Chapter 2.1
Standards

Standards set the **basis** for harmonised PCF throughout **supply chains and industries.** Various standards that provide high-level frameworks on how to implement PCF exist, but they **do not fully answer all practical questions** on PCF. Therefore, there is a **need for methodologies** that **make standards applicable** by translating them into practice. Ideally, these methodologies provide **product-specific PCF rules** to ensure high consistency and accuracy. However, when product-specific rules do not exist, less detailed sector-specific rules should be applied. Wherever possible, **harmonisation between standards and methodologies to obtain comparable PCF** is crucial.

Standards as the basis for harmonised product carbon footprint tracking and tracing

To ensure that PCF data collection, quality, quantification, reporting and sharing, as well as auditing are harmonised across different players, value chains, industries, and nations, standards provide high-level guidance on carbon accounting. More specifically, they determine system boundaries or define rules on how to identify, classify, and track emissions over time. In doing so, standards aim to set an overarching basis for carbon accounting's interoperability and comparability of different products and companies as well as enable credibility and transparency for customers, competitors, or supply chain partners.

2.1.1 Product carbon footprint tracking and tracing standards are part of a wider standards network

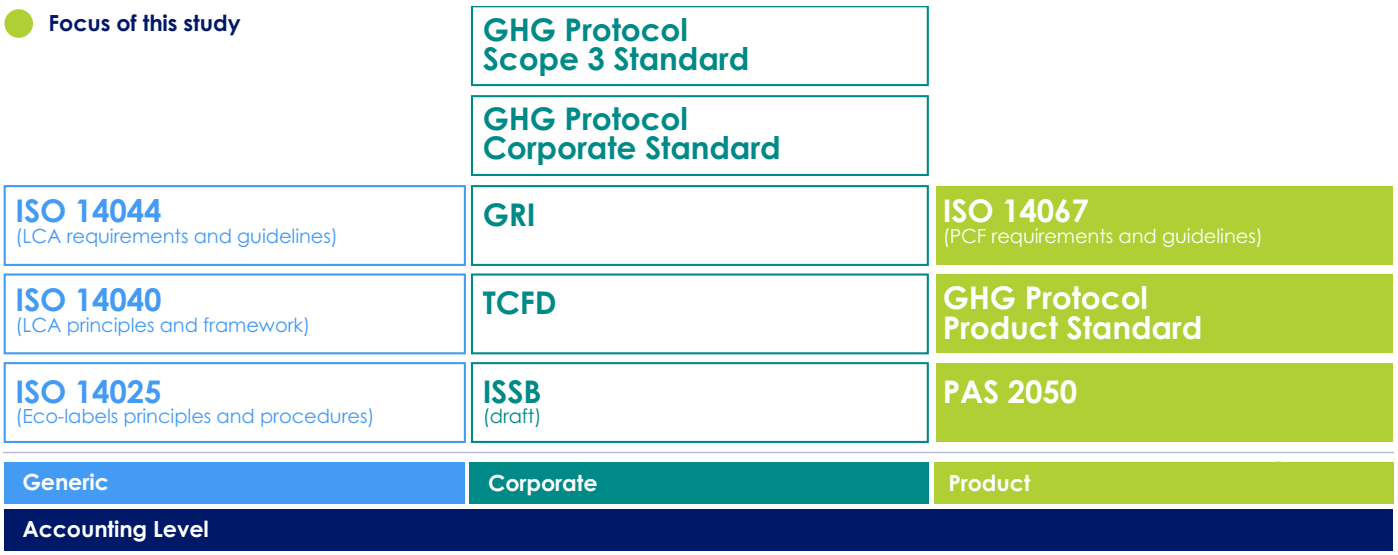
Yet, no sole gold standard has emerged from the network of various standards with different scopes (cf. Figure 8). While ISO 14044 and 14040 lay the basis for conducting LCAs, the GHG Protocol Scope 3 and Corporate Standards provide information on carbon accounting at the company level. In this realm of corporate-level accounting, the International Financial Reporting Standards' (IFRS) International Sustainability Standards Board (ISSB) recently launched a draft of corporate sustainability disclosure standards, namely the prototype climate and general disclosure standards. The ISSB has recently collected feedback on this draft and is now finalising the corporate sustainability disclosure standards on that basis. To ensure that these standards are applicable and in line with already existing standards, the ISSB is codeveloping its standards with the Global Reporting Initiative (GRI). The ISSB standards require…

- a complete, neutral, and accurate depiction of an entity's significant sustainability risks and opportunities as part of the entity's general purpose financial reporting;
- a definition of material information, including an entity's impacts on society and the environment that could reasonably be expected to affect the entity's future cash flows and events considered to have low likelihood but high potential impact on the entity's future cash flows;
- a consistent approach for disclosing significant sustainability-related risks and opportunities that consider an entity's governance, strategy and risk management, supported by metrics and targets; and
- further requirements and guidance that support the provision of comparable and connected information.

Given the reach and relevance of IFRS as the global standard for corporate financial disclosure, the ISSB standards to be finalised can be expected to quickly achieve broad adoption in practice and therefore become the global gold standard for corporate sustainability disclosure and raise overall reporting consistency, improve audit standards, as well as lower audit costs. The ISSB standards will likely also improve product-related carbon data for scopes 1-3 by raising the consistency, quality, availability, and relevance of corporate carbon data.[17] Also, the recently proposed regulation by the United States Securities and Exchange Commission (US SEC) that, once adopted, would require listed companies to disclose their climate-related performance, will further accelerate the adoption of carbon accounting.[18]

17 https://www.ifrs.org/groups/international-sustainability-standards-board/, IFRS 2021a, IFRS 2021b, Investment Executive 2022
18 Reuters 2022

Figure 7: Overview and structure of different carbon accounting standards



2.1.2 Product-level standards act as foundations for product carbon footprint tracking and tracing quantification and communication methodologies and guidelines

Besides generic and corporate-level foci, norms for carbon accounting at the product level also exist that are especially relevant for achieving harmonised and accurate PCF. Due to a lack of one generally and internationally applicable product-level gold standard, multiple standards arose and include ISO 14067, PAS 2050, or the GHG Protocol Product Standard. While they all provide information on how to conduct PCF measurements, ISO 14067 provides rather generic guidance, whereas PAS 2050 and GHG Protocol Product Standard go into more detail:

- **ISO 14067** was published in 2018 and is considered an international reference standard for conducting PCF. It defines the general and high-level principles, requirements, and guidelines for the quantification of products' C2Grave carbon footprints. Initially, it has been developed to make existing PCF approaches comparable and harmonise them.[19]
- **PAS 2050** provides consistent and internationally applicable standards for quantifying PCF. It promotes the use of sector-specific product category rules (PCRs) and guides their development. Even though it has been developed by the British Standards Institute (BSI), it is being used internationally. The first, consensus-based version has been released in 2008 and the revised version (2011) drew upon learnings from the development of the GHG Protocol Product Standard.

19 https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/07/12/71206.html

- The **GHG Protocol Product Standard** is an internationally applicable standard for quantifying and publicly reporting PCF. Like PAS, it also promotes the development and use of sector-specific PCRs. The GHG Protocol, a collaboration of the World Resources Institute (WRI) and WBCSD, built on the initial version of PAS 2050 to develop the first version of the Product Standard in 2011. Unlike PAS 2050, the GHG Protocol also provides guidance for publicly reporting product-specific GHG emissions.[20] Note that the WBCSD under the PACT initiative is working on the so-called Pathfinder Framework, which provides an approach to account and exchange company-specific data based on the GHG Protocol. For this purpose, the Pathfinder Framework can be considered as a standard that PACT uses to develop sector-specific applications such as the Automotive PACT (A-PACT).[21]

Some publicly available resources aim to support companies in navigating the space of product-level standards, including a factsheet from the GHG Protocol[22] or an article by PRé.[23]

2.1.3 Several key questions on product carbon footprint tracking and tracing have not been fully answered in standards but must be addressed by practitioners case by case

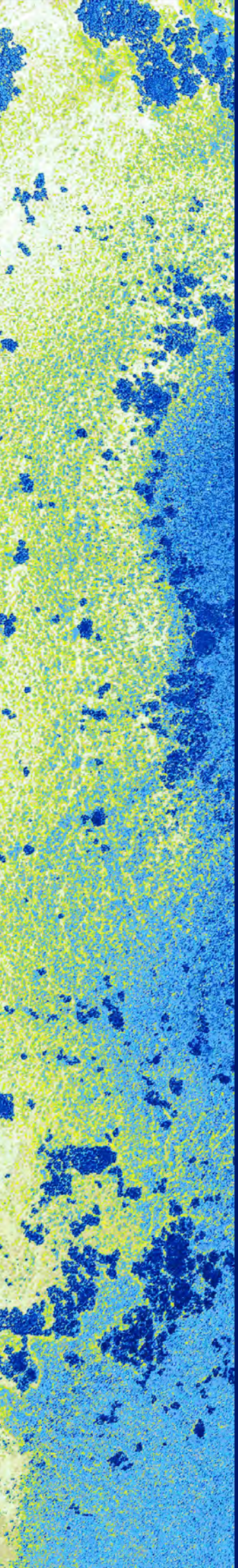
Even though a variety of standards exist, important questions remain unanswered. Many of these are highly relevant for carbon accounting in the chemical sector:

- **Inputs used for energy generation:** How should the portion of feedstock that is used to generate energy in-process (e.g., consumed during the reaction and leading to carbon emissions) for production processes be allocated?
- **Credit vs. average system:** To what extent can footprints of a chemical process be allocated to a specific product (credit system) instead of being averaged over multiple product outputs (average system)? More specifically, a credit system would allow allocating impacts or, e.g., efficiency measures to be 'bundled' and accredited to a sub-section of the products, even if the impacts are not physically related to those products. This can help create a market for greener products but bears the risk of greenwashing (e.g., if efficiency measures are bundled on a sub-section of production and the respective products are then sold as "zero-carbon" even though physically they are not). Average systems could eliminate this risk since impacts are being averaged across all products. However, this requires full transparency regarding all production processes that are within the system's scope, which is extremely difficult in chemical sites since a single chemical production site usually already includes multiple companies and a vast amount of products.

20 GHG Protocol n.d.
21 https://www.carbon-transparency.com/
22 GHG Protocol n.d.
23 PRé 2022

- **Physical link in mass-balancing:** When recycled feedstock is mixed with virgin feedstock as input to a production process, all output products can be (partially) declared as recycled products. When extending the system boundaries, products that do not include any recycled feedstock might also be traded as recycled products even though there is no physical link to any recycled feedstock (e.g., when they are produced at a different site). Doing so can entirely disconnect the allocation and trading of credit from reality (i.e., remove the physical link). This, in turn, can open the door for misleading marketing claims and dramatically limit the system's transparency. Eventually, requiring a physical link in mass-balancing can solve these issues, but standards do not explicitly define how to handle this issue.
- **Batch level vs. temporal optimisation:** To what extent can variances in footprints of a product category be averaged over time?
- **Handling of multifunctionality / multi-output processes:** In standards, the allocation of specific chemical products and production processes where multi-functionality occurs leaves room for interpretation. For some chemicals, sector consensus on allocation exists. However, for example, the application of system expansion to specific by-products requires further specification. This includes the allocation to product system boundaries (i.e., sold product versus studied product). Note that the TfS upstream scope 3 guidance provides general allocation hierarchies for multi-output processes.
- **End-of-life emissions and circular feedstock:** Standards only state that the accounting for end-of-life emissions depends on the route (e.g., recycling or disposal/incineration). However, they do not define this in more detail by providing route-specific information. Note that the recently launched TfS guideline partly addresses this issue by specifying in more detail how the cut-off and substitution approaches should be applied (including energy recovery). TfS does, however, not specify the databases to use for the respective route.
- **Cradle-to-grave (C2Grave) vs. cradle-to-gate (C2Gate):** Many standards demand the accounting of the products' full life cycle (i.e., C2Grave). However, for value chain management, C2Gate is more efficient as well as more feasible today and also allows cumulating C2Grave and cradle-to-cradle (C2C) footprints if all upstream players pass their C2Gate to downstream actors.

These issues show that based on the standards, more granular, product-specific guidelines and methodologies must be developed to enable harmonised PCF calculation and reporting. Even then, carbon accounting will always require professional and skilful tailoring to each organisation's situation. To ensure maximum consistency and accuracy, product-level rules should always be prioritised over less detailed sector-specific or even more generic rules.



Chapter 2.2
Consumer interface

Product carbon labels aim to inform consumers about a product's environmental performance at the point of sale (i.e., the **consumer interface**). By doing so, product carbon labels can create **"push"** and **"pull" effects** for greener products. To achieve these effects, consumers need to notice, easily access, believe, understand, and be **able to act according to the label information.** Also striking a **balance** between **accuracy and cost** for **data collection** is key. Besides, identifying ways of creating additional business value beyond sheer labelling supports the long-term buy-in of companies. Nevertheless, PCF labels should only be considered one of several reasons to collect the data and implement the processes required for them.

Consumer interface to test product carbon label impact and efficiency

The third key building block is the consumer interface. Product carbon labels present information on the carbon footprint of a particular product and, in doing so, they aim to inform consumers at the point of sale about its environmental performance. Many different design options for carbon labels exist (e.g., third-party verified vs. trust-based, quantitative vs. qualitative, relative vs. categorical vs. absolute, etc.) that can determine consumer understanding. Quantitative labels should follow standards for Environmental Product Declaration (EPD) by ISO 14025 and 14040. Next to carbon labels, various other labels exist that provide information on, e.g., nutrition factors or a product's energy efficiency.[24]

2.2.1 Pull factor: Learnings from various eco-labels highlight the importance of consumer understanding

Product carbon labels have had mixed success in changing consumer behaviour (i.e., create a 'pull' effect for greener products). Consumer understanding is the main factor for eco-label success in driving better consumer decisions and can contribute to increasing demand for sustainable products. However, labels are only successful in changing consumer behaviour under certain conditions: Consumers need to notice, easily access, believe, understand, and be able to easily act according to the label information.[25] The learnings from various eco-labels highlight the importance of consumer understanding.

EcoLeaf label (introduced in Japan in 2002) is a qualitative label that has multiple criteria (carbon emissions, acidification, resource use, etc.) that are calculated by using LCA including a third-party verification. A key challenge of this label is the lack of comparability between labelled products.[26]

The Carbon Footprint in Products (CFP) label (introduced in Japan in 2009) is a quantitative label that uses carbon emissions as a single criterion which is calculated by using the LCA including a third-party verification. Unfortunately, most consumers were not able to interpret the label's absolute number representing the product's carbon emissions. As a result, the label was not successful.[27]

Tesco's carbon trust label (introduced in the UK in 2007) is a quantitative label that uses carbon emissions as a single criterion which is issued by the Carbon Trust.[28] However, consumers struggled to understand the label's messaging. For retailers and brands, it resulted in insufficient competitive pressure but relatively high costs, leading only to small benefits for Tesco and the environment.[29]

24 Team analysis, https://www.environdec.com/home
25 Financial Times 2020
26 https://ecoleaf-label.jp/english/about/index.html
27 https://www.cfp-japan.jp/english/overview/index.html
28 https://www.carbontrust.com/what-we-do/assurance-and-labelling/product-carbon-footprint-label
29 The Guardian 2012

2.2.2 Push factor: Perceived consumer behaviour drives businesses to improve their products

While product labels have had mixed success in changing consumer behaviour directly, they tend to be more effective in incentivising companies to improve their products ('push' effect for greener products) by giving them more data to manage their supply chain and in particular, creating positive reputational effects. This is particularly relevant for consumer brands as they have the biggest incentive to build positive associations with their brands and in turn has driven the development of more sustainable products by some companies. Experience has shown that labels should cover a sufficiently large scope of products by different companies as well as be recognisable, comparable, and accurate enough to create this 'push' effect. Examples of labels that have the potential or have already proven to be successful in creating 'push' effects on companies include:

- **The Guideline Daily Amount (GDA) traffic light label** (introduced in the UK in 1998) is a voluntary label with the intention to aid consumer understanding of the nutritional content of food. It gives relative information on average daily intake as well as a categorical traffic light system. Research has proven its effect on consumers by empowering them to choose healthier products and easily compare different food products. This, in turn, also has positive effects on food producers since it urges them to produce healthier food.[31]
- The **EU energy label** (introduced in the EU in 1994) mandates producers of certain consumer electronics to signal the energy efficiency of their devices. It is currently using a categorical scale from A (most energy efficient) to G (least efficient) including colour-coding. It influences the buying decisions of most consumers, but it is unclear whether consumers' energy cost savings or other benefits (e.g., environmental) are the main drivers. The label is considered very effective as it is expected to bring energy savings of approximately 230 Mtoe (million tonnes of oil equivalent) by 2030.[32]
- The **Foundation Earth label** (pilot started in 2021 in Europe), established by Foundation Earth, a non-profit organisation backed by several large food companies especially in the UK and EU, aims to communicate the environmental friendliness of food. Criteria used for this label are water usage, water pollution, carbon emission, and biodiversity. The measurement follows a scale from A+ (best score) to G based on an LCA approach.[33] The effects of the label are still unknown but its well-designed approach is promising.

31 Euractiv 2017
32 https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/about_en
33 https://www.foundation-earth.org/pilot-launch/

2.2.3

Failures and the limited impact of previous carbon labels show that they are not a panacea

On the one hand, the above-outlined experiences with existing product carbon labels show that they have had mixed success in changing consumer behaviour (i.e., create a 'pull' effect for greener products). This is mainly due to the challenge that besides prioritising environmental factors in their decision, consumers need to notice, easily access, believe, understand, and be able to act according to the label information. On the other hand, product labels tend to be effective in incentivising companies to improve their products ('push' effect for greener products) by creating reputational effects and giving them more data to manage their supply chain. This affects consumer brands most strongly. Besides these two effects, data collection and verification tends to create significant costs that have led many labels to fail in the long run. Balancing PCF accuracy vs. cost for data collection is key and depends on the specific context. Identifying additional business value beyond sheer labelling supports the long-term buy-in of engaged companies. In conclusion, product labels should be developed with great care and only be considered one of several reasons to collect the data and implement the processes required for them.

Chapter 2.3
Industrial practice and technology

Corporate (private sector) and collaborative (non-profit) initiatives are **improving carbon data availability and quality** throughout the **supply chain** and, therefore, **reducing costs** for PCF quantification and reporting for all value chain actors. In this context, the **Partnership for Carbon Transparency (PACT)** by the World Business Council for Sustainable Development (WBCSD) can be considered the **emerging leading multilateral initiative,** providing an umbrella framework for PCF rules ("Pathfinder Framework") and ensuring comparability of different PCF. Besides, the **Together for Sustainability (TfS) initiative** has published **upstream scope 3 guidance** for the chemical sector. As a big upstream actor, BASF has positioned itself as fast-moving player in the chemical sector by providing its PCF data to its huge network of downstream actors. On the downstream end of the supply chain, consumer-facing brands like VW can cascade demand for PCF data to their upstream supplier networks. Moreover, technology and data platforms are providing tools that enable PCF data exchange. Together, synergies between such upstream players, downstream brands, and technology and data platforms have the potential to unfold dynamics that accelerate PCF.

Industrial practice and technology pioneers are accelerating product carbon footprint tracking and tracing

Industrial practice and technology is the third main building block in the domain of carbon tracking and tracing. It can generally be structured into two archetypes:

First, various collaborative, multilateral (non-profit) initiatives, like PACT and TfS, bring together different stakeholders from within as well as across industries. These multilateral initiatives are developing harmonised methodological guidelines to translate standards into practice and promote their adoption. Second, there are corporate (private sector) initiatives, initiated by individual companies such as BASF and SAP, which each recognised the benefits and relevance of PCF. These companies are now pushing into the PCF market with their own PCF-related initiatives and offerings.

Together, both collaborative and corporate initiatives have pushed PCF towards a tipping point on methodological consolidation and improvement of reporting – the momentum is now enhancing carbon data availability as well as quality throughout the supply chain and, thus, reducing costs for PCF quantification and reporting.

2.3.1 Collaborative/ multilateral initiatives develop product carbon footprint tracking and tracing methodologies in close collaboration with industry and foster their adoption

A multitude of multilateral initiatives such as the Partnership for Carbon Transparency (PACT), the Science Based Target initiative (SBTi), the Environmental Product Declaration International (EPD International), or Catena-X are evolving PCF from multiple angles: some focus on a specific industry whereas others develop sector-agnostic tools.The reporting focus can also differ across the multilateral initiatives since some target corporate-level while others focus on product-level reporting (cf. Figure 9).[34] To achieve accurate and consistent PCF, it is crucial to generally prioritise using product-level, sector-specific PCF rules if possible.

- SBTi developed a methodology that allows businesses to set Science Based Targets (SBTs) that then act as their foundation for long-term decarbonisation based on global carbon budgets. To do so, SBTi offers several methodological approaches to set and track the achievement of the SBTs, mostly at the corporate rather than product level.[35]

Figure 8: Overview of multilateral / collaborative initiatives

	Corporate-level accounting	Product-level accounting
Industry-agnostic initiatives	SBTi	PACT EPD International
Industry-specific initiatives	WBCSD Chemical Sector guidance	GBA GHG rulebook TfS Product Carbon Footprint Guideline Catena-X

34 SBTi 2020a, SBTi 2020b, WBCSD 2013, WBCSD 2021, https://sciencebasedtargets.org/, https://www.environdec.com/, https://catena-x.net/
35 SBTi 2020a, SBTi 2020b, https://sciencebasedtargets.org/

- In 2013, the WBCSD published the **WBCSD Chemical Sector guidance** (Guidance for Accounting and Reporting Corporate GHG Emissions in the Chemical Sector Value Chain) that supports chemical companies in reporting and accounting GHG emissions (scopes 1 – 3) on a corporate level. The guidelines are based on the GHG Protocol and aim to improve the harmonisation, comparability, and consistency of emission data.[36]
- The WBCSD has recently launched **PACT,** a collaborative initiative that aims to provide methodological guidance as well as the technical infrastructure for the accounting and exchange of product-level, primary emission data throughout the whole value chain.[37] PACT can be considered the emerging leading multilateral initiative on improving scope 3 carbon data exchange and is developing the **Pathfinder Framework** (cf. Box 1) that aims to harmonise existing standards as well as the actual sharing of emission data across companies and industries.[38] With the **Pathfinder Network,** PACT also seeks to provide the technical infrastructure that provides the network for exchanging emission data.
- **EPD International** is an internationally accepted methodology for calculating and communicating LCA-based PCF for various industries. EPDs rely on PCRs that are being developed continuously in close collaboration with industry partners and can be certified by programme operators like EPD International AB.[39]
- The **TfS** initiative (cf. Box 2) has recently published its "Product Carbon Footprint Guideline"[40], a solution for upstream scope 3 GHG emissions PCF calculation, reporting, and auditing. Their guideline is specifically targeting the chemical industry and is in line with existing standards like ISO and GHG Protocol and methodologies such as PACT.
- **Catena-X** aims to build a platform and its technical infrastructure that connects all stakeholders from the automotive industry to enable consistent data exchange throughout the entire value creation process. In doing so, Catena-X also focuses on exchanging standardised GHG emission data throughout the automotive supply chains and has published a library of rules[41] that define how data should be exchanged in their network.[42]
- The **Global Battery Alliance (GBA) GHG rulebook** is a methodological application of carbon accounting rules and standards to provide guidance to battery value chain participants to calculate as well as report the battery carbon footprint based on primary data and in compliance with PEF and PEFCRs. Version 1.3 focuses on the C2Gate emissions of lithium-ion batteries for electric vehicles. It can be applied to all kinds of lithium-ion chemistries as well as raw materials, active or passive materials, and components across the electric vehicle battery value chain.[43]

As of the time of conducting this study, based on desk research and dozens of expert interviews, these initiatives constitute the main ones driving PCF. Given their particular relevance, especially for the chemical sector, WBCSD Pathfinder Framework and TfS are outlined in more detail below.

36 WBCSD 2013
37 https://www.carbon-transparency.com/
38 WBCSD 2021b
39 https://www.environdec.com/
40 TfS 2022
41 https://catena-x.net/de/standard-library
42 https://catena-x.net/
43 GBA 2022

Box 1: WBCSD Pathfinder Framework

Purpose

The Pathfinder Framework, developed by WBCSD, focuses on the accounting and exchange of GHG emission data throughout the whole value chain. It establishes a network of networks that aims to harmonise the use and understanding of existing standards as well as the actual sharing of emission data across companies and industries.

Context and Description

- The Pathfinder Framework aims to tackle the lack of access to sufficiently granular, accurate and verified primary GHG emission data across the value chain. It assumes that accounting and data access issues are the major underlying reasons.
- To solve this problem, the Pathfinder Framework is based on existing standards like the GHG Protocol, the EU's PEF, or EPD International to provide guidance to businesses on how to account for and exchange emission data. It enables the use of primary data and includes a quality assurance as well as a verification scheme to ensure comparability and reliability.
- The Pathfinder Framework acts as an industry guideline, such that participation is voluntary.

Scope

- Geographical scope: global
- Industry scope: industry-agnostic and tries to push cross-industry collaboration
- Calculation basis: LCA, C2Gate
- Participants: jointly developed by 35 stakeholders from industry and the broader decarbonisation ecosystem
- Reporting focus: both product- and organisation-level

Results/ Learnings

Developing an industry-agnostic framework requires cross-industry collaboration with players throughout the entire supply chain as well as relevant standardisation bodies.
Most likely, quick wins can be achieved by:

- establishing a common ground by harmonising and guiding data exchange.
- reporting C2Gate emissions: By linking up all players' C2Gate emissions, the entire supply chain is covered. In a more mature stage, players can consider downstream (often approximated ex-ante) emissions.

Box 2: Global 'Together for Sustainability' (TfS) initiative

Purpose

TfS is a global initiative (international, non-profit association based in Belgium) that brings together 40 chemical companies to collectively develop and deliver a standard for environmental, social, and governance performance of chemical supply chains.

Context and Description

- The TfS framework (consisting of Assessment, Audit, and KPIs) enables chemical companies to assess and audit their environmental, labour and human rights, ethical, as well as sustainable procurement performance of their suppliers. The TfS KPIs facilitate continuous improvements within these four categories.
- Recently, TfS published its "Product Carbon Footprint Guideline"[44], a solution for scope 3 GHG emissions PCF calculation, reporting, and auditing specifically in the chemical industry.
- The TfS Product Carbon Footprint Guideline is in line with the relevant ISO and GHG Protocol standards. As a "drop-in," it specifies guidelines provided by the WBCSD Pathfinder Framework, Catena-X, and others.
- TfS is also preparing the implementation of technical infrastructure that enables chemical companies to share footprint data with their supply chain.

Scope

- Geographical scope: global
- Industry scope: chemical sector
- Calculation basis: LCA, C2Gate
- Participants: jointly developed by 34 chemical companies

Results/ Learnings

- TfS's Product Carbon Footprint Guideline that significantly contributes to harmonising PCF approaches in the chemical industry.

44 TfS 2022

2.3.2 Corporate (private sector) players adopt methodologies and provide tools as well as carbon data to push product carbon footprint tracking and tracing

Global software corporations are moving into the space of PCF and have the potential to significantly accelerate the general PCF evolvement: Amongst others, Microsoft, SAP, Salesforce, and Siemens have launched initiatives. Given these companies' market positions, their initiatives can be expected to provide effective PCF tools to countless businesses just by rolling out new software features to existing clients:

- **SAP:** Its Product Footprint Management software allows companies to identify a product's impact ex-ante instead of ex-post by integrating emission data across the entire supply chain. Besides, their software enables GHG emission data exchange with other supply chain actors to drive transparency.[45]
- **BCG:** Its CO2 AI is a software solution that enables companies to accurately measure and reduce their scope 1 – 3 emissions by as much as 40% by setting appropriate targets.[46] BCG and SAP announced plans to integrate their solutions to scale their impacts.[47]
- **Salesforce:** Its Sustainability Cloud enables customers to more efficiently quantify, manage, and audit their scope 1-3 emission data. The software also provides seamless access to public data sets following international standards.[48]
- **Microsoft:** Microsoft announced a sustainability management portal that enables businesses to "streamline data connections and more easily and effectively record, report and reduce their emissions."[49]
- **Siemens:** In November 2021, Siemens launched 'Estainium', a blockchain-enabled platform for harmonised environmental data exchange across supply chain actors.[50]

Besides such big players, a plethora of start-ups and smaller corporate approaches that develop technology-based tools to make carbon data measurement and management more convenient are populating the fragmented space and competing for market share. Even though differentiation between these innovative start ups is low, some rather generalist players are active across sectors (e.g., Watershed Normative, Carbmee, or Altruistiq) whereas others focus on certain industries (e.g., CarbonCloud in food and agriculture or Circulor in Metals). To accelerate decarbonisation, these players are striving to move beyond managing sustainability data in alignment with industry and regulatory requirements to enabling data-driven decision-making.

Even the most progressive innovators in the space are facing severe problems with collecting the sustainability data (even though PCF standards are advanced): On the one hand, it is relatively easy to collect scope 1 and 2 data from their corporate clients (also because regulation is ahead on these scopes). However, businesses have no policies in place that require the reporting of these scopes. On the other hand, scope 3 data collection is therefore a major hurdle since all companies would have to report their scope 1 and 2 emissions to enable their supply chain partners to calculate their scope 3 emissions.

45 https://www.sap.com/products/product-footprint-management.html
46 https://co2ai.com/
47 BCG 2022
48 https://www.salesforce.com/products/sustainability-cloud/overview/
49 https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard?activetab=pivot_2:primaryr12, ZDNet 2021
50 https://www.estainium.eco/en/

For most companies, the data is fragmented in different legacy systems, which makes it very costly to ingest it in an automated, real-time, seamless manner (if possible at all). To solve this, start-ups are working hard on developing data pipelines that can automate at least parts of this data collection. However, they still mostly rely on their clients uploading conventional spreadsheets, which tremendously limits their ability to scale their products without sacrificing the accuracy of the data.

Figure 9: Overview of start-ups (non-exhaustive)

2.3.3 The bigger picture: Together, corporate upstream 'nodes', downstream brands, as well as technology and data platforms can be big levers for entire supply chain transparency

As the previous sections have shown, there is a long way to go for PCF to become commonplace despite the significant momentum we are seeing. Our analysis shows that rather than thinking of the roll-out of PCF across economies as a linear, one-by-one process, a more efficient approach may be to focus on key corporate players in the global value chains: Making what we refer to as upstream **"nodes"**, downstream **"brands", as well as "enablers"** move first has the potential to trigger cascading effects that could allow break-throughs in PCF (cf. Figure 11):

So-called upstream **"nodes"** (i.e., large corporates interacting with a multitude of up- and downstream players) are critical since they are nodes in the supply chain network, connecting a vast amount of up- and downstream players. Hence, by providing their emission data to the network, they can accelerate the availability of high-quality PCF data across the entire supply chain. Examples of such upstream nodes include BASF, Google, and Microsoft:

- In the chemical industry, BASF has been leading the way in advancing a consistent PCF methodology for the chemical sector: In 2020, BASF developed an in-house solution for calculating the C2Gate PCF of all 45,000 BASF products to offer to its customers. It is now sharing its accounting methodology with the industry as a basis for consistent application.[51]

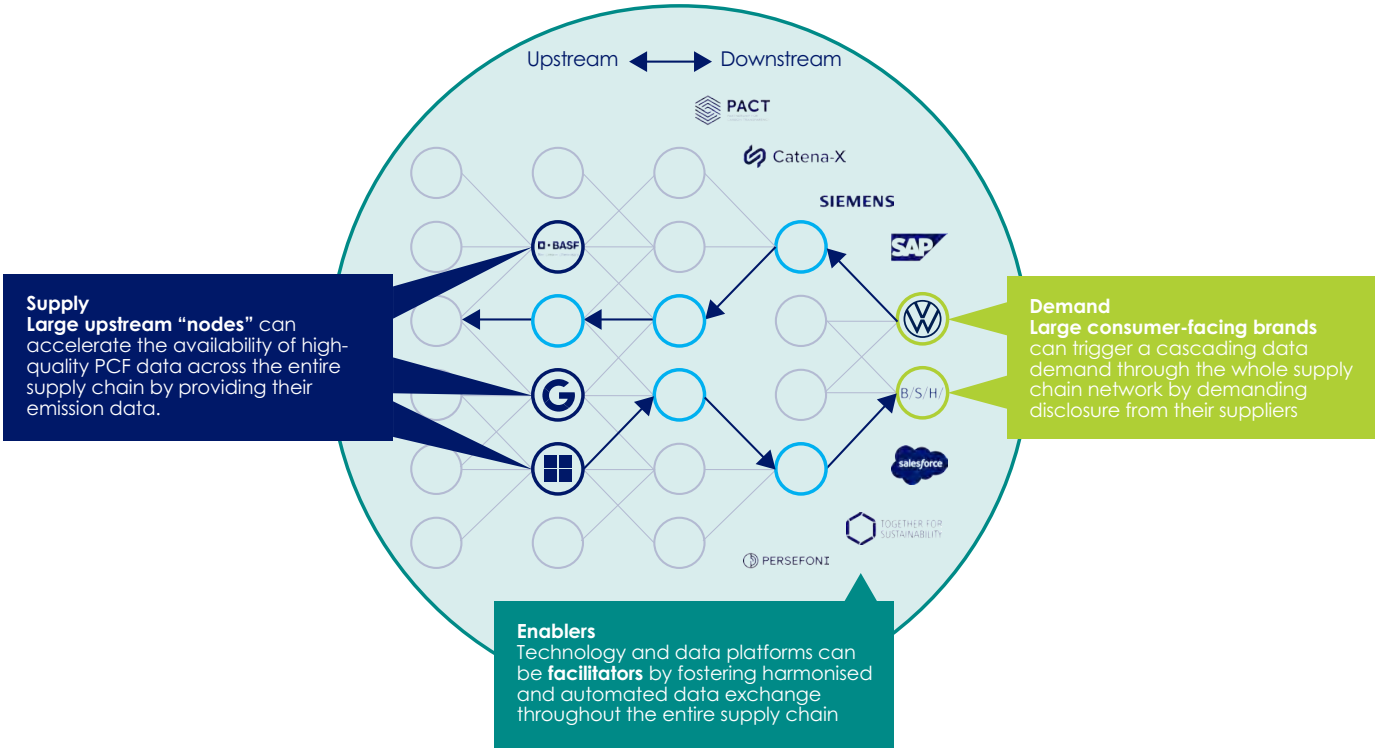
51 https://www.basf.com/global/en/who-we-are/sustainability/we-drive-sustainable-solutions/quantifying-sustainability/product-carbon-footprint.html, iPoint-systems GmbH 2021

- Google and Microsoft launched a product that lets their customers track and optimise their carbon emissions related to the usage of Google's and Microsoft's cloud services (both solutions including scope 1-3 emissions). Google also plans to integrate its solution into Salesforce's Sustainability Cloud.[52]

On the other end of the value chain, large consumer-facing **"brands"** can trigger a cascading PCF data demand through the whole supply chain network by demanding disclosure from their suppliers – while the direct influence may be limited to immediate (tier 1) suppliers, total effects may cascade along the value chain. For example, when consumer-facing brands like VW or Bosch-Siemens-Hausgeräte (BSH) increasingly demand GHG data from tier 1 suppliers as part of their sourcing requirements in order to be able to calculate and reduce their PCF, these tier 1 suppliers often pass on reporting requirements upstream.[53]

In addition, PCF **"enablers"** can facilitate the flow of data between upstream nodes and downstream brands: Enablers are technology and data platforms with enough reach across the supply chain that can foster harmonised and automated data exchange by providing integrated solutions for PCF measurement and management. They are just now pushing into the space and could dominate it quickly. Examples of such technology and data platforms include players like SAP, Salesforce, or Siemens, multilateral initiatives like Catena-X or PACT, as well as start-ups like Sweep, Persefoni or Watershed.

Figure 10: Dynamics between nodes, brands, as well as technology and data platforms



52 https://cloud.google.com/carbon-footprint, https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard
53 BSH 2021, VW 2022, https://www.volkswagenag.com/en/news/stories/2019/02/clean-mobility-starts-with-suppliers.html, https://www.volkswagenag.com/en/sustainability/sustainability-in-the-supply-chain.html,

Chapter 2.4
Public policy

Despite its potential, regulators have often struggled with implementing public policies that enable large-scale and effective PCF. A major **shortcoming** is that companies are often **reluctant to support PCF policies** since implementing PCF is still costly. By developing its **Product Environmental Footprint (PEF) programme,** a method for measuring and communicating the potential life cycle environmental impacts of a product, the **EU introduced a showcase PCF policy that even has the potential to become an international blueprint:** EU PEF is being developed in close collaboration with industry players to ensure practical applicability and feeds into various other EU initiatives that are of relevance for corporate carbon management.

Public policy as key enabler for large-scale product carbon footprint tracking and tracing, but more work is needed

Public policy is key to defining any economy's working principles and is the fourth and final critical building block. In climate action, decisive policy has proven to be indispensable for initiating the decarbonisation of sectors (e.g. electric mobility and renewables). PCF is no different: As we have seen in the previous sections, notwithstanding positive trends in frameworks, standards, private sector and multilateral action, PCF remains fragmented. By utilising the recent advances and mandating consistent and comprehensive PCF, policy makers could fast-track the emergence of PCF significantly.

2.4.1 Even though policy is one of the strongest levers for advancing product carbon footprint tracking and tracing, multiple government product carbon footprint tracking and tracing initiatives have failed in the past

Despite its potential, regulators have not managed to implement policies that enable large-scale and effective PCF so far. Past examples of attempts to establish effective PCF policies include:

- In France, **BPX 30 – 323** (cf. Box 3) aimed to establish a multicriteria approach to calculate PCF.[54]
- In Japan, the **Environmental Labelling Programme (ELP)** (cf. Box 4) differentiates products with lower carbon footprints using labels that indicate the product's environmental impact to trigger more sustainable consumer behaviour as well as enable businesses to reduce their products' footprint.[55]

54 EC-DG Env 2010, EC-JRC 2011, MEDDE 2013
55 Expert interviews, CFP 2015, https://ecoleaf-label.jp/english/about/index.html, https://www.cfp-japan.jp/english/overview/index.html, Yamamoto 2009

Unfortunately, both programmes have failed or are no longer active. There are different reasons for this, as researchers interviewed for this study concluded: First, the cost for data collection as well as the cost for measuring and calculating the PCF are too high. Second, there is a lack of tools to efficiently measure and exchange harmonised PCF data, leading to a lack of carbon data availability. Third, although there exists a general interest in carbon footprint information, effective communication can be a barrier such that the impact on consumer decisions was lower than expected.

Box 3: Learnings from France – BPX 30 – 323

Purpose

BPX 30 – 323 is a methodology for the quantification and communication of environmental impacts of consumer products, led by Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) and Association Française de Normalisation (AFNOR). It aims to contribute to and evolve in alignment with international, harmonising efforts (e.g., EU legislation).

Context and Description

- BPX 30 – 323 is based on the French legislation "Grenelle" and has been developed by the ADEME / AFNOR platform that combines 300 organisations
- It was a one-year national project, starting in 2011 and is often described as a "repository of good practices"
- It uses a multicriteria approach: a mandatory carbon footprint indicator plus other indicators
- BPX 30 – 323 develops PCRs in collaboration with industry players as well as a database that enables the calculation of PCF using generic data

Scope

- Geographical scope: international
- Full-LCA scope
- Industry scope: agnostic, focusing on mass-market consumer products
- Participants: 300 stakeholders (businesses and NGOs)

Current status and next steps

- Inactive

Results/ Learnings

- High cost of data collection, sometimes also due to reluctancy of suppliers to provide data
- Consumers are generally interested in carbon footprint information, however effective communication can be a barrier
- Future success in harmonisation and standardisation requires international collaboration

Box 4: Learnings from Japan – The Environmental Labelling Programme (ELP)

Purpose

The ELP differentiates products with lower carbon footprints using labels that indicate the product's environmental impact to trigger more sustainable consumer behaviour as well as enable businesses to reduce their products' footprint.

Context and Description

- After the Japanese government decided to approve an action plan for achieving a low-carbon society in 2008, the Carbon Footprint of Products (CFP) project was launched in 2009 to enable businesses to add labels to their products that indicate the GHG footprint. The CFP pilot phase was completed in 2012 and CFP was privatized.
- In 2017, CFP was merged with EcoLeaf, which includes a larger variety of impact factors beyond GHG and had existed since 2002. The integrated programme's name is ELP.
- The ELP is based on LCA calculations and implemented through the development of product-specific category rules (PCRs) as well as third-party label auditing.
- There is no legal framework for the programme. All the activities related to the programme are undertaken voluntarily.

Scope

- Local scope: Japan
- Full-LCA scope, C2Grave
- Industry scope: agnostic, by product groups; mainly consumer products
- Participants in 2015: ~1200 products with CFP label, ~1700 products with EcoLeaf label

Current status and next steps

- Officially, the ELP is still running. Practically, however, the labels are rarely in use, such that the programme is considered inactive.

Results/ Learnings

Three main reasons for failure due to limited traction:

- Costs for measuring and calculating the PCF were too high
- Lack of availability of relevant data and data exchange throughout the supply chains
- Lower than expected impact on the consumer's decision

However, the project revealed several learnings, amongst others:

- Establish methodologies that avoid competitive disadvantages for reporting companies due to a lack of comparability
- Ensure accuracy and reliability of the PCF label
- Educate and engage consumers

One PCF project that is still active and under continuous development is the **EU PEF** (cf. Box 6), a method for measuring and communicating the life cycle environmental impact of a product. It aims to promote the demand and supply of environmentally friendly products in the EU and to standardise their marketing. Moreover, it also aims to enable the transition to a circular economy and to reduce the environmental impacts of products, considering the products' entire supply chains. Using LCAs, it calculates environmental impacts across 16 environmental categories. To do so, so-called Product Environmental Footprint Category Rules (PEFCRs) have been developed that provide technical guidance on how to conduct a PEF study for a specific product category.

EU PEF methodology and its learnings feed into various other EU initiatives that are of relevance for the chemical sector:[56]

- **European Green Deal (EGD)**
  Europe's new agenda for sustainable growth that aims to transform the EU into a modern, resource-efficient, and competitive economy. Key objectives: net-zero by 2050, economic growth decoupled from resource use, no person and no place left behind.
- **Circular Economy Action Plan (CEAP)**
  As one of the main building blocks of the EGD, the CEAP includes initiatives along the entire life cycle of products that aim to make the EU circular. The Single Market for Green Products Initiative (SMGP) is one of the included initiatives. Priority sectors: electronics and information and communication technology (ICT), batteries and vehicles, packaging, plastics, textiles, food, and construction.
- **Ecodesign for Sustainable Products Regulation (ESPR)**
  ESPR (03/2022) aims to increase available product information to operators, consumers and procurers to offer and choose sustainable products – through solutions such as digital passports and tagging. ESPR was adopted by the EU in March 2022 and revises the Ecodesign Directive, which forces manufacturers to reduce products' energy consumption, by extending its scope to PEF categories.[57] Currently, the EU is considering including intermediary products such as chemicals within the scope of ESPR.
- **EU Data Strategy**
  The EU Data Strategy discusses initial ideas for "digital twins" and "digital product passports", and calls for a common European data space to make important data for circular value creation along the supply chains available.
- **REACH**
  REACH (registration, evaluation, authorisation and restriction of chemicals) aims to protect human health and the environment through better and earlier identification of chemical substances' intrinsic properties. It will be extended in the next years to also require the reporting of environmental impacts, which will enhance PEF data availability (especially for downstream players) in the chemical sector.

Application of and reporting according to EU PEF are voluntary as of today but will be legally required through the EU's ESPR and other EU initiatives.

56 EC 2020, expert interviews, https://ec.europa.eu/environment/chemicals/reach/reach_en.htm, https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en, https://www.bmu.de/faqs/umweltpolitische-digitalagenda-digitaler-produktpass
57 European Parliament 2022

While PEF is being developed in an EU context and will be mandatory only within the bloc as a first step, given the size of the EU domestic market and thoroughness in the development of the methodology, EU PEF is the most significant policy development for PCF application and will likely influence future PCF frameworks globally. However, PEF's high level of detail can make its application costly for businesses which leads to a limited adoption in practice.[58]

Box 5: Digital Product Passport (DPP)

Purpose

A Digital Product Passport (DPP) is an electronic record in form of "a structured collection of product-related data with predefined scope". This product related data is registered, processed, and shared electronically amongst companies, authorities, and consumers. Ownership and access rights differ and need to be agreed on.[59] A DPP can be accessed, e.g., via QR codes, a digital watermark, or RFID chip, which are linked to an unique identifier for each product.

Context and the use case of DPPs for PCF

- DPPs aim at creating transparency along the supply chain, enabling efficiencies in information transfer, and making information on products sold available across the product lifecycle.
- DPPs are introduced in the proposal for an Ecodesign for Sustainable Products Regulation (ESPR), published in March 2022. While DPPs will follow a generic basic design, sectoral modulations will adapt the design to different product groups.[60]
- DPPs will entail information on the sustainability (e.g., Product Environmental Footprint (PEF) profiles), origin, composition, and repair and disassembly possibilities of a product.
- DPPs can support realising PCF in three ways:[61]
  - **Data collection:** DPPs support the data collection required to calculate PCF. Even if companies might still need additional traceability and data collection tools, DPPs can serve as central interface, carrying product or material-specific data. This way, life-cycle data can be monitored and managed, including information required to report and exchange on GHG emissions along the value chain. At the same time, data quality and availability will be accelerated.
  - **PCF communication:** DPPs improve the communication of the PCF of a product, which can play a decisive role for customers, investors, and other stakeholders. The Product Environmental Footprint (PEF) profile (see box below) is a requirement under the ESPR, the battery carbon footprint under the Battery Regulation.
  - **Regulatory push:** Making the PCF/PEF mandatory to be reported via DPPs for certain product groups will act as regulatory push for advancing and implementing PCF, such as seen under the Battery Regulation (see example below). Harmonised standards and methodologies emerge to comply with the regulatory requirements.

Recent DPP implementation: The battery passport

- A battery passport is a DPP for each individual battery, including information on the battery model (e.g., material composition, carbon footprint, responsible sourcing information) and the individual battery (e.g., usage of the battery and state of health).
- In December 2020, the European Commission proposed a new Battery Regulation, which was provisionally agreed on in December 2022. The aim of the legislation is to ensure batteries placed on the EU market are sustainable and safe throughout their entire lifecycle. Amongst others, the mandatory battery passport is introduced.
- Companies placing large batteries on the EU market need to declare the battery carbon footprint. Since companies will be required to make the information on the carbon footprint accessible via the battery passport, the battery passport can serve as blueprint for PCF reporting via DPPs.
- The carbon footprint calculation builds on PEF and PEFCR. As some room for interpretation in the application of these exists, the Battery Pass Consortium[62] and the Global Battery Alliance (GBA)[63] develop detailed product-specific methodologies for the primary data collection and accounting along the battery lifecycle. For the purpose of harmonised methodological approaches to content and technical requirements, the Battery Pass Consortium aligns closely with different actors and initiatives advancing battery or product passports, such as the GBA[64] or Catena-X (see information in box above).

58 EU 2020, EU COM 2019, expert interviews
59 Galatola 2022
60 Wuppertal Institut 2022
61 Wuppertal Institut 2022
62 https://thebatterypass.eu/
63 GBA 2022
64 https://www.globalbattery.org/

Box 6: Learnings from the EU – Product Environmental Footprint (PEF)

Purpose

The PEF is a method for measuring and communicating the potential life cycle environmental impact of a product. It aims to promote the demand and supply of environmentally friendly products in the EU and to standardise their marketing.

Context and Description

- The EU is currently introducing a way of measuring and communicating the environmental performance of products across 16 categories marketed in the EU's single market.
- Besides promoting environmentally friendly products, it also aims to enable the transition to a circular economy and to reduce the environmental impacts of products, considering the products' entire supply chains.
- Using LCAs, it calculates environmental impacts within 16 environmental categories. To do so, it uses Product Environmental Footprint Category Rules (PEFCRs) that provide technical guidance on how to conduct a PEF study for a specific product category.
- Participation and reporting are voluntary as of today and will likely be legally required through the EU's ESPR and other EU initiatives.
- REACH, an existing EU regulation for the chemical sector, will be extended in the next years to also require the reporting of environmental impacts, which will enhance PEF data availability (especially for downstream players) in the chemical sector.

Scope

- Geographical scope: EU
- Full-LCA scope
- Industry scope: agnostic
- Participants: 280 volunteering companies in the pilot phase (2013-2018)

Current status and next steps

- The ~5 years transition phase to prepare for the potential policy adoption implementing the PEF ended in December 2021. This phase aimed to provide frameworks for monitoring the implementation of existing PEFCRs, developing new PEFCRs, and new methodological developments.
- The EU will further develop and continuously update the PEF methodology in the coming years and it is expected to become an essential building block for the EU policy landscape

Results/ Learnings

- So far, a vast amount of…
  - methodological (regarding modelling requirements, data and data quality requirements, and life cycle impact assessment) …
  - procedural (developing PEFCRs, minimum requirements for users to conduct PEF studies, and verification and validation procedures of PEF studies), and
  - editorial (terminology and definitions) …

...changes have been implemented

- The PEFCRs are very comprehensive such that adoption in practice is limited as of today.
- After fundamental alignment, the methodology's further development and administration will be managed by an independent expert unit rather than an industry consortium.

2.4.2 Learnings from government initiatives: Global harmonisation and improved data availability are key success factors

The above-described policy initiatives reveal several learnings. On a higher level, they are connected to the need for international harmonisation and collaboration as well as the improvement of data availability. More specifically, to make PCF policy effective, more work is needed[65]:

- **Integration with existing guidelines:** Closely integrate (multi-)national, public regulation with existing and industry-accepted guidelines to build on accepted standards and methodologies as well as harmonise approaches.
- **Collaborative PCR development:** Initially develop PCRs in close, international collaboration with industry players. After fundamental alignment, engage an independent expert panel with their operation and administration. In doing so, particularly challenging is finding a balance that ensures that PCRs lead to accurate PCF quantification whilst not being too detailed to ensure that the methodology is still applicable in practice and not costly.
- **Consumer understanding:** A lack of consumer understanding of carbon labels limits their impact. Therefore, ensure easy access, trust in the label, as well as a clear presentation (e.g., by using visual marking and using contextualised values for meaningful comparisons).
- **Data-centricity:** As of today, data availability is the bottleneck. Focus on developing open, standardised, easily accessible, and decentralised databases that enable data exchange across value chain actors and industries. Again, finding a balance between accuracy and the corporate burden is key in doing so. Besides, a key issue is the lack of policies that require companies to report their scope 1 and 2 emissions, even though this would tremendously improve scope 3 data availability.
- **Level the playing field:** Make PCF labelling mandatory sector-wide (consumer markets) to rule out competitive disadvantages for reporting companies. Use industry- and product-specific rules (like PCR) to recognise different circumstances and decide on which product life cycles must be included and which stages can be included in the PCF calculation.

65 Expert interviews, team analysis

Chapter 3:

RECOMMENDATIONS

Based on the analysis laid out in this report, we conclude with the following recommendations for action for governments, industrial manufacturing companies, multilateral initiatives as well as chemical companies. All recommendations are globally applicable and structured around the four building blocks of this analysis.

Chapter 3 summary:

Those aiming to advance PCF should focus on further developing practical, harmonised, and globally applicable PCF **policies, methodologies,** as well as **technical infrastructure** for data sharing to keep the current momentum and unlock more progressive regulation as well as business value, enabling PCF to be adopted more broadly. **Labels** should only be considered as a **by-product of PCF.**

Since chemical companies' products are inputs to a huge number of downstream companies, they are well-positioned to become PCF pioneers and lead the way. Specifically, we advise chemical companies to **leverage and align with existing work** (especially TfS Product Carbon Footprint Guideline) as well as **make carbon accounting a strategic priority.** Players who have already implemented PCF schemes should use their economic importance to **put pressure on governments** to enact policies, and pro-actively develop suggestions for solving remaining methodological and technical challenges. Besides, chemical companies should make downstream consumer-facing supply chain partners aware of the business value of PCF and put pressure on them to implement PCF.

Overall, **international** and **cross-industry collaboration** is key since separate national approaches would lead to a tremendous increase in overall effort and cost, insufficient harmonisation, and PCF tools of lower quality. Therefore, even countries with a relatively larger base of small and medium-sized companies (SMEs), operating domestically rather than internationally, should **build on existing standards, methodologies, and initiatives,** and minimise customisation or even work on standalone initiatives.

3.1 Governments should develop and adopt effective product carbon footprint tracking and tracing policies

Since effective policy is a key enabler for PCF, governments play a critical role in advancing PCF:

Governments can use the momentum created by consumer pressure to **implement sophisticated PCF policies** that require businesses to report their PCF and/or introduce mechanisms that link PCF reporting with business value (like CBAM). Since the vast majority of companies already have visibility into their scope 1 and 2 emissions, **policies** should **enforce the reporting** of these emissions as this would inherently provide the **required scope 3 emissions data** for value chain partners.

As a prerequisite, **practical and robust tools** that enable convenient PCF must be available to industry players. Hence, governments should **endorse and potentially financially support** the ongoing development of methodologies that translate standards into action (e.g., TfS or PACT) to ensure their alignment with (future) legislation. Moreover, local governments in particular should **actively support businesses in implementing PCF,** e.g., through subsidies, training, or fostering collaboration and exchange of knowledge within and throughout industries.

To ensure the soundness and applicability of PCF policies, policy makers should **build on established norms** such as the IFRS ISSB standards and learn from existing initiatives such as the EU Corporate Sustainability Reporting (CSR) Directive that demand **more carbon disclosure**[66]**.** Besides, governments should closely engage with industry players to take into account business needs throughout the policy development process and, akin to financial company data, phase in PCF assurance and **audit requirements to ensure the credibility of PCF reporting.**

Besides, policy makers should prioritise **harmonising policies internationally** (e.g., between EU and Japan or later North America and Japan), to cater for today's highly connected, international supply chains.

3.2 Industrial manufacturing companies should leverage consumer pressure for decarbonisation

Downstream industrial manufacturing companies should **pro-actively comply with emerging disclosure rules** (e.g., Task Force on Climate-related Financial Disclosures (TCFD), ISSB) and showcase the feasibility and business-related benefits of PCF. In addition, pioneer players should **demand ambitious climate policy** (not least as a differentiator) and shape the ongoing development of methodologies that translate standards into action (e.g., TfS, PACT, or EU PEFCRs) to ensure they are broadly applicable.

Due to their relatively close exposure to customers, manufacturing companies should **leverage consumer pressure** for decarbonisation and instate low-CO2 purchasing rules to cascade carbon transparency upstream and manage their own upstream scope 3 emissions. This will also enable them to **aggregate product lifecycle data** for consumer information, e.g., for easily understandable consumer carbon labels based on best practice and targeting consumer understanding. To make PCF data collection, processing, and reporting as efficient as possible, we advise investing in (digital) technologies that facilitate PCF.

66 European Council 2022

Moreover, industrial manufacturing companies can **leverage their PCF activities** to showcase PCF benefits to second movers, contribute to the development of **open-source and decentralised databases,** as well as optimise the design of their own products to decrease use phase emissions.

3.3 Multilateral initiatives should further galvanise industry coordination and catalyse policy action

To decrease the cost burden for businesses to report PCF and harmonise disclosure, multilateral initiatives should **co-develop practical PCF methodologies** by bringing together and cooperating with industry players throughout the value chain and across industries. These methodologies should be **based on recognised standards,** build on existing work like PACT to ensure their international applicability and ease of use, as well as facilitate automated data collection, secure and credible exchange, as well as efficient auditing.

Besides, multilateral initiatives are well-placed to **broadcast the urgency** of the need for PCF action and then coordinate industry to act. To policy makers, they should supply developed methodologies and databases as proofs of concept and basis for regulation. Lastly, we encourage multilateral initiatives to offer policy makers the evidence of cost and benefits of wide-scale adoption of harmonised disclosure rules at the corporate- and product level.

3.4 Chemical companies should pro-actively shape the product carbon footprint tracking and tracing landscape in collaboration with the entire ecosystem

Chemical manufacturing companies can advance PCF whilst generating business value for themselves and achieving decarbonisation targets. **Overall, chemical companies should engage with the ecosystem to shape the emerging landscape and its tools.**

Even though standards for PCF already exist, it still requires expert knowledge to apply them in practice. Therefore, chemical companies should actively shape the development and refinement of methodologies that **translate standards into practice.** Doing so requires facilitating **industry collaboration** (both up- and downstream), choosing an approach that focuses on the "willing" and progressive industry peers first. Moreover, leveraging and **aligning with existing work on advancing PCF is key** to avoiding increasing fragmentation and inconsistencies between approaches. Since we consider them some of the globally leading initiatives, we advise chemical companies to use as well as **contribute to the further development** of the TfS Product Carbon Footprint Guideline for the chemical sector specifically and, in doing so, strongly align with PACT and EU PEF.

First, to ensure the commitment of the entire company, chemical companies should make carbon accounting a strategic priority by **introducing environmental KPIs into C-level decision-making and risk management.** This will also enable the integration of PCF with company-wide carbon tracking and tracing, which is key for more holistic decarbonisation that is not only based on measuring and managing the footprints of particular products.

Second, chemical companies should **invest in (digital) technologies** to increase efficiency and minimise costs of data collection, PCF calculation, data exchange across the supply chain, as well as auditing. Besides, for the sake of speed, efficiency and best value for money, proactive corporates wishing to initiate PCF should apply the 80/20 principle according to **"materiality-based" reporting** by prioritising PCF for activities, production processes, and products that have the highest footprints. Harmonised C2Gate PCF data can then be passed on downstream. Quick wins can be achieved when big **"nodes" in particular are amongst the first players exchanging their C2Gate data.** After a proof of concept phase with progressive players, the results could be used to showcase the feasibility of PCF to also convince players that do not move by themselves.

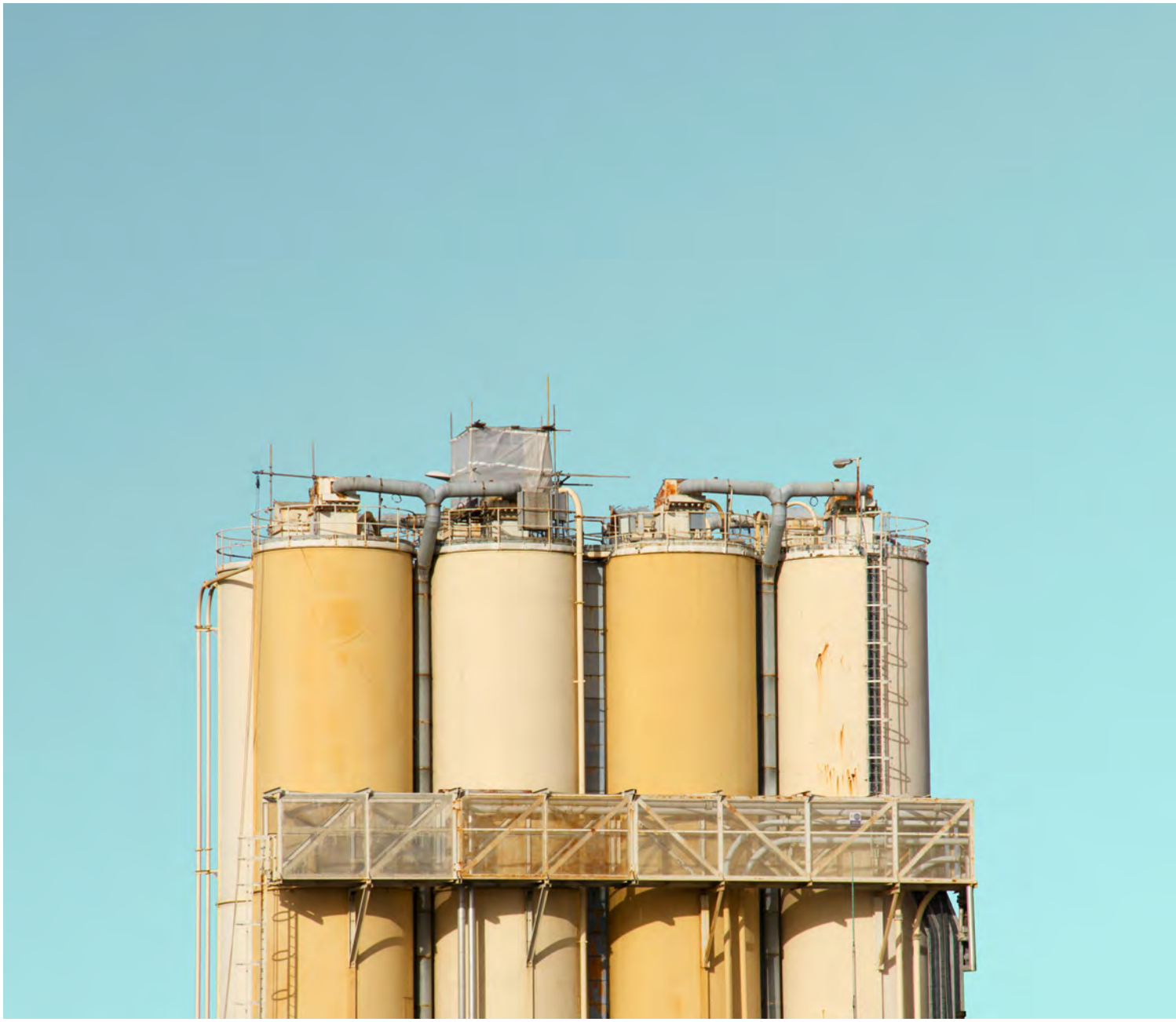
Third, we urge chemical companies to **contribute their PCF data** to shared or open-source databases (while protecting their sensitive information) to enable other, less advanced or progressive players to make use of more granular industry averages as long as they are not able to perform accurate PCF quantifications by themselves.

Beyond implementing PCF today in anticipation of coming policy requirements, **chemical companies should also use their political leverage** to influence regulators to enact policies that support carbon data exchange and contribute expertise to ensure the effectiveness and practical applicability of policies.

Chemical companies should also make downstream consumer-facing supply chain partners aware of the **business value of PCF** and put pressure on them to implement PCF. This will also allow these downstream actors to implement trusted, accurate, and broadly adopted product carbon labels that are easy to grasp and provide relative rather than absolute quantified footprint information to their customers.

Therefore, even countries with a strong national rather than international economic focus should integrate with leading global initiatives rather than developing their own, domestically-focused, approaches.

These countries could build on, e.g., PACT on the industry side as well as EU PEFCR / EU ESPR on the government side, and ensure that their PCF activities are strongly aligned with these international initiatives. Policy makers and businesses could make it their hallmark contribution to global PCF initiatives to create support mechanisms as well as translate existing methodologies and data bases (e.g., ecoinvent[67]) into practical and easily digestible guidelines for domestic companies to help them benefit from PCF. In doing so, such countries would not only be able to efficiently implement practical and effective PCF but also set an example on how to adopt existing international PCF guidelines and customise them according to national requirements.



67 https://ecoinvent.org/

CONCLUSION

Effective product carbon footprint tracking and tracing policies, methodologies, as well as technical infrastructures for data sharing might scale product carbon footprint tracking and tracing in the chemical sector and beyond

Past efforts to create **product carbon labels** have been largely **unsuccessful.** One of the main reasons for failure is that the **benefits** did **not justify the effort and cost,** since product carbon **labels' cost-benefits analysis is likely negative** for participating companies. To advance PCF in the chemical sector and beyond, future actions should prioritise the **development of effective PCF policies, methodologies**, as well as **technical infrastructures** for **data sharing** and consider labels only **one additional by-product of PCF.**

The mounting **pressure for decarbonisation** of all **value chains,** together with a **legislative push** especially **by the EU** (e.g., ESPR, PEF) or the new ISSB corporate climate disclosure have the potential to scale **global PCF tracking and tracing** within the next years and across industries.

On the one hand, **standards have evolved** and are now largely complete, but still often require some more sectoral guidance and will never remove the **need for case by case methodological expertise** for **large-scale adoption** in practice.

Policy does play a key role in driving **PCF adoption** throughout sectors, and especially **EU legislation** has a **high potential** for success.

On the other hand, **businesses** can gain a range of **benefits from PCF** as well as **overcome cost and technological barriers** through a balance between accuracy and pragmatism. The latest in developments in technology, climate policy, and synergies between upstream nodes, downstream brands, as well as data and technology platforms could mean that **PCF could scale i**n the chemical sector and beyond. Now is the **right time** for **policy makers and industry executives** around the world to **collectively develop solutions** that help PCF scale and pave the way to a decarbonised future.

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GLOSSARY

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

AFNOR
Association française de normalisation

C2C
Cradle-to-cradle

C2Gate
Cradle-to-gate

C2Grave
Cradle-to-grave

CBAM
Carbon Border Adjustment Mechanism

CCF
Corporate carbon footprint

CEAP
Circular Economy Action Plan

CFP
Carbon Footprint in Products

CSR
Corporate Social Responsibility / Corporate Sustainability Reporting

EGD
European Green Deal

EPD
Environmental Product Declaration

EPD International
Environmental Product Declaration International

ESPR
Ecodesign for Sustainable Products Regulation

GDA
Guideline daily amount

GHG
Greenhouse gas/gases

GRI
Global Reporting Initiative

ICT
Information and communication technology

IEA
International Energy Agency

IFRS
International Financial Reporting Standards (foundation)

ISSB
International Sustainability Standards Board

LCA
Life cycle assessment

OEF
Organizational Environmental Footprint

PACT
Partnership for Carbon Transparency

PCF
Product carbon footprint tracking and tracing

PCR
Product category rules

PEF
Product Environmental Footprint

PEFCR
Product Environmental Footprint Category Rules

REACH
Registration, Evaluation, Authorisation and Restriction of Chemicals

SBTi
Science Based Targets Initiative

SMGP
Single Market for Green Products Initiative

SPI
Sustainable Products Initiative

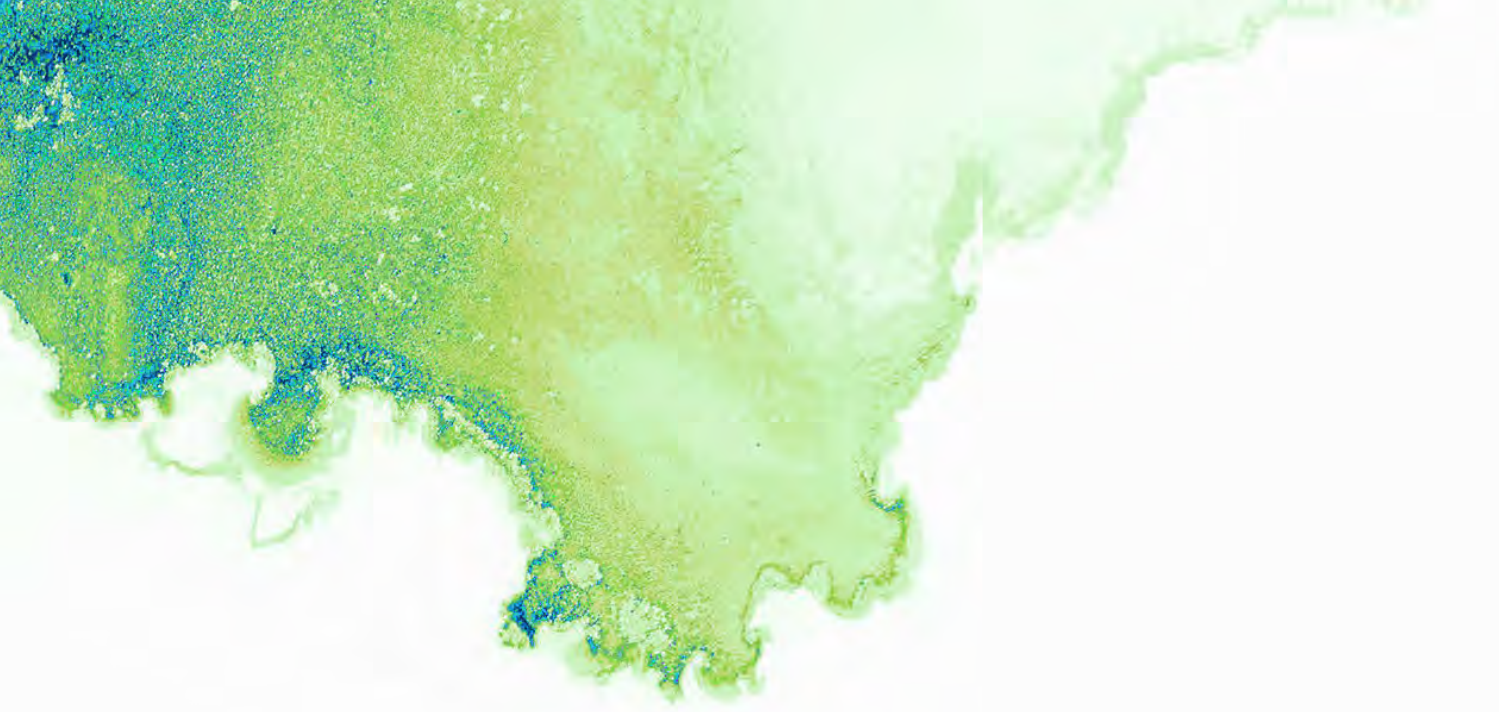
TCFD
Task Force on Climate-related Financial Disclosures

TfS
Together for Sustainability

US SEC
United States Securities and Exchange Commission

VCI
Verband der Chemischen Industrie – German association of the chemical industry

WBCSD
World Business Council for Sustainable Development



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