

Addressing the Need for Accurate and Comparable Greenhouse Gas Data:

The COMET Framework

LED BY JORDY LEE CALDERON

with contributions from

Perrine Toledano, Suzanne Greene, Paolo Natali, Martin Dietrich Brauch, Nicole Smith, Bhargavi Chekuri, Jay Lemery, Stephen Lezak, Sarah Hitt, Gajanana Hegde, Charles Cannon, Sebnem Duzgun, Shannon Hughes, Caleb Workman, Cansu Demirkan, Lachlan Wright, John Biberman

MARCH 2023

The
Payne Institute
for Public Policy

 COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

Columbia Center
on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL
AND THE EARTH INSTITUTE, COLUMBIA UNIVERSITY



THE COALITION ON MATERIALS EMISSIONS TRANSPARENCY (COMET)

The Coalition on Materials Emissions Transparency (COMET) began as a collaboration between the Columbia Center on Sustainable Investment (CCSI), the Colorado School of Mines (CSM), RMI (formerly known as the Rocky Mountain Institute), and the Secretariat of the United Nations Framework Convention on Climate Change (UN Climate Change). Its objective is to advance accurate and transparent greenhouse gas accounting through a harmonized set of principles, standards, and reporting requirements. This harmonization would allow for independent verification of the emissions reported by companies, industries, and their supply chains, thus benefiting all stakeholders. Without this harmonization, much of the world's greenhouse gas data will remain incomparable and potentially misleading, which undermines the world's ability to manage greenhouse gas emissions.

COMET was first launched at the World Economic Forum Summit in January 2020 and has dedicated initial research to harmonizing current greenhouse gas accounting. This paper serves as a landscape assessment and overview of methods to build more accurate and comparable greenhouse gas data, as well as a formulation of the principles underpinning the COMET Framework.

Going forward, the COMET work plan will be led by the Colorado School of Mines and the Columbia Center on Sustainable Investment. Please contact Jordy Lee regarding future collaboration.

CORRESPONDING AUTHOR

Jordy Lee Calderon

jorlee@mines.edu

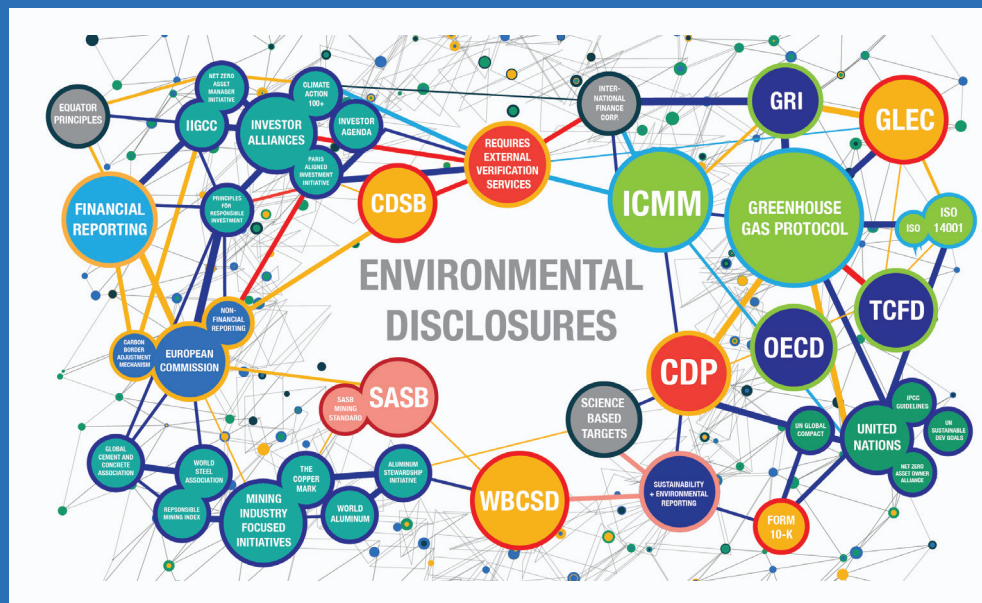
The authors would like to extend a special thank you to Krisha Tracy and Trinity Lloyd from Google, Joanna Jobson and Allyson Book from Baker Hughes, Steve Takeuchi and Ruriko Aoki from the Sumitomo Corporation of Americas, Paul Nelson from Saoradh Enterprise Partners, and Toni Lefton from the Colorado School of Mines for their support.

Executive Summary

While companies and governments face mounting pressure to set and achieve climate targets, global efforts to curb greenhouse gas (GHG) emissions have yet to address a persistent obstacle: the absence of a standardized way to accurately measure and compare GHG emissions from different products and companies. There is currently no regulatory body that verifies the accuracy of published GHG data, nor any widely adopted standard for how companies should calculate their GHG emissions. There is no agreement on what qualifies as low-carbon goods or investments, nor any common repercussions for misrepresenting GHG data. To this end, the GHG data that is currently being published and used by companies and other stakeholders is vastly underregulated and potentially damaging to global climate efforts.

Without a consistent way to measure and discuss GHG emissions, there is also no consistent way to measure and discuss any progress in decarbonization efforts. There is currently no consistent way to measure GHG reductions by companies, nor any common way to assess the feasibility of net-zero pathways, the benefits of low-carbon goods, the viability of sustainable investments, the feasibility of new decarbonization technologies, the cost of carbon, or any of the other mechanisms the world is depending on to meet global climate goals. Thus, decarbonization and sustainability efforts on a national and global scale will not succeed without a new foundation of trusted and auditable climate data.

Figure i. Examples of GHG tools, frameworks, and disclosure platforms



The current approach of obtaining GHG emissions data relies heavily on individual companies to report on their impacts without much guidance and support from researchers, regulators, and supply chain partners. Companies are expected to independently identify complex emissions sources, find accurate data, evaluate that data against global benchmarks, and then relay that information in the form of a sustainability report. Furthermore, the reports companies produce must also satisfy the hundreds of different tools, frameworks, and disclosure platforms that they are under pressure to engage with — all of which have unique data requirements and objectives (Figure i). Together, this approach creates inconsistent data and numerous opportunities for intentional or unintentional greenwashing and misleading claims.

This current reliance on companies to produce unregulated, self-reported data has proven to be unreliable. Academic investigation and industry reports have consistently found that self-reported GHG data is incomparable, inaccurate, and potentially misleading. The rapid growth of environmental reporting has thus evolved into a source of complication for companies reporting their emissions and those who need to interpret these reports. Today, key actors often struggle to separate signals from noise, and the value of environmental data is being obscured. The solution is to standardize emissions reporting by companies.

Standardized reporting will enable accurate estimation of supply chain emissions, independent verification of companies' reported emissions, and easy comparisons of the emissions caused by different companies and products. Creating a standard will require a more robust understanding of emissions across different commodities, and intensive research on existing supply chains to ensure all associated GHGs are accounted for.

To that end, COMET is developing a unified framework of principles, standards, and reporting requirements so the emissions associated with commodities and intermediate goods can be transparent and verifiable. This paper contributes to this goal by mapping the landscape of carbon accounting methods for materials and commodities, highlighting the key differences between existing GHG accounting methods, and explaining how GHG data can be standardized.

COMET's standardized and universal framework will improve emissions accounting to support actionable insights. A greater understanding of these emissions will help inform companies and nations as they work towards their emissions reduction targets and develop policies to support the planet and environmental health.

ABBREVIATIONS

COMET	Coalition on Materials Emissions Transparency
ESG	Environmental, Social, and Governance
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
ICMM	International Council on Mining and Metals
NGO	Non-governmental Organization
SBTi	Science Based Targets Initiative
SLO	Social License to Operate
TCFD	Task Force on Climate Related Financial Disclosures

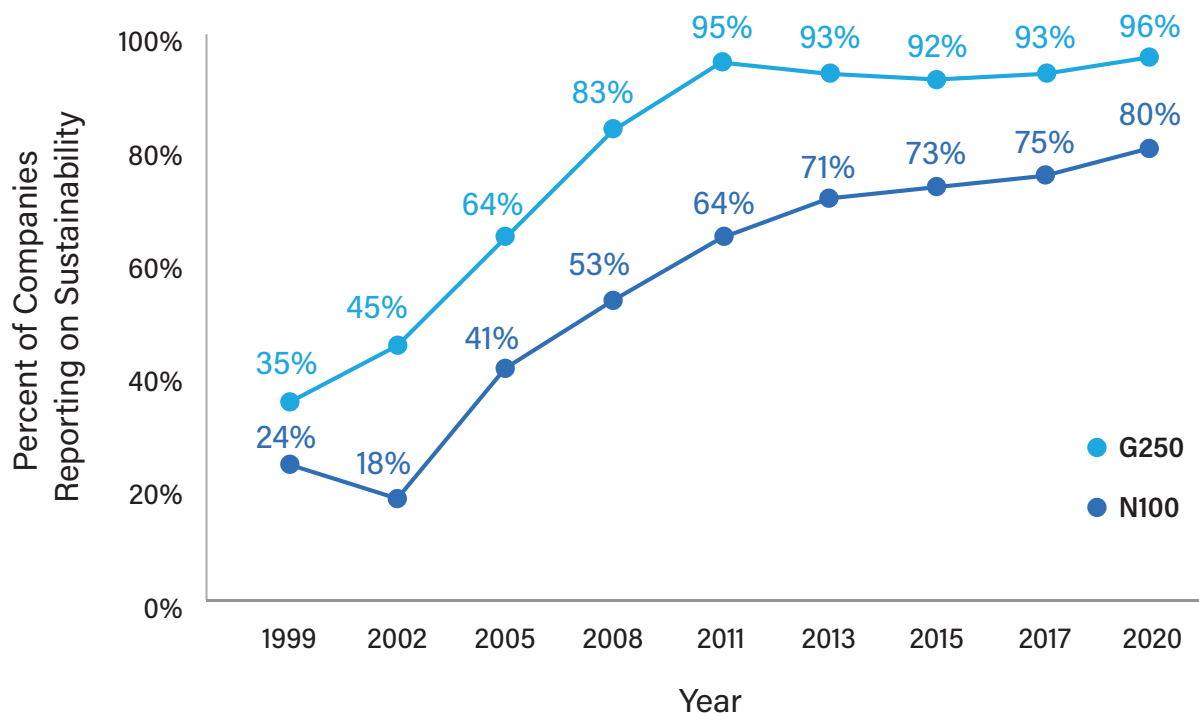
Contents

1. How and Why Companies Measure Emissions	1
Current Carbon Accounting Methods	2
Growing Problems with the Current System	5
Net-Zero Plans Can Be Misleading	6
Carbon Offsets Can Further Complicate Carbon Accounting and Net-Zero Commitments	8
Sustainable Investors Are Forced to Work with Inaccurate Data	9
Global Sustainability Efforts are Being Diminished	11
2. Addressing Current Carbon Accounting Challenges	13
How do we begin to standardize GHG data?	17
3. The COMET Framework	21
A. Commodity-Specific Reporting Requirements	21
B. Standardized Data Requirements	22
C. Working with Fixed Reporting Boundaries and Corporate Data	24
D. Harmonizing and Supporting Existing Carbon Disclosure Tools	26
4. Conclusion and Next Steps	27
Glossary	29
References	32

1. How and Why Companies Measure Emissions

Growing concerns for human health and the economic impacts of global climate change have led to increased pressure on companies to disclose their greenhouse gas (GHG) emissions¹ and adopt emissions-reduction targets. Many companies have announced plans to align their operations with global climate goals and to make measurable progress in minimizing climate-related risks. Environmental reporting has become so common that 96% of the world's largest 250 companies provided reports on sustainability initiatives in 2020 (Figure 1), and more than 80% of global GDP is now anchored by **net-zero commitments** [2]–[4].

Figure 1. Growth in global sustainability reporting rates since 1993: N100 and G250 (The N100 are the 100 largest companies in 41 countries; the G250 comprise the top 250 companies in the Fortune Global 500) [3]



Source: Modified from KPMG Survey of Sustainability Reporting 2020

“There is currently no regulatory body that verifies the accuracy of published data nor any widely adopted standard for what qualifies as low-carbon goods or investments.”

The mainstreaming of GHG reporting is key to facilitating global decarbonization and preparing companies for a low-carbon future. The reports prepared by companies serve as one, if not the primary, source of GHG data in difficult-to-decarbonize industries such as mining, metals, cement, oil, gas, and plastics [5]–[14]. Unfortunately, calculating and reporting GHG emissions remains mostly voluntary and unregulated.

Despite the importance of corporate GHG data, there is currently no regulatory body that verifies the accuracy of published data² nor any widely adopted standard for what qualifies as low-carbon goods or investments [5]. Furthermore, there is no agreement on how companies should calculate their GHG emissions; most companies are expected to independently research what emissions to report. Consequently, there are rarely major repercussions for misrepresenting emissions data³ and no universally recognized way for companies to report their environmental impacts. Instead, many companies self-publish and verify their own GHG accounting findings through annual **sustainability reports** and **carbon disclosures** which are primarily created for investors and other stakeholders. This addresses some stakeholder needs but has also created concerns regarding the accuracy of using unregulated, unstandardized data to investigate and regulate the impacts of hard-to-decarbonize industries.

CURRENT CARBON ACCOUNTING METHODS

As much of the world’s climate data currently comes from what companies choose to publish, many tools have been created to help companies more easily disclose GHG data. These **carbon disclosure tools** (CDP,⁴ Global Reporting Initiative (GRI), Science-Based Targets initiative (SBTi)) have been developed by non-governmental organizations (NGOs) and business

1 Emissions, carbon, and GHGs are commonly used in expressions such as “carbon accounting,” “embodied carbon,” “carbon footprint,” “low-carbon standard,” and “decarbonization,” to include the emission of carbon-based molecules and all seven types of emissions commonly assessed by policymakers and climate scientists: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride (NF₃).

2 The European Union and other governments sometimes require verification of selected GHG data through programs such as the Emissions Trading System (EU ETS); however, this type of verification focuses on compliance and does not account for GHG issues outlined in this document.

3 The United States Securities and Exchange Commission fined a company for misstatements and omissions regarding Environmental, Social, and Governance (ESG) for the first time in May, 2022 [1]. The EU has similarly fined organizations for GHG emissions-related activities, but often only for public negligence and gross misstatements.

4 The CDP was formerly known as the Carbon Disclosure Project.

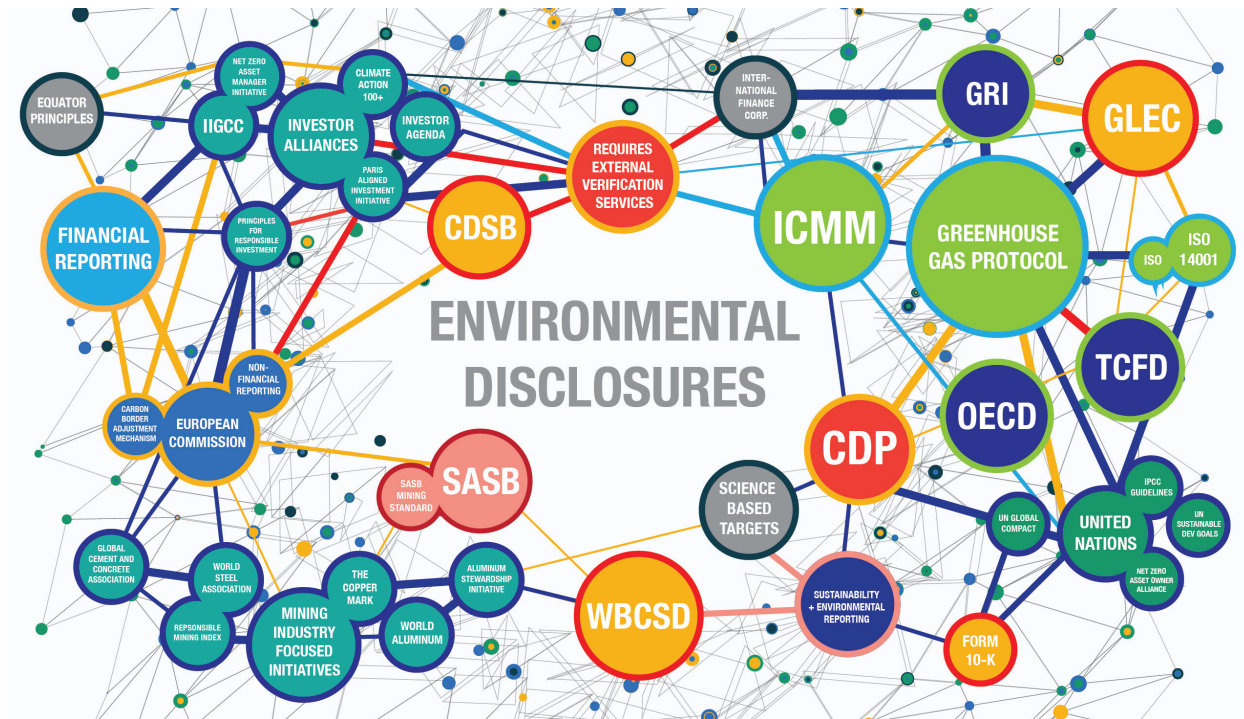
consortiums to help companies identify what they should include in sustainability reports. For example, as many financial institutions are concerned about **climate-related financial risks**, they have helped to develop the Task Force on Climate-Related Financial Disclosures (TCFD). The TCFD works to “develop recommendations on the types of information that companies should disclose to support investors, lenders, and insurance underwriters” [15]. Similarly, the GHG Protocol provides a framework for companies to understand what emissions they are responsible for (**scope 1, 2, and 3 emissions**) [16]. Initiatives such as the SBTi have begun to help companies “set science-based emissions-reduction targets”, and the GRI helps companies to “be transparent and take responsibility for their impacts” [17] [18].

Unfortunately, there are now hundreds of carbon disclosure tools (Figure 2) that companies are under pressure to engage with, thus complicating GHG accounting efforts. Companies often need to reframe their GHG data to satisfy the requirements outlined by the TCFD, the CDP, the GRI, the SBTi, and other carbon disclosure tools. These tools often have unique requirements, and they can diverge in their primary function, attribution level (company or product), coverage (sector, material, region), inclusion boundaries (definition of supply chain emissions), impacts (climate-specific or general pollution), type of GHGs (CO₂, CH₄, NO_x), scope (direct versus indirect emissions), and type of data permitted (how much companies are allowed to estimate). Many of these tools also do not verify data; thus, a company’s original GHG data can be modified and widely published on numerous platforms without being checked for accuracy.

Furthermore, almost all carbon disclosure tools lack a widely adopted **reporting standard** for how companies should gather and calculate GHG data [5]. The method one company uses to obtain data for the TCFD, CDP, GRI, etc., is often fundamentally incomparable to the method another company uses. Because of this, academic studies have found that many of the sustainability reports that a company produces using carbon disclosure tools (Figure 2) are often fundamentally incomparable to those of similar companies, which means that the underlying GHG data are also often incomparable [5] [8] [19]–[39].

“The method one company uses to obtain data for the TCFD, CDP, GRI, etc., is often fundamentally incomparable to the method another company uses.”

Figure 2. Snapshot of carbon accounting methods, reporting programs, and standards that mining and metals companies are under pressure to engage with. Many other industries also have dozens of carbon tools they are expected to engage with.



Companies often report confusion about which carbon disclosure tools to use and can be pressured by stakeholders and investors to use numerous tools. For example, the CDP has investors managing over US\$110 trillion in assets requesting that thousands of companies use CDP questionnaires [40]. Other important global organizations such as the International Council on Mining and Metals (ICMM), which represents the world’s largest mining and metals companies, require their members to publicly report their sustainability performance using the GRI Sustainability Reporting Standards [41]. The Sustainability Accounting Standards Board (SASB) Investor Advisory Group has 55 members representing 12 countries and US\$41 trillion in assets under management who “call upon” companies to use SASB standards in their investor disclosures [42].

Although each carbon disclosure tool has been created for an important purpose and has helped facilitate GHG disclosures, the current GHG accounting landscape has become extremely complicated. With hundreds of tools, pressure from investors, and minimal guidance, there has been an overt focus on reporting as much data as possible, rather than data that are accurate, comparable, and easy to understand.

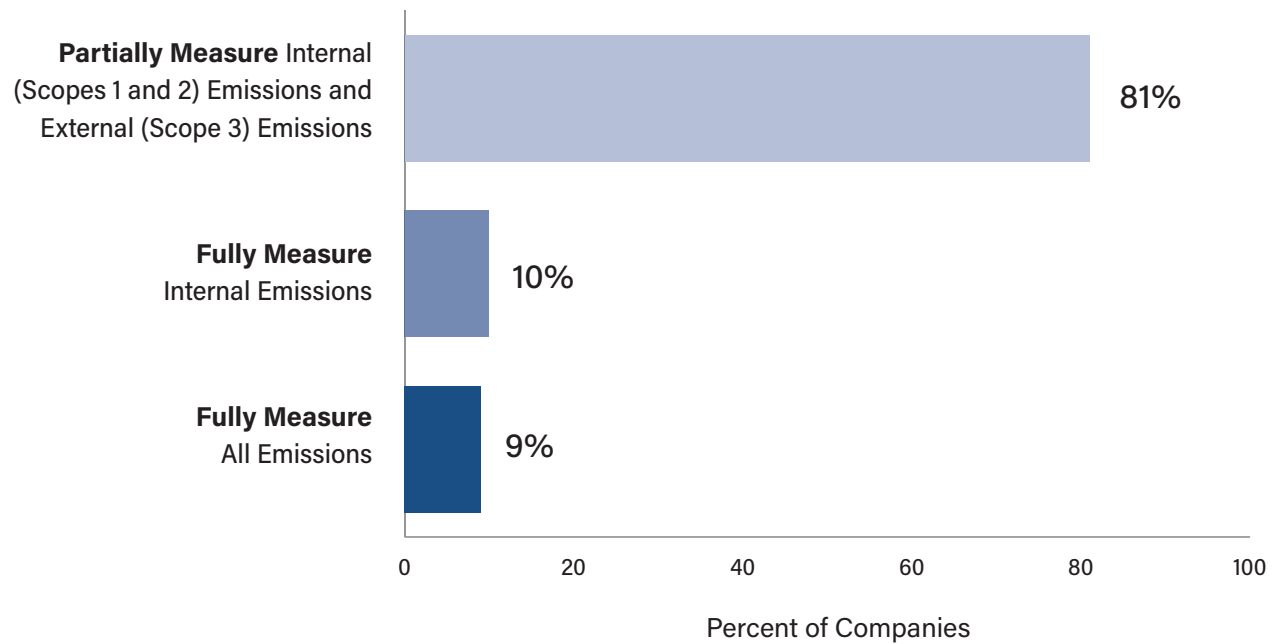
GROWING PROBLEMS WITH THE CURRENT SYSTEM

With hundreds of carbon reporting tools available, thousands of companies reporting their GHG emissions, no comparability between companies or tools, and no simple way for stakeholders to scrutinize the accuracy of carbon disclosures or sustainability reports, the rapid growth of environmental reporting has devolved into a source of complication for companies reporting their emissions and those who must interpret these reports. Today, key actors often struggle to separate signals from noise, and the value of environmental data is being obscured. Carbon reporting and the resulting data have become so common and so convoluted that there is often no easily accessible way to verify the accuracy of reported claims. As Mark Carney, former chair of the Financial Stability Board, famously cautioned when introducing the TCFD in 2015, the “surfeit of existing schemes and fragmented disclosures means a risk of getting ‘lost in the right direction’” [43].

Unfortunately, a steadily growing body of research has shown that despite well-established and widely accepted carbon disclosure tools, companies are often unable to produce accurate and comparable GHG data [5] [8] [19]–[39]. Even when using the same carbon disclosure tool in the same industry, published sustainability reports and carbon disclosures are often incomparable, inaccurate, and “fundamentally misleading” [5] [8] [19]–[39]. Similarly, investigations by the Boston Consulting Group recently found that 91% of companies are not using carbon disclosure tools correctly, and that companies estimate an average error rate of 30–40% in their reported emissions [44] [45]. Approximately 80% of companies admit that they knowingly omit some emissions when reporting and/or are unable to fully measure their carbon footprint [45]. Ultimately, only 9% of companies were found to accurately quantify their total GHG emissions (Figure 3) [44] [45].

“Today, key actors often struggle to separate signals from noise and the value of environmental data is being obscured.”

Figure 3. According to the Boston Consulting Group [45], 91% of companies fail to measure the full scope of their emissions.



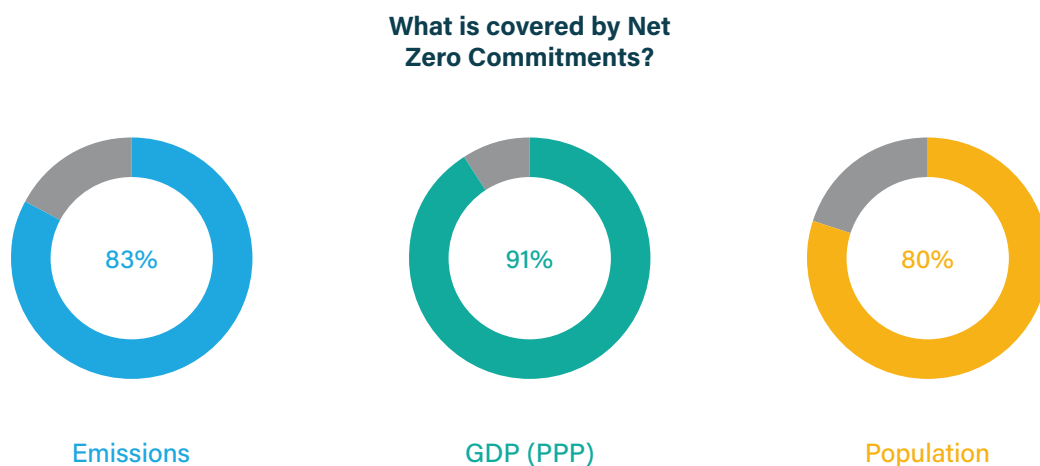
Source: BCG Carbon Measurement Survey, 2021.

With inaccurate and misleading corporate emissions data often serving as a primary source for broader GHG data and decision-making, the positive impacts of many global climate protection efforts are significantly undermined. Governments, regulatory bodies, and consumers are likely making misguided decisions. Furthermore, it is becoming clear that many companies are struggling to understand their own GHG footprints at a time when the **Intergovernmental Panel on Climate Change** and other climate research groups warn that action and decarbonization must happen ‘now or never’ [46] [47].

NET-ZERO PLANS CAN BE MISLEADING

Carbon disclosures often serve as the basis and barometer for decarbonization claims and **net-zero commitments** [17] [48]. However, many net-zero claims have recently come under scrutiny for not being data-driven or for a company’s inability to effectively communicate how it plans to decarbonize [36] [49]–[53]. These criticisms align with research showing that companies are often unable to accurately measure or disclose their emissions, which is an important prerequisite for gauging internal progress towards becoming carbon-neutral (net-zero) [5] [8] [19]–[39] [45].

Figure 4. Net-zero commitments have become popular in recent years [49]



Source: <https://zerotracker.net/>

Zero Tracker, a project aimed at increasing the transparency and accountability of net-zero targets, reports that 88% of emissions and 90% of GDP are now covered by net-zero pledges (Figure 4) [49]. However, less than one-third of companies with net-zero targets have met the “minimum procedural standards” required to make such claims, meaning that most claims were not science-based or lacked clear plans for delivery [49] [54]. Similarly, research published in the Corporate Climate Responsibility Monitor estimated that pledges by 25 of the world’s largest companies will only reduce their emissions by 40% on average, not 100%, as suggested by their net-zero announcements (Figure 5) [55] [56]. This lack of consistency and agreement in net-zero definitions has allowed some of the world’s largest companies to make net-zero claims that have been described as “rife with misleading practices” [48].

With sustainability reports and carbon disclosures demonstrating accuracy concerns, it is not surprising that net-zero targets also face challenges in maintaining transparency. Many questions remain as to how much of the world’s estimated climate progress is based on misleading claims and flawed data. Are decarbonization efforts also off by 40% like reported emissions? Will companies still knowingly omit emissions when they announce they have met their decarbonization goals? How do unfounded net-zero claims affect climate policy and sustainable investing? Does the world actually have a plan to decarbonize?

Figure 5. Net-zero claims by the world's 25 largest companies are not as comprehensive as implied [48]



Source: Corporate Climate Responsibility Monitor 2022

CARBON OFFSETS CAN FURTHER COMPLICATE CARBON ACCOUNTING AND NET-ZERO COMMITMENTS

The unstandardized use of **carbon offsets** further complicates the accuracy of GHG data, allows for companies to make misleading claims, and undermines decarbonization efforts [48] [49] [51] [54] [57]–[62]. Many of the world's largest companies now use carbon offsets in their sustainability reports and net-zero claims despite the lack of consensus on how carbon offsets can be used or how they should be reported [48] [49] [51] [54] [57]–[62]. Should companies be able to offset all of their emissions? What counts as an "offset" and who is responsible for making sure GHG emissions are actually reduced?

Despite the absence of any universal standard for how carbon offsets can be used, some of the world's largest companies are already applying carbon offsets to report that they have achieved carbon neutrality/net-zero. Other companies are also claiming carbon neutrality for specific products through carbon offsets, which can mislead consumers into believing that the company is carbon-neutral as a whole [48]. For example, Apple, one of the world's most valuable companies, declared it had achieved carbon neutrality in 2020,⁵ but is actually using "offsets that cover only 2% of the company's GHG emission footprint" [48] [63]. Deutsche Post similarly claims carbon neutrality of its

5 Carbon-neutrality claimed for 2020 only covers operations (scopes 1 and 2), business travel, and employee commuting. Apple has since actively worked toward decarbonizing its supply chain.

deliveries in Germany, despite less than 1% of the company's total emissions being offset [48] [64]. Even with independent, credible efforts to create carbon markets, it has been found that carbon offsets are systematically over-credited by almost 30% [42] [57] [58]. At the national level, some countries have claimed that their trees absorb carbon "four times faster than similar forests" in neighboring countries [66].

Other large companies are using emissions reductions achieved by their customers and counting them as their own "offsets." Ikea plans to be "climate-positive" by 2030, partially by counting emissions reductions from customers using Ikea solar panels [48] [56] [65]. Similarly, companies are claiming emissions reductions by "storing carbon" in products, although this carbon could be rereleased into the atmosphere within 20 years [48]. This misuse of offsets and **insetting** — the reduction of a purchasing company's supply-chain or sector of climate impact — diminishes the importance of working with partner companies to understand supply chain emissions.

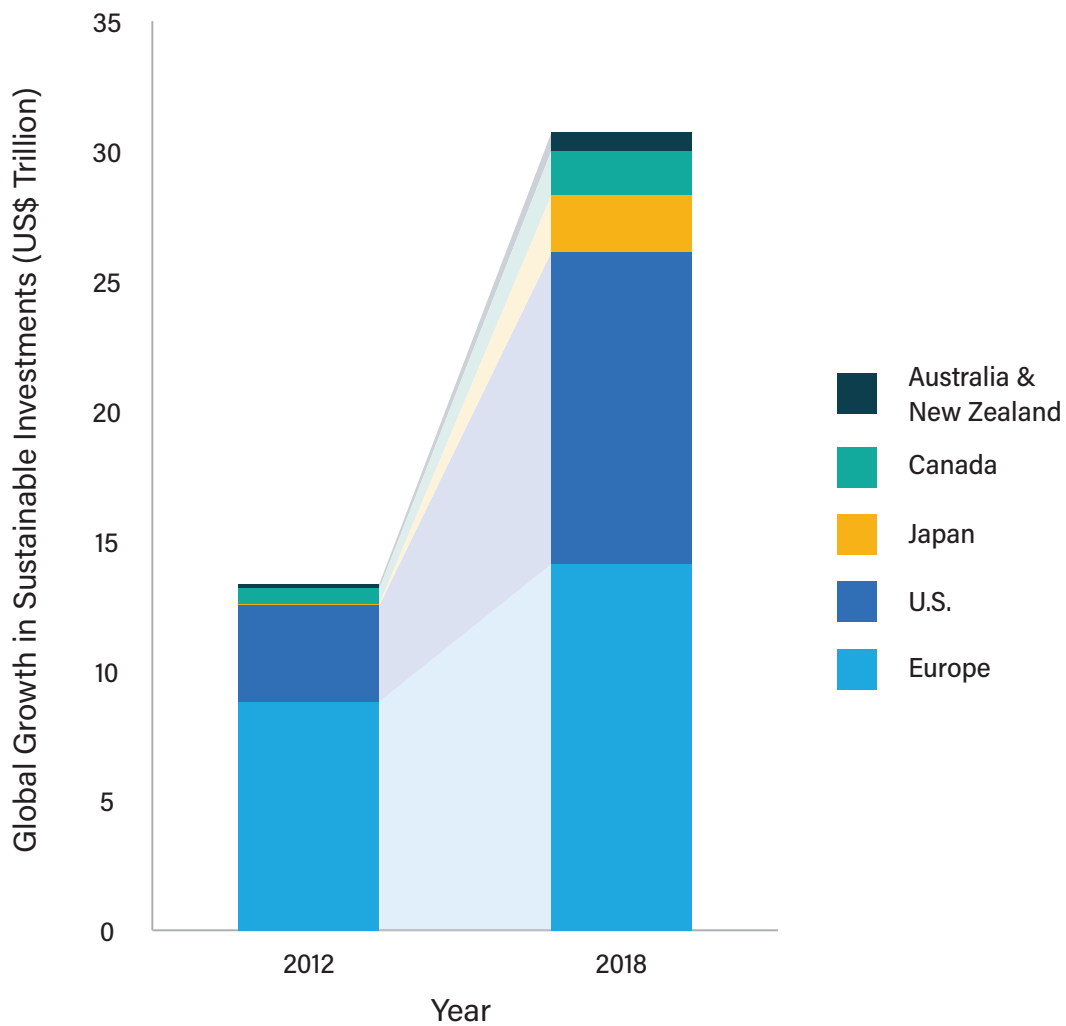
Ultimately, companies worldwide are ignoring some emissions in their net-zero goals, potentially counting the emissions reductions of others as their own, and misrepresenting their decarbonization efforts via unverifiable and over-credited carbon offsets. This focus on carbon offsets enables companies to make misleading claims about their decarbonization progress, but worse still it perpetuates the idea that carbon offsets are a simple, viable option for global decarbonization. The truth is that carbon offsets are often unregulated and undefined, and their use distracts from actual decarbonization efforts that are based on more sustainable practices for industrial processes.

"Companies worldwide are ignoring some emissions in their net-zero goals, potentially counting the emissions reductions of others as their own, and misrepresenting their decarbonization efforts via unverifiable and over-credited carbon offsets."

SUSTAINABLE INVESTORS ARE FORCED TO WORK WITH INACCURATE DATA

Despite numerous challenges associated with verifying and interpreting unstandardized GHG disclosures and net-zero commitments, investors have already committed heavily to sustainable and "low-carbon" assets, which are on track to exceed US\$53 trillion by 2025; representing more than one-third of the projected total assets under management (Figure 6) [2] [5] [8] [19]–[39] [49] [52] [67] [68]. To guide these investments, there has been a "climate-intelligence arms race" between climate service providers who analyze sustainability reports, supply chains, production capacities, demand models, and other market mechanisms affected by climate change [69] [70]. Unfortunately, sustainable investment efforts are likely underperforming due to the unreliability of carbon data [69] [70].

Figure 6. Global growth in sustainable investments (US\$ trillion) [71]



Source: Global Sustainable Investment Alliance, Mar 2019

*COMET and its partners cannot affirm the sustainable investment labels discussed in this document.

Researchers have warned that integration of climate risk into business and financial decision-making has “leap-frogged the current capabilities of climate science and climate models by at least a decade” and that sustainable investing does not have the data it needs to function efficiently [5] [70] [72]. Furthermore, opaque analysis and usage of climate data has turned some financial markets into “black boxes” which are a “cause of concern, both for the integrity of science and for the potential impacts on consumer behavior and public policy” [69].

These concerns become more pronounced with examination of the quality of information used to help build financial climate models. Aside from

accuracy concerns, more than half of the companies surveyed by Ernst & Young reported that their ESG data is housed in simple spreadsheets, and only 8% of respondents reported a set of procedures to drive application of ESG data across their organization [73] [74]. Furthermore, there appears to be “little evidence” of “the involvement of climate science in the development of recommendations made by the TCFD, the EU high-level expert group on sustainable finance, or the Climate-Related Market Risk Subcommittee of the U.S. Commodity Futures Trading Commission” [70] [72] [75] [76].

Even as climate change is being discussed as an existential threat, investment firms and individuals are finding it difficult to identify which companies and ventures they should support to limit its effects [77] [78]. Even when institutions work to provide simple environmental, social, and governance (ESG) ratings, companies can receive a high score from one rater and a middling or low score from another. The resulting confusion has provided “a perennial opportunity” for **greenwashing** [78] [79]. Given these conditions, why would a company spend capital to decarbonize when it cannot be recognized for the effort or when it is easy for other companies to make the same claims without investing the same capital?

GLOBAL SUSTAINABILITY EFFORTS ARE BEING DIMINISHED

With decades of academic research highlighting accuracy concerns, no transparency in how companies are calculating their emissions, no means of easily verifying environmental claims, and financial institutions potentially misusing data to invest trillions of dollars, the flaws in the current carbon accounting system are clearly undermining many of its original objectives. Actual efforts to decarbonize and create net-zero pathways are diminished by companies that inadvertently misreport their emissions or publicly commit to net-zero goals with no strategies to meet them. Carbon offsets and carbon-capture technologies perpetuate the belief in technological salvation and the fact that companies can buy their way out of climate change—when in actuality the dependence on offsets is making climate solutions less viable by taking away investment opportunities from long-term industrial decarbonization projects [80]. Finally, with no clear way for financial institutions or consumers to invest sustainably, companies lack clear financial incentives to decarbonize.

These disconnects between companies, researchers, financial institutions, and consumers constitutes a rapidly growing risk to global markets. The world is rapidly advancing toward more complex and time-sensitive uses of climate data, such as digital carbon accounting, carbon border taxes, blockchain,

“Integration of climate science into business risks and financial decision-making has leap-frogged the current capabilities of climate science and climate models by at least a decade.”

“There must be accurate, comparable, and auditable climate data to maximize the potential of net-zero commitments, carbon offsets, sustainable investing, and other climate solutions derived from GHG data.”

and low-carbon certifications, and it is clear that they cannot succeed with the current state of environmental data. Even national regulation and data requirements through the U.S. Securities and Exchange Commission and the European Commission are developing emissions disclosure requirements and carbon taxes based on broadly accepted disclosure tools despite their current unreliability [1] [81].

There must be accurate, comparable, and auditable climate data to maximize the potential of net-zero commitments, carbon offsets, sustainable investing, and other climate solutions derived from GHG data [5] [69] [70] [80] [82] [83]. However, standardizing GHG data is not an easy task and will require collaborating with industry leaders to define environmental claims, working with investors to understand differentiating criteria, and helping companies to find the data required for more accurate carbon accounting. Without a consistent means of measuring and discussing GHG emissions, progress in decarbonization efforts cannot be assessed. Thus, a common carbon language is urgently needed to advance sustainability conversations.

2. Addressing Current Carbon Accounting Challenges

Ultimately, the lack of comparability and accuracy in GHG disclosures is the result of unstandardized data published by companies and no simple means of verifying claims regarding their environmental performance. As most companies are unique, stakeholders have had to rely on companies to provide their own data. This is analogous to asking students to create their own report cards without explaining the grading criteria in any detail, but instead telling them that good grades will be rewarded, and bad grades are subject to expulsion and fines. To this end, not every company is guilty of greenwashing, and many companies are actively trying to do better, but a complex, misunderstood, self-policed system with clear financial incentives to report the lowest GHG emissions possible should not be the sole, trusted source for accurate carbon data.

By asking companies to do their own research and by not providing the necessary support, the current carbon accounting ecosystem forces companies to publish data that may not be as accurate as possible. For example, the **GHG Protocol**, the world's most widely used carbon accounting tool, serves as the basis for many other tools and net-zero commitments and asks companies to make numerous independent decisions that directly impact how their emissions are calculated [51] [84]. Every company using the GHG Protocol must make choices for setting **organizational boundaries** (Chapter 3 of the GHG Protocol Corporate Standard), determining which emissions they are responsible for (scopes 1, 2, and 3) (Chapter 4), and determining how to identify and calculate GHG emissions (Chapter 6) [84]. These choices drastically affect the emissions that a company reports and how they are calculated, and it is these choices that also lead to incomparable sustainability reports and carbon disclosures.

It is not possible to compare GHG emissions reports if companies are all choosing to report on different topics and have different ideas of what GHG emissions they are responsible for. Furthermore, even if similar companies agree on organizational boundaries and scopes, many are limited by their ability to access granular operating data and **emissions factors** [44] [45]. So not only

“It is not possible to compare GHG emissions reports if companies are all choosing to report on different topics and have different ideas of what GHG emissions they are responsible for.”

are companies reporting on different topics, but they are also struggling to find the data they need to report on the topics they chose. Consequently, every choice that a company independently makes concerning emissions estimates, boundaries of responsibility, and data sources can impact the accuracy and comparability of its reported GHG emissions (Figure 7).

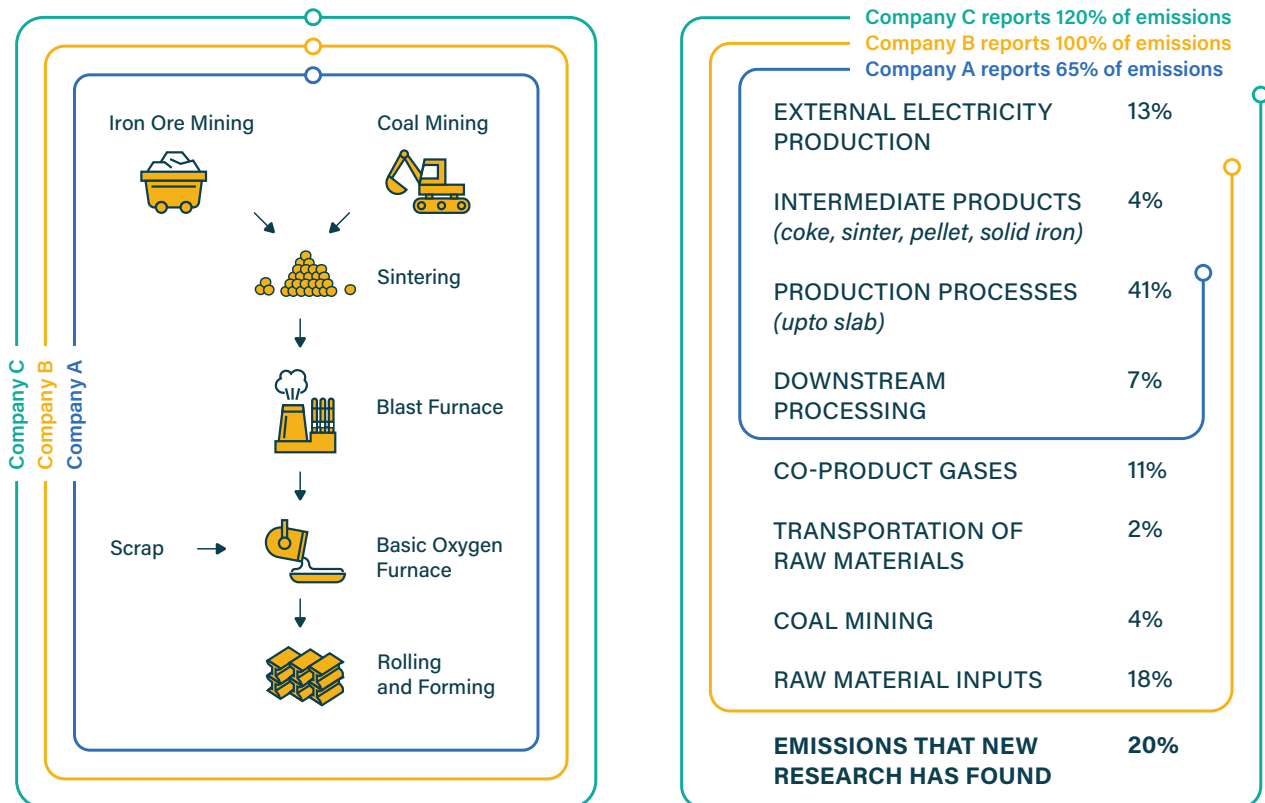
Unfortunately, what makes GHG data even more difficult to understand, aside from asking companies to report everything themselves, is that companies often simply report their total emissions without explaining their calculations, whether they used averaged values, whether they excluded any emissions categories, or whether they actually measured anything themselves. There is currently no easy way to understand why companies report their emissions in a specific way or what math (if any) is involved in their calculations. With such a lack of transparency and standardization, it is often not possible to determine if similar companies are making the same choices or reporting emissions in the same way (Figure 7). A company may calculate its emissions very differently from its competitors, and there is no simple way to know for sure.

“The GHG Protocol is likely responsible for enabling widespread adoption of corporate GHG disclosures. As early as 2016, 90% of Fortune 500 companies were using the GHG Protocol (directly or indirectly) to measure their carbon emissions [16]. Most, if not all, of the world’s largest companies began with the GHG Protocol when they started reporting GHG emissions. Similarly, the TCFD was revolutionary and has enabled the financial industry to accelerate decarbonization efforts. Sustainable investing and the concept of climate-related financial risk have turned decarbonization from an act of goodwill into a corporate necessity. The world owes the GHG Protocol and the TCFD a debt of gratitude for beginning the GHG accounting conversations that have helped to limit catastrophic climate change. However, an updated carbon accounting system is urgently needed.”

Figure 7. Although companies A, B, and C may have the same operations, they may not report the same information

Many companies have similar operations and produce materials in the same way. However...

companies can choose to exclude data and values by changing their **reporting boundary**.



Company A: Wants to report low emissions to get more investments and partnerships. They choose to ignore some of their emissions and publicly report that their steel only releases **1.2 kg CO₂/kg steel**. The global average is 1.9 kg CO₂ / kg steel, so many banks and companies want to work with them and their "green steel". There is no easy way for anyone to know what emissions they are not reporting.

Company B: Is a global leader and asks for GHG information from all the companies they work with. They are always looking for more sustainable options and work closely with their suppliers. They report that they emit **1.6 kg CO₂/ kg of steel**. No one (including academic researchers) can figure out why Company B is 25% worse for the planet than Company A.

Company C: Is like Company B, but they have also spent \$700,000 on new GHG monitoring tools and life cycle assessments. They invest heavily in research so that they can make informed decisions about decarbonization and fossil fuels. They find out that they actually emit **1.9 kg CO₂/ kg of steel**, and it is likely that Company A and B do as well. They report **1.6 kg CO₂/ kg of steel**.

“Asking companies to conduct complex, internal environmental audits without much guidance has proven to be ineffective.”

As it stands, companies can drastically alter their reported emissions when they decide to do any of the following:

- Use industry averages instead of direct measurements
- Choose not to report on certain emissions categories
- Disagree with competitors on the boundaries they are responsible for reporting on
- Disagree on how base year emissions are calculated
- Use old data or studies that are not representative of current operations
- Not report on emissions unique to their industry because they were not explicitly asked to do so
- Allocate emissions differently from industry competitors (mass, volume, cost), or assign emissions to subsidiaries
- Use less than reputable data sources
- Measure electricity usage at different intervals [85]
- Use conflicting data sources or double-count emissions
- Use different monitoring technologies with different levels of granularity (satellite data vs. sensors)
- Use a different carbon disclosure tool than their competitors

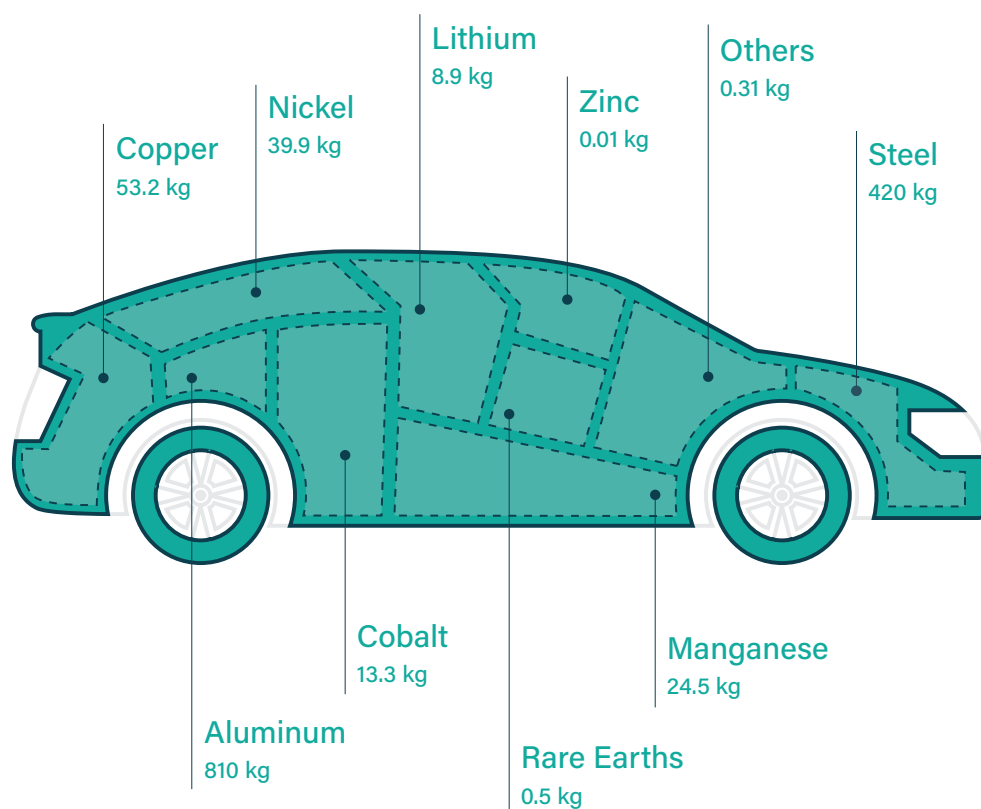
Given the many ways that companies can inadvertently corrupt their GHG data, the lack of harmonization and guidance on GHG accounting and reporting places an unreasonable burden on companies to evaluate the environmental impact of their operations, produce data, evaluate the data against global benchmarks, prepare detailed and complex reports, and contextualize the findings in a form useful for investors and other stakeholders [86]. Asking companies to conduct complex, internal environmental audits without much guidance has proven to be ineffective in producing reliable data and is no longer compatible with meeting contemporary climate goals. To this end, although existing carbon accounting tools may have popularized GHG disclosures, a modified, collaborative approach to carbon accounting that enables greater accuracy and comparability and works to harmonize the hundreds of carbon accounting tools is now required.

HOW DO WE BEGIN TO STANDARDIZE GHG DATA?

To standardize GHG data, companies must fully understand what GHG emissions they are responsible for and how those emissions are calculated, measured, and reported. Unfortunately, for most companies, it would be time-consuming to impose specific reporting requirements, especially for those who

make unique, consumer-facing products,⁶ such as automotive manufacturers, electronics companies, construction firms, and others operating in **downstream industries**. However, as most companies do not produce many of the materials they use (copper wire, steel beams, cement), and often modify and assemble different commodities and intermediate goods as part of a **value chain**, it is possible to begin standardizing GHG data by standardizing the emissions associated with commodities and intermediate goods (Figure 8).

Figure 8. Materials required to build an electric vehicle



More accurate GHG data can be enabled by first standardizing the emissions reported by upstream companies that produce and sell steel, oil, natural gas, copper, plastics, cement, etc. These companies and their respective industries account for a large portion of global GHG emissions and do not have accurate,

⁶ Environmental product declarations (EPDs) and comparative life-cycle assessments (LCAs) have greatly helped GHG research, and will likely advance GHG discussions; however, these approaches are far from comprehensive.

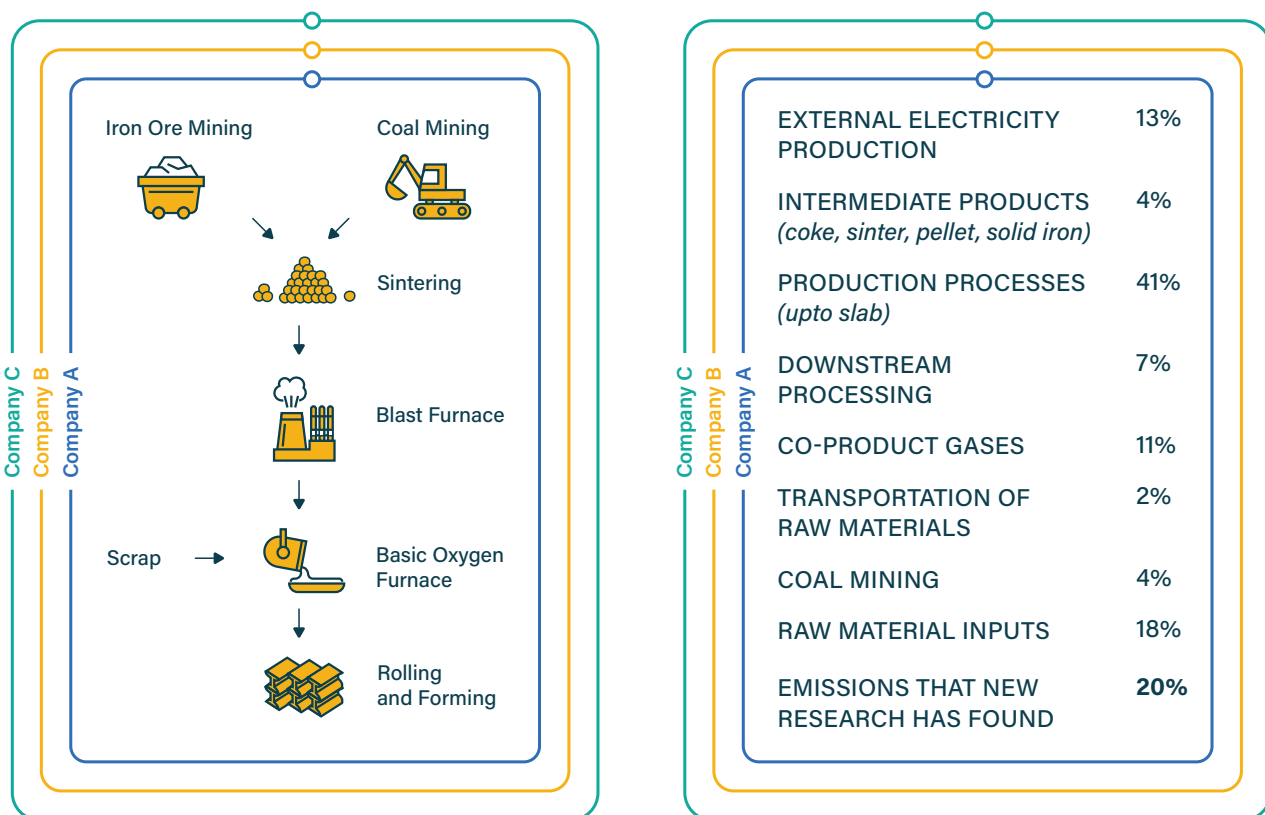
comparable, and standardized GHG disclosures. In fact, numerous reports and academic studies have found that upstream mining, oil, gas, and commodity companies are particularly inaccurate in reporting their environmental impacts [5]–[8] [21]–[23] [25] [39] [82] [87]–[91].

Standardizing reporting requirements for commodities and intermediate goods would simultaneously address consistency issues for much of the world’s industrial GHG emissions (steel, oil, natural gas, and cement emissions) and make it easier for downstream companies to obtain more accurate GHG data. Creating GHG reporting requirements for commodities is also relatively straightforward, as most upstream companies produce a standardized product with standardized compositions (e.g., AISI Type 304 SS steel). Thus, it is possible to create standardized data requirements (reporting emissions from AISI Type 304 SS steel requires X data points for steelmaking, produced by Y measurements) (Figure 9).

Figure 9. It is possible to standardize data requirements for commodities

Companies producing the same product...

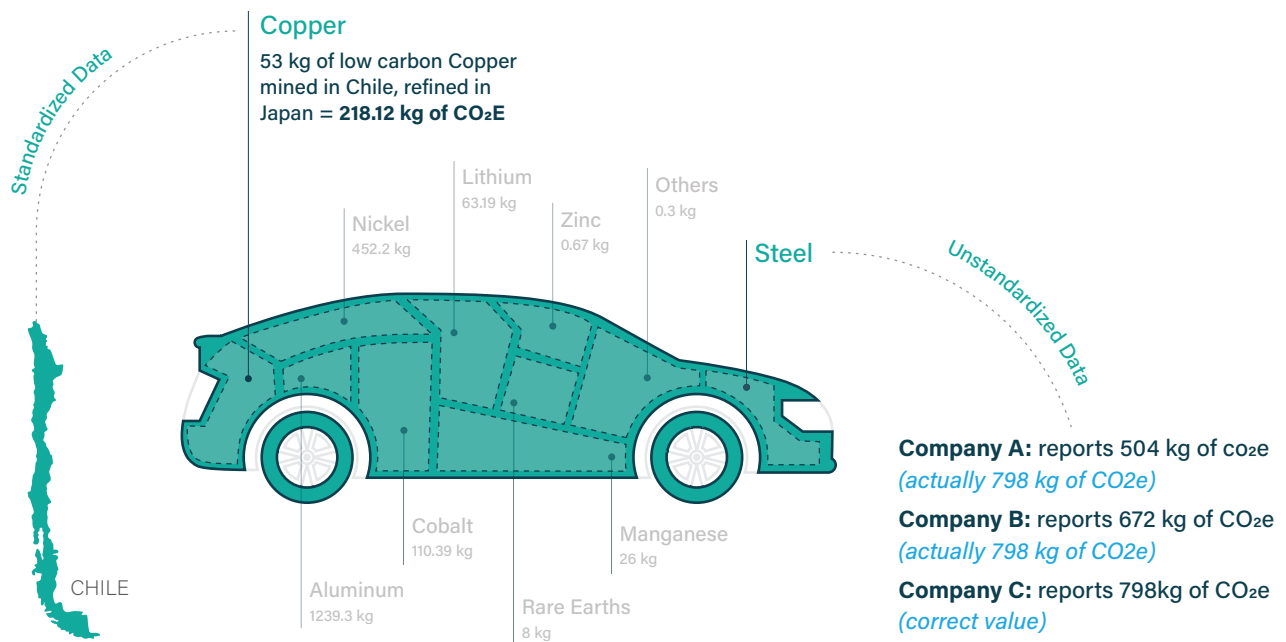
need to report the same information and with the same level of detail



Once accurate, verifiable emissions data for commodities and intermediate goods are available, it will be considerably easier for downstream companies to compare suppliers and understand the emissions embodied in their products. For example, instead of having automotive manufacturers conduct research on nickel and copper, they can confidently rely on standardized data to understand exactly where their materials come from, what their environmental impacts are, and how those impacts compare to other companies and supply chains (Figure 10). This can eventually be expanded to include information on social, governance, and other environmental issues.

This type of simplified supply-chain carbon accounting is possible if all upstream companies are measuring and reporting in the same way. Furthermore, communication between upstream and downstream companies can create opportunities to collaborate on decarbonization efforts and net-zero pathways across supply chains (insetting, carbon offsets, and sustainable investing with better data and partnerships).

Figure 10. Companies must understand the materials they are using to fully understand the environmental impacts of their products



A framework is needed that can help standardize environmental disclosures for commodities and intermediate goods and work with downstream companies (automotive, electronics, etc.) to ensure that their needs are being met. The framework must be aligned with existing carbon disclosure tools to leverage the work that companies are already doing to report their impacts. The framework must also be able to serve as a technical foundation for accurate carbon accounting and as a means of harmonizing existing carbon accounting efforts to enable comparability.

3. The COMET Framework

COMET is developing a harmonized set of principles, standards, and reporting requirements that will work with existing carbon accounting tools to create accurate and auditable GHG data for commodities and intermediate goods.

This framework will be built upon:

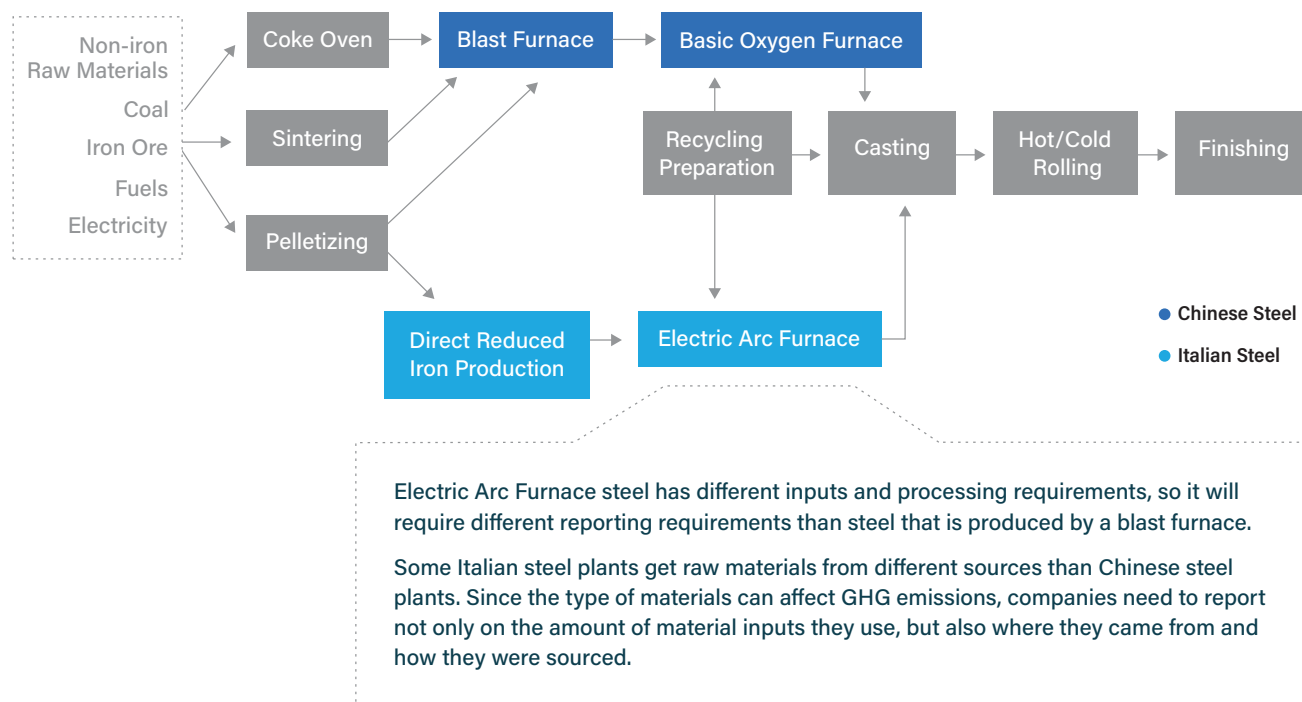
- A. Commodity-Specific Reporting Requirements
- B. Standardized Data Requirements
- C. Fixed Reporting Boundaries and Corporate Data
- D. Harmonized Carbon Disclosure Tools

A. COMMODITY-SPECIFIC REPORTING REQUIREMENTS

The COMET Framework will identify what data are needed to accurately account for emissions from different commodities.

Creating commodity-specific reporting requirements requires an in-depth, technical understanding of commodities, production processes, and associated emissions. This research can be supported by life-cycle assessments, academic studies, emissions modeling tools, sustainability reports, and net-zero pathways, all of which can help identify specific data required to account for different supply chains (e.g., Italian steel) and different production processes (electric arc furnace steel vs. blast furnace steel). Ultimately, this research will help identify what companies must disclose to accurately account for emissions embodied in their products (e.g., 1 ton of AISI Type 304 SS steel, produced in an electric arc furnace by an Italian steel company) (Figure 11).

Figure 11. Researching industrial processes can clarify what data are required to accurately account for emissions sources

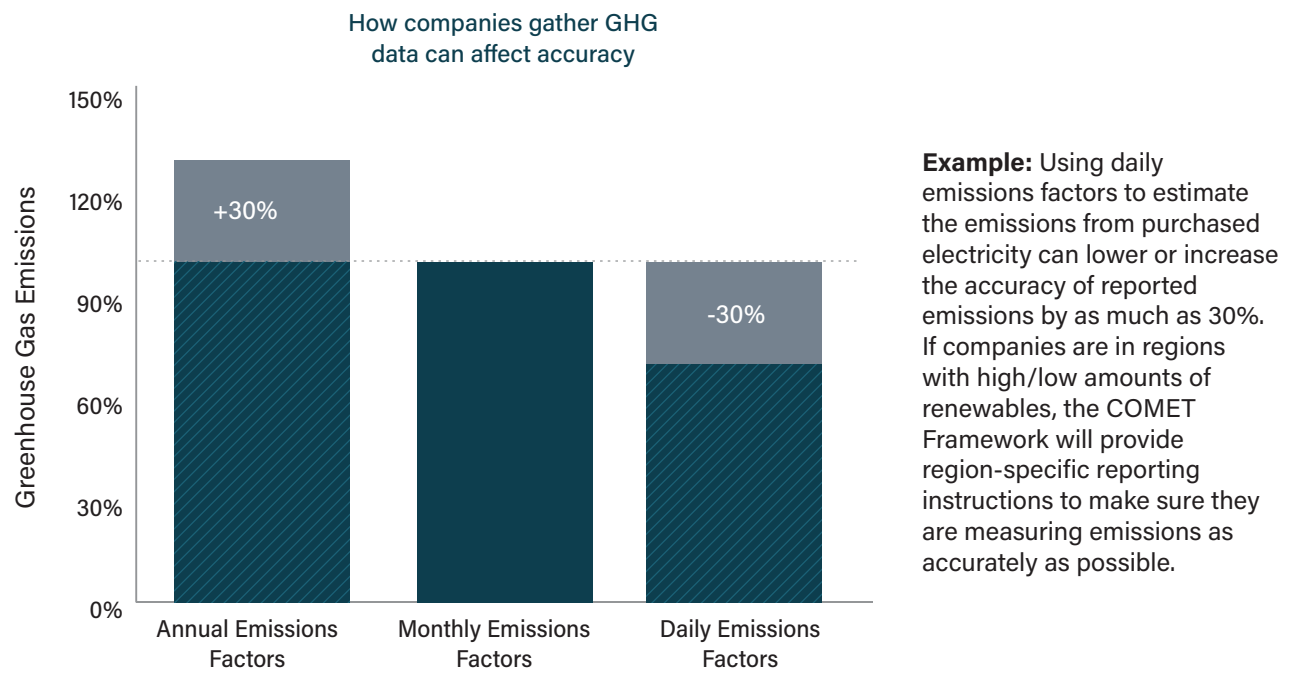
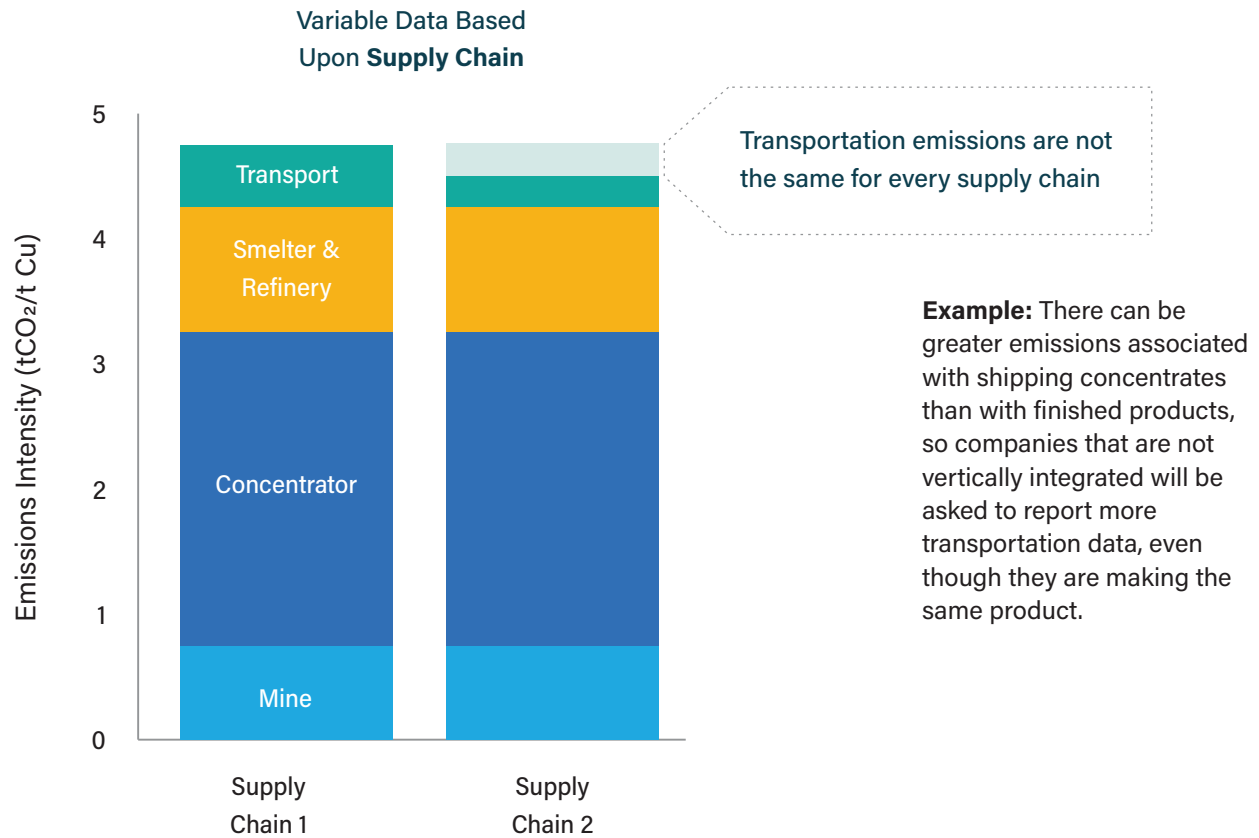


B. STANDARDIZED DATA REQUIREMENTS

Once the COMET Framework has identified the data required to account for commodity emissions, it will identify how the data should be gathered and reported.

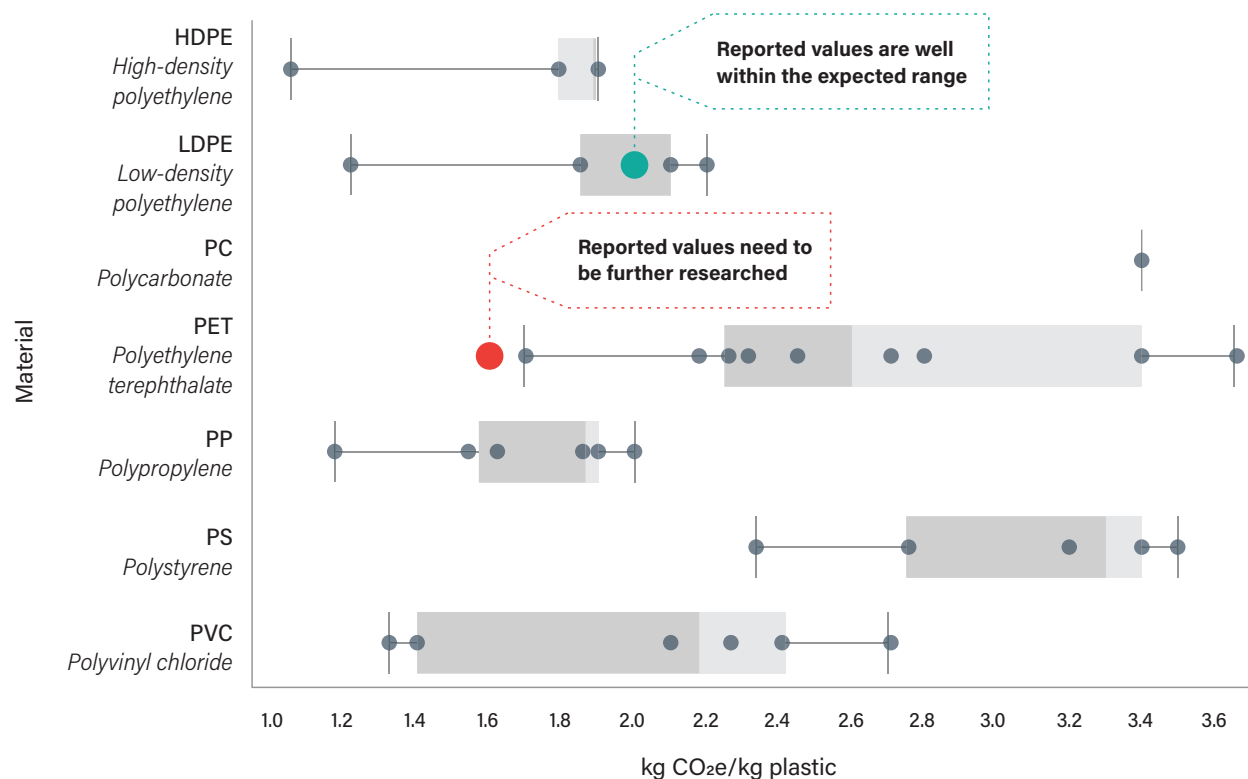
COMET will perform sensitivity analyses on the data requirements identified in **A (Commodity-Specific Reporting Requirements)** to understand the variability of different emissions measurements, industrial processes, and global supply chains. For regions with different production processes, global supply chains, and environmental concerns, COMET will create specific data requirements based upon those differences (Figure 12). If different supply chains produce the same product in the same way but with different emissions intensities, COMET will create specific reporting instructions for those supply chains. For example, if one company reports high emissions for a specific process and another reports low emissions for the same process, COMET will research and incorporate the source of the discrepancy (Figure 12). It will ask companies to disclose how they measured important values, ensure they are using primary data whenever possible, and work to better understand how to accurately address their emissions concerns.

Figure 12. Different supply chains and production routes will have different data requirements to properly account for their emissions



With the research on emissions data and emissions variability, COMET will create open-access benchmarks so that all stakeholders can check that reported data are within acceptable ranges and that emissions are properly accounted for.

Figure 13. Publishing Emissions Data Will Allow Stakeholders to Better Understand Reported Data



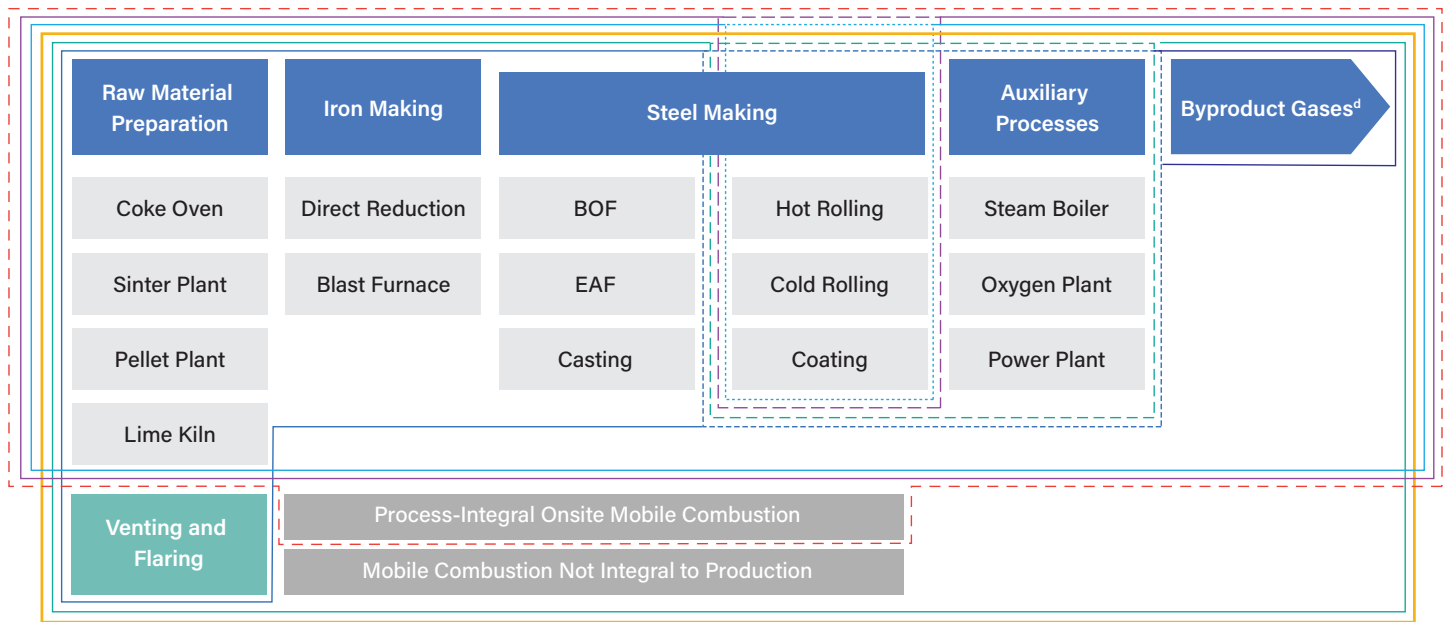
C. WORKING WITH FIXED REPORTING BOUNDARIES AND CORPORATE DATA

The COMET Framework will help companies understand which emissions they are responsible for and how those emissions can be allocated to their products.

Many companies are not responsible for producing commodities entirely by themselves (e.g., many steel companies do not mine iron ore); likewise, many do not exclusively produce one product (e.g., petroleum refineries produce gasoline, diesel, and other petrochemicals). COMET will help companies understand how they can transform their corporate-level data (Scope 1, 2, and 3) into **product-level data** (e.g., kg CO₂e/kg AISI 304 steel) so that their

emissions are properly accounted for and allocated to all of the products they produce. This will require that stakeholders agree on a **fixed reporting boundary** for different commodities so that there is no disagreement (Figure 14) on what emissions data must be reported for one ton of AISI Type 304 SS steel or other commodity.

Figure 14. Emission scope nuances defined by different steel accounting methodologies^{ab}



- Mandatory Inclusion
- - - - Inclusion for processes located on-site
- Environment Canada
- World Steel
- ISO 14404 Series
- IPCC Guidelines^c
- GHG Protocol
- EU ETS

- a. Diagram adapted from World Steel and ISO 14404.
- b. As Responsible Steel recognizes the use of multiple methodologies including GHG Protocol, EN 19694, and ISO 14404, it is not included in this diagram.
- c. Because IPCC is intended for national GHG inventories, many sources are listed outside the iron and steel supply chain. Volume 2, Chapter 1 covers emissions from mobile machinery in manufacturing, while Volume 2, Chapter 3 covers “combustion emissions from all remaining transport activities...not otherwise reported under...Manufacturing Industries and Construction.”
- d. Each methodology provides a unique treatment of byproduct gases, which can be reused onsite or offsite. See Byproduct Gas Emissions for more information.

Research on allocation of corporate emissions and fixed reporting boundaries will help external stakeholders understand what emissions are embodied in the materials they are purchasing and which companies are responsible for those emissions.

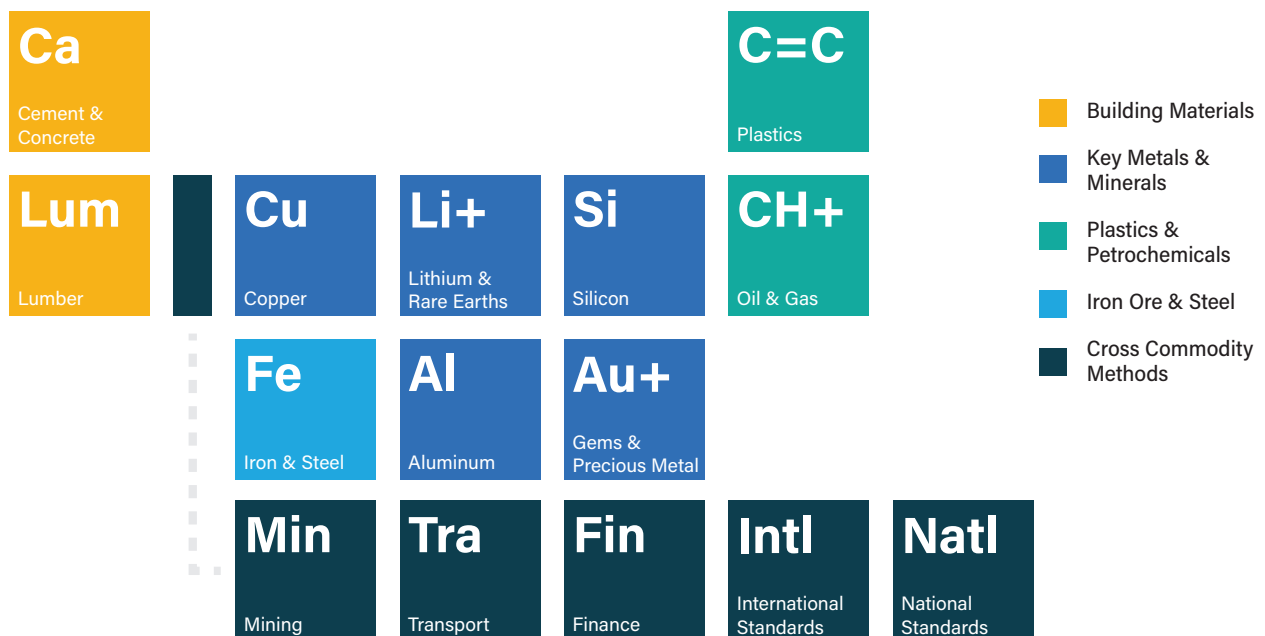
D. HARMONIZING AND SUPPORTING EXISTING CARBON DISCLOSURE TOOLS

COMET will support, simplify, and harmonize the existing carbon reporting landscape.

Hundreds of important carbon disclosure tools have been developed to ensure that stakeholders have the data they need to gauge progress in their environmental performance. To this end, the COMET Framework does not seek to replace existing carbon accounting tools, but rather to support and improve how companies use their data with these tools.

COMET will dedicate much of its efforts to ensuring that its research aligns with and easily integrates into the current carbon accounting landscape by helping companies provide more accurate data to carbon disclosure tools. Companies who report to the CDP, TCFD, and GRI should view the COMET Framework as a resource to help them satisfy reporting requirements and ensure they are maximizing the benefits of their decarbonization efforts.

Figure 15. COMET will harmonize the carbon reporting landscape to generate simpler and comparable reporting requirements



4. Conclusion and Next Steps

Global efforts to manage GHG emissions face a persistent obstacle: the absence of a standardized way of measuring and comparing GHG emissions along a value chain and with enough precision to deliver actionable insights. With these deficiencies, net-zero pathways, carbon reduction efforts, sustainable investments, carbon markets, carbon taxes, and sustainability reports are materially diminished. With little time left to limit the irreversible, catastrophic effects of climate change (Figure 16), understanding and utilizing accurate GHG data is essential. Current carbon accounting efforts are therefore undermining our ability to address climate change and its dire health and social impacts.

Creating a harmonized reporting landscape with easily verifiable data will support and reinvigorate many of the

world's sustainability efforts. It will be easier for companies to create net-zero pathways if they understand their emissions better. Furthermore, companies can help their suppliers and purchasers decarbonize if they trust the emissions data they share. Refined digital carbon accounting and blockchain technologies could enable a level of traceability and responsibility never seen before, but only if we can be confident in the data that is recorded in distributed ledgers. For sustainable, low-carbon investing, economic models can be updated with accurate, in-depth corporate emissions data to assess how specific components of a business are affected by climate change. The COMET Framework can advance the creation of differentiated markets, research into new decarbonization technologies, and fundamental comparability between company data (Figure 16).

Figure 16. There is little time to drastically reduce annual GHG emissions [92]

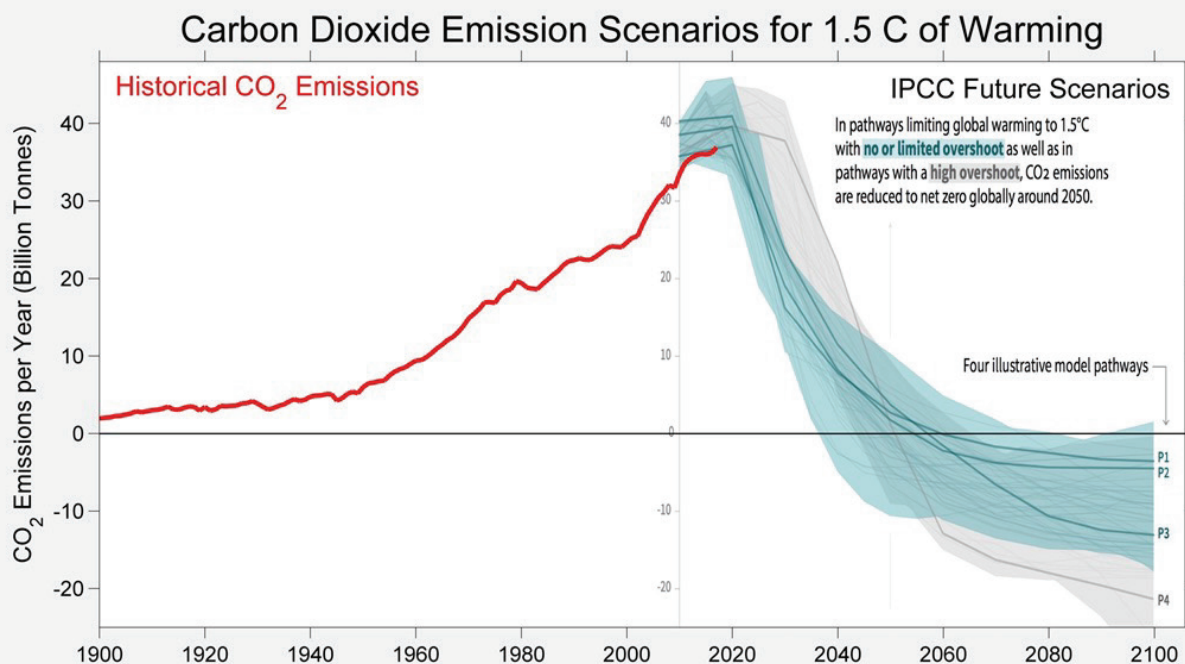
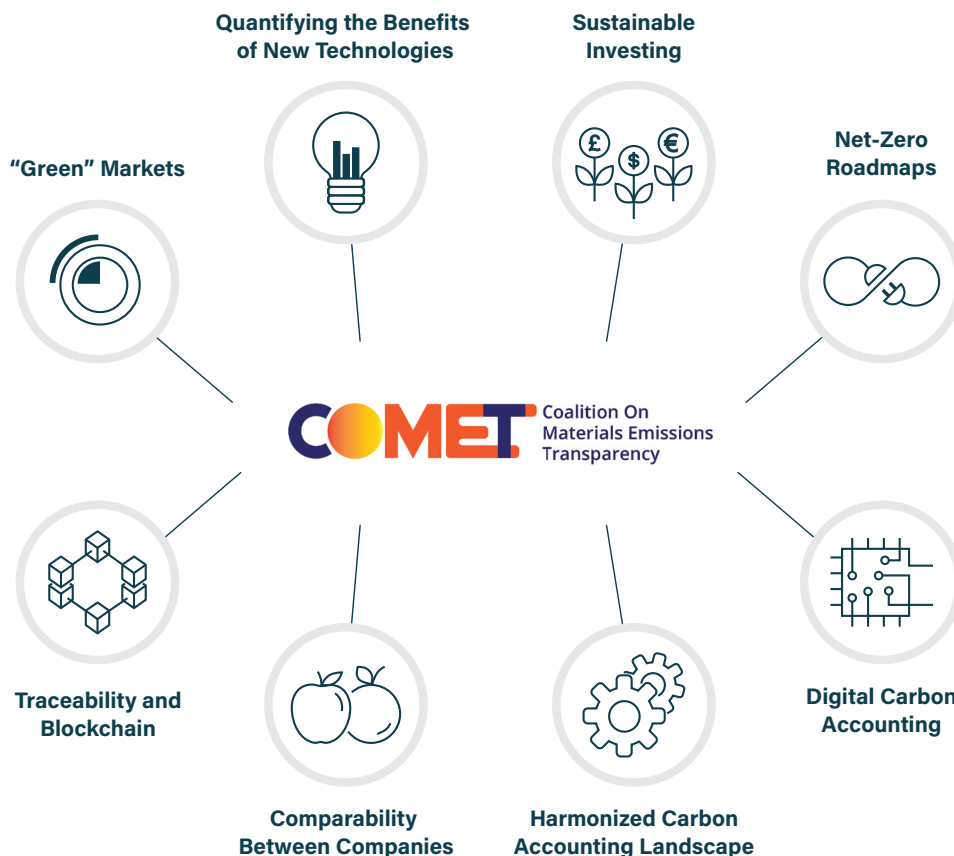


Figure 17. Standardizing GHG accounting and disclosures can enable new technologies and market tools for decarbonization



It is a well-known axiom that it is not possible to manage that which cannot be measured. COMET strives to enable the next frontier of carbon accounting at a time when many of the world’s largest emitters are searching for better ways to make emissions reporting actionable. Global climate change poses numerous, escalating harms already being felt worldwide [93] [94]. Improving and standardizing how emissions are accounted for are paramount to accurately calculating climate change-related risks and opportunities. Removing uncertainty in carbon accounting helps nations work more strategically toward limiting the global temperature rise to less than 1.5 °C. Furthermore, global health and climate action policies can be better defined and informed if we can agree on how to quantify the problem.

The next step in this process is to create partnerships with key stakeholders in industry, policy, research, and finance. If you would like to be involved in COMET or are conducting similar research, please let us know. COMET is an open-access academic research initiative whose sole focus is the harmonization of the carbon accounting landscape. This is a time-sensitive objective that can be achieved through cooperation with research institutions, non-profit organizations, companies along supply chains, financial institutions, and anyone working to anyone working to address the global climate emergency.

– **The Coalition on Materials Emissions Transparency**

Jordy Lee | jorlee@mines.edu

Perrine Toledano | ptoled@law.columbia.edu

Glossary

BASE YEAR EMISSIONS: Emissions accounting and decarbonization efforts for many companies are based on emissions calculated for a single year. If a company announces that it has reduced its emissions by 30%, this reduction is often calculated with respect to a base year. Base years act as a reference point to compare emissions and are often recalculated without direct oversight or explanation of how operations have changed or what it means for a company's past or future carbon disclosures.

CARBON: In this paper, carbon is used as a shorthand to refer to the six primary greenhouse gases considered by the Kyoto Protocol: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).

CARBON ACCOUNTING: Carbon accounting is used here to refer to any process by which organizations quantify and report their GHGs. Carbon is typically accounted for via three scopes: 1) a company's direct emissions from its own operations, 2) emissions associated with electricity used for heat and power, and 3) indirect emissions from the company's upstream and downstream supply chain.

CARBON DISCLOSURE: A publicly available report, document, or other form of media that a company uses to disclose GHG emissions that they have found to be associated with their operations or practices.

CARBON DISCLOSURE TOOL: A framework, standard, platform, or guidance document created to help

companies report their GHG emissions. This includes helping companies identify their emissions and report specific information that shareholders have identified as important, thus acting as a platform for companies to publish results or provide guidance on how to calculate GHG data.

CARBON OFFSETS: A reduction in GHG emissions, usually represented by a certificate, that is used by companies to "offset" their GHG emissions. Carbon offsets can be traded as part of commercial programs.

COMMODITY-SPECIFIC CHALLENGE: An environmental, social, or governance issue that is important and relevant to certain raw materials that may not be well-understood or considered relevant by stakeholders outside the industry.

DOWNSTREAM INDUSTRIES (COMPANIES): Companies that purchase goods and services from those who produce commodities or intermediate goods (i.e., mining companies, oil and gas producers) or sell consumer-facing goods and rely on supply chains.

EMBODIED EMISSIONS: The total emissions to create a product or the sum of historical emissions to create a product.

EMISSIONS FACTOR: A value representing the emissions intensity of a product or activity. The value is usually represented as kg of CO₂e per process, volume, weight, or amount of material. For example, 1.9 kgCO₂e/kg steel means that 1.9 kg of carbon dioxide was released during the creation of 1 kg of steel.

ENVIRONMENTAL, SOCIAL, AND GOVERNANCE (ESG) PRINCIPLES: Environmental refers to how a company contributes biological, chemical, or physical stressors to an ecosystem, most commonly the Earth as a whole. Social refers to a company's interaction or ongoing relationship with employees, local communities, customers, and others directly involved in operations. Governance refers to a company's leadership, transparency, and approach to solving environmental and social issues, among other operational needs.

FIXED REPORTING BOUNDARIES: There are often disagreements about what information is required to account for the emissions of a specific product or commodity. For a fixed boundary, all operations that occur within the boundary must be accounted for to properly estimate emissions.

FRAMEWORK: A common corporate accounting structure used to convey emissions data effectively to external stakeholders. Framework is often used as a synonym for methodology but is more specific to reporting platforms and structured efforts by initiatives and NGOs.

GREENHOUSE GAS PROTOCOL: The GHG Protocol provides a methodology for companies to report their greenhouse gas emissions by walking them through the steps required to identify their emissions, ways to calculate them, and important information to disclose. The GHG Protocol has helped shape many of the ways that companies think about their emissions, including use of Scope 1, 2, and 3 emissions.

GREENWASHING: The use of misleading claims and statistics by corporations to present themselves or their products as more sustainable than they actually are.

INSETTING: Emissions reductions in a company's supply chain or sector of climate impact.

MARKET DIFFERENTIATION: Establishment of a premium or separate market for commodities with prices built to reflect the positive environmental, social, and governance principles used in their extraction, processing, and transportation.

METHODOLOGY: The process through which environmental impacts are quantified and measured before being used in sustainability reports, platforms, or other disclosures

NET-ZERO COMMITMENT: A commitment by a company to balance the GHG it emits with the amount it removes from the atmosphere. Cumulatively, by combining emissions and carbon offsets, it can reach "net-zero" emissions.

ORGANIZATIONAL BOUNDARIES: The operations that a company is responsible for, based on operational structure.

PLATFORM: An external, dedicated organization that exists to report and relay environmental, social, and governance principles as reported and disclosed by companies. Platforms often have their own frameworks that they ask companies to use to report emission values and other metrics.

PRODUCT-LEVEL DATA: Much of the world's published GHG data pertain to emissions produced by companies. Product-level data pertain to emissions caused by the creation of a single product, otherwise known as "embodied emissions" and "Product Carbon Footprint".

REPORTING STANDARD: A commonly applied method of how GHG data should be gathered, evaluated, and reported.

SCOPES 1, 2, AND 3: Scope 1 refers to emissions caused by a company's direct activities. Scope 2 refers to emissions caused by the electricity, steam, heating, and cooling that a company uses or purchases. Scope 3 refers to emissions caused by a company's indirect activities. See the Greenhouse Gas Protocol Corporate Guidance Document for more information.

SOCIAL LICENSE TO OPERATE: The ongoing approval by local stakeholders required for a project to be accepted and legitimized.

STANDARDS: A set of rules and practices that a company agrees to abide by in its operations.

STAKEHOLDER: An independent party involved or invested in the performance of a project/company due to financial, social, or external obligations.

SUPPLY CHAIN: The processes and inputs required to create a product or service. For something such as an automobile, this includes everything from the mining of the raw materials to the finished car sold to a customer.

SUSTAINABILITY REPORTS: Reports that companies create to help publicize and discuss their sustainability with stakeholders. They are often self-published on a company's website and are created by the company's communications or public relations teams, and include discussions about their climate goals, current impacts, and any information that a company feels compelled to disclose.

UNSTANDARDIZED DATA: Data that have not been verified or that do not accurately represent the process or materials that they are meant to quantify or describe.

VALUE CHAIN: The range of activities and processes involved in bringing a product from conception to end use.

References

- [1] "SEC.gov," Mar. 21, 2022. <https://www.sec.gov/news/press-release/2022-46> (accessed Mar. 24, 2022).
- [2] K. Impact, "Towards Net Zero: How the world's largest companies report on climate risk and net zero transition," KPMG Impact, Nov. 2020. [Online]. Available: <https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/11/towards-net-zero.pdf>
- [3] "The Time has Come: The KPMG Survey of Sustainability Reporting 2020," KPMG Impact, Dec. 2020. [Online]. Available: <https://assets.kpmg/content/dam/kpmg/uk/pdf/2020/12/the-time-has-come-kpmg-survey-of-sustainability-reporting-2020.pdf>
- [4] "80% of world economy now aiming for net zero - but not all pledges are equal." <https://www.ox.ac.uk/news/2021-11-01-80-world-economy-now-aiming-net-zero-not-all-pledges-are-equal> (accessed Mar. 20, 2022).
- [5] J. Lee, M. Bazilian, B. Sovacool, and S. Greene, "Responsible or reckless? A critical review of the environmental and climate assessments of mineral supply chains," *Environ. Res. Lett.*, vol. 15, no. 10, p. 103009, Oct. 2020.
- [6] R. A. Alvarez et al, "Assessment of methane emissions from the U.S. oil and gas supply chain," *Science*, vol. 361, no. 6398, pp. 186–188, Jul. 2018.
- [7] J. Lee, C. Sorensen, J. Lemery, C. F. Workman, H. Linstadt, and M. D. Bazilian, "Managing upstream oil and gas emissions: A public health oriented approach," *J. Environ. Manage.*, vol. 310, p. 114766, May 2022.
- [8] S. E. Greene, "What are we missing? Scope 3 greenhouse gas emissions accounting in the metals and minerals industry," *Materiaux et Techniques*, vol. 105, May 2018, doi: 10.1051/mattech/2018014.
- [9] U. S. Epa and OAR, "Greenhouse Gas Reporting Program (GHGRP)," Jun. 2014, Accessed: Jun. 19, 2020. [Online]. Available: <https://www.epa.gov/ghgreporting>
- [10] "Home ;," GCCA, Nov. 06, 2018. <https://gccassociation.org/> (accessed Mar. 27, 2022).
- [11] "ASI Home," Aluminium Stewardship Initiative, Apr. 25, 2015. <https://aluminium-stewardship.org/> (accessed Mar. 27, 2022).
- [12] "Home," ecoinvent. <https://ecoinvent.org/> (accessed Jan. 23, 2022).
- [13] "About our statistics." <https://www.worldsteel.org/steel-by-topic/statistics/about-our-statistics.html> (accessed Jun. 14, 2021).
- [14] "Core Documents - The Copper Mark", Accessed: Mar. 25, 2022. [Online]. Available: <https://coppermark.org/assurance-process/core-documents/>
- [15] "Task Force on Climate-related Financial Disclosures | TCFD - Homepage," TCFD. <https://www.fsb-tcfd.org/> (accessed Aug. 25, 2019).

- [16] "About Us." <https://ghgprotocol.org/about-us> (accessed Nov. 21, 2020).
- [17] SBTi, "SBTi Criteria and Recommendations," vol. Version 5.0, Oct. 2021, [Online]. Available: <https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf>
- [18] "About GRI." <https://www.globalreporting.org/information/about-gri/Pages/default.aspx> (accessed Jan. 19, 2020).
- [19] J. M. Moneva, P. Archel, and C. Correa, "GRI and the camouflaging of corporate unsustainability," *Accounting Forum*, vol. 30, no. 2, pp. 121–137, Jun. 2006.
- [20] O. Boiral, "Boiral,O.(2013) "Sustainability reports as simulacra? A counter-account of A and A+ GRI reports", *Accounting, Auditing & Accountability Journal*, 26(7): 1036-1071," *Accounting Auditing & Accountability Journal*, vol. 26, no. 7, pp. 1036–1071, Sep. 2013.
- [21] J.-F. Henri and O. Boiral, "Is Sustainability Performance Comparable? A Study of GRI Reports of Mining Organizations," *Bus. Soc. Rev.*, vol. 56, no. 2, pp. 283–317, 2015.
- [22] C. Kincaid and N. M. Smith, "Diversity and inclusion in mining: An analysis of indicators used in sustainability reporting," *The Extractive Industries and Society*, vol. 8, no. 4, p. 100981, Dec. 2021.
- [23] A. Fonseca, M. L. McAllister, and P. Fitzpatrick, "Sustainability reporting among mining corporations: a constructive critique of the GRI approach," *J. Clean. Prod.*, vol. 84, pp. 70–83, Dec. 2014.
- [24] L. Klaaßen and C. Stoll, "Harmonizing corporate carbon footprints," *Nat. Commun.*, vol. 12, no. 1, p. 6149, Oct. 2021.
- [25] D. Mulvaney, "Are green jobs just jobs? Cadmium narratives in the life cycle of Photovoltaics," *Geoforum*, vol. 54, pp. 178–186, Jul. 2014.
- [26] T. Busch, M. Johnson, and T. Pioch, "Corporate carbon performance data: Quo vadis?," *J. Ind. Ecol.*, vol. 26, no. 1, pp. 350–363, Feb. 2022.
- [27] P. J. Callery and J. Perkins, "Detecting False Accounts in Intermediated Voluntary Disclosure," *AMD*, vol. 7, no. 1, pp. 40–56, Mar. 2021.
- [28] H. Fan, Q. Tang, and L. Pan, "An international study of carbon information asymmetry and independent carbon assurance," *The British Accounting Review*, vol. 53, no. 1, p. 100971, Jan. 2021.
- [29] E. Stanny, "Reliability and Comparability of GHG Disclosures to the CDP by US Electric Utilities," *Social and Environmental Accountability Journal*, vol. 38, no. 2, pp. 111–130, May 2018.
- [30] F. Depoers, T. Jeanjean, and T. Jérôme, "Voluntary Disclosure of Greenhouse Gas Emissions: Contrasting the Carbon Disclosure Project and Corporate Reports," *J. Bus. Ethics*, vol. 134, no. 3, pp. 445–461, Mar. 2016.
- [31] D. M. Patten, "The relation between environmental performance and environmental disclosure: a research note," *Accounting, Organizations and Society*, vol. 27, no. 8, pp. 763–773, Nov. 2002.
- [32] A. Kolk, D. Levy, and J. Pinkse, "Corporate Responses in an Emerging Climate Regime: The Institutionalization and Commensuration of Carbon Disclosure," *European Accounting Review*, vol. 17, no. 4, pp. 719–745, Dec. 2008.
- [33] C. H. Cho and D. M. Patten, "The role of environmental disclosures as tools of legitimacy: A research note," *Accounting, Organizations and Society*, vol. 32, no. 7, pp. 639–647, Oct. 2007.

- [34] R. Simnett, A. Vanstraelen, and W. F. Chua, "Assurance on Sustainability Reports: An International Comparison," *The Accounting Review*, vol. 84, no. 3, pp. 937–967, 2009.
- [35] O. Boiral, M.-C. Brotherton, L. Rivaud, and D. Talbot, "Comparing the uncomparable? An investigation of car manufacturers' climate performance," *Bus. Strat. Environ.*, Feb. 2022, doi: 10.1002/bse.3017.
- [36] S. Y. In and K. Schumacher, "Carbonwashing: ESG Data Greenwashing in a Post-Paris World," in *Settling Climate Accounts: Navigating the Road to Net Zero*, T. Heller and A. Seiger, Eds. Cham: Springer International Publishing, 2021, pp. 39–58.
- [37] O. Boiral, M.-C. Brotherton, A. Yuriev, and D. Talbot, "Through the Smokescreen of the Dieselgate Disclosure: Neutralizing the Impacts of a Major Sustainability Scandal," *Organ. Environ.*, p. 10860266211043561, Nov. 2021.
- [38] I. Heras-Saizarbitoria, L. Urbietta, and O. Boiral, "Organizations' engagement with sustainable development goals: From cherry-picking to SDG-washing?," *Corp. Soc. Responsibility Environ. Manage.*, vol. 29, no. 2, pp. 316–328, Mar. 2022.
- [39] D. Talbot and O. Boiral, "GHG Reporting and Impression Management: An Assessment of Sustainability Reports from the Energy Sector," *J. Bus. Ethics*, vol. 147, no. 2, pp. 367–383, Jan. 2018.
- [40] "Why disclose as a company." <https://www.cdp.net/en/companies-discloser> (accessed Jan. 23, 2022).
- [41] "Assurance and Validation Procedure." <https://www.icmm.com/en-gb/about-us/member-requirements/assurance-and-validation-procedure> (accessed Jan. 23, 2022).
- [42] J. Guillot, "Investors Fuel Market Movement for Comparable ESG Data," SASB, Jan. 26, 2021. <https://www.sasb.org/blog/investors-fuel-market-movement-for-comparable-esg-data/> (accessed Jan. 23, 2022).
- [43] M. Carney, "Mark Carney: Breaking the tragedy of the horizon - climate change and financial stability," Oct. 2015, Accessed: Dec. 11, 2019. [Online]. Available: <https://www.bis.org/review/r151009a.pdf>
- [44] D. Shepherd, "Over 90% of Firms Aren't Measuring Emissions Correctly, BCG Says," *Bloomberg News*, Oct. 13, 2021. Accessed: Jan. 10, 2022. [Online]. Available: <https://www.bloomberg.com>
- [45] C. Degot, R. Hutchinson, S. Duranton, M. Lyons, and H. Maher, "Use AI to Measure Emissions—Exhaustively, Accurately, and Frequently," *BCG Global*, Oct. 13, 2021. <https://www.bcg.com/publications/2021/measuring-emissions-accurately> (accessed Mar. 21, 2022).
- [46] M. McGrath, "Climate change: IPCC scientists say it's 'now or never' to limit warming," *BBC*, *BBC News*, Apr. 04, 2022. Accessed: Jun. 15, 2022. [Online]. Available: <https://www.bbc.com/news/science-environment-60984663>
- [47] "Climate Change 2022: Impacts, Adaptation and Vulnerability." <https://www.ipcc.ch/report/ar6/wg2/> (accessed Jun. 15, 2022).
- [48] NewClimate Institute, "Corporate Climate Responsibility Monitor 2022," *NewClimate Institute*, Feb. 06, 2022. <https://newclimate.org/2022/02/07/corporate-climate-responsibility-monitor-2022/> (accessed Mar. 26, 2022).
- [49] "Net Zero Tracker." <https://zerotracker.net/> (accessed Mar. 22, 2022).

- [50] "Generation IM: Trends Report," Generation IM: Trends Report. <https://str2021.generationim.com/chapters/introduction> (accessed Jan. 10, 2022).
- [51] "Net Zero by 2050," IEA. <https://www.iea.org/reports/net-zero-by-2050> (accessed Mar. 15, 2022).
- [52] KPMG, "Net-Zero-Commitments-Where-is-the-plan.pdf," KPMG International, 2021. [Online]. Available: <https://assets.kpmg/content/dam/kpmg/xx/pdf/2021/10/net-zero-commitments-where-is-the-plan.pdf>
- [53] "Screening of websites for 'greenwashing': half of green claims lack evidence," European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_21_269 (accessed Jan. 12, 2022).
- [54] "Post-COP26 Snapshot," Net Zero Tracker. <https://zerotracker.net/analysis/post-cop26-snapshot/> (accessed Mar. 22, 2022).
- [55] NewClimate Institute, "Press Release - Corporate Climate Responsibility Monitor 2022," NewClimate Institute, Feb. 06, 2022. <https://newclimate.org/2022/02/07/press-release-corporate-climate-responsibility-monitor-2022/> (accessed Mar. 26, 2022).
- [56] P. Galey, "'Net-zero' promises from major corporations fall short, climate groups say," NBC News, Feb. 07, 2022. <https://www.nbcnews.com/science/environment/net-zero-promises-major-corporations-fall-short-climate-groups-say-rcna14460> (accessed Mar. 26, 2022).
- [57] "Most corporations support net-zero, but only one-third plan to address all of their indirect emissions," edie.net. <https://www.edie.net/news/9/Most-corporations-support-net-zero-but-only-one-third-plan-to-address-all-of-their-indirect-emissions/> (accessed Mar. 26, 2022).
- [58] G. Grassi et al., "Critical adjustment of land mitigation pathways for assessing countries' climate progress," Nat. Clim. Chang., vol. 11, no. 5, pp. 425–434, Apr. 2021.
- [59] J. Calma, "The math isn't adding up on forests and CO2 reductions," Apr. 29, 2021. <https://www.theverge.com/2021/4/29/22410367/forest-offsets-trees-carbon-dioxide-accounting> (accessed Mar. 26, 2022).
- [60] L. Song and J. Temple, "The Climate Solution Actually Adding Millions of Tons of CO2 Into the Atmosphere," ProPublica. <https://www.propublica.org/article/the-climate-solution-actually-adding-millions-of-tons-of-co2-into-the-atmosphere> (accessed Mar. 26, 2022).
- [61] S. Fankhauser et al., "The meaning of net zero and how to get it right," Nat. Clim. Chang., vol. 12, no. 1, pp. 15–21, Dec. 2021.
- [62] J. Rogelj, O. Geden, A. Cowie, and A. Reisinger, "Net-zero emissions targets are vague: three ways to fix," Nature, vol. 591, no. 7850, pp. 365–368, Mar. 2021.
- [63] "Apple charges forward to 2030 carbon neutral goal, adding 9 gigawatts of clean power and doubling supplier commitments," Apple Newsroom. <https://www.apple.com/newsroom/2021/10/apple-charges-forward-to-2030-carbon-neutral-goal-adding-9-gigawatts-of-clean-power-and-doubling-supplier-commitments/> (accessed Mar. 27, 2022).

- [64] "GoGreen." <https://www.deutschepost.com/en/business-customers/insights-news/gogreen.html> (accessed Mar. 27, 2022).
- [65] "What does being climate positive mean for IKEA?" <https://about.ikea.com/en/sustainability/becoming-climate-positive/what-is-climate-positive> (accessed Mar. 27, 2022).
- [66] "Countries' climate pledges built on flawed data, Post investigation finds," The Washington Post, The Washington Post. Accessed: Jun. 15, 2022. [Online]. Available: <https://www.washingtonpost.com/climate-environment/interactive/2021/greenhouse-gas-emissions-pledges-data/>
- [67] Bloomberg Professional Services, "ESG assets may hit \$53 trillion by 2025, a third of global AUM," Bloomberg Professional Services, Feb. 23, 2021. <https://www.bloomberg.com/professional/blog/esg-assets-may-hit-53-trillion-by-2025-a-third-of-global-aum/> (accessed Jan. 11, 2022).
- [68] S. Kishan, "There's 35 Trillion Invested in Sustainability, but 25 Trillion of That Isn't Doing Much," Bloomberg News, Aug. 18, 2021. Accessed: Jan. 11, 2022. [Online]. Available: <https://www.bloomberg.com>
- [69] J. M. Keenan, "A climate intelligence arms race in financial markets," *Science*, vol. 365, no. 6459, pp. 1240–1243, Sep. 2019.
- [70] T. Fiedler, A. J. Pitman, K. Mackenzie, N. Wood, C. Jakob, and S. E. Perkins-Kirkpatrick, "Business risk and the emergence of climate analytics," *Nat. Clim. Chang.*, vol. 11, no. 2, pp. 87–94, Feb. 2021.
- [71] I. Ghosh, O. Wallach, and M. Lu, "Visualizing the Global Rise of Sustainable Investing," *Visual Capitalist*, Feb. 05, 2020. <https://www.visualcapitalist.com/rise-of-sustainable-investing/> (accessed Mar. 26, 2022).
- [72] M. Green, "Scientists warn over misuse of climate models in financial markets," Reuters, Reuters, Feb. 08, 2021. Accessed: Mar. 19, 2022. [Online]. Available: <https://www.reuters.com/article/us-climate-change-investors-idUSKBN2A81TU>
- [73] E. S. G. Reporting, "How finance professionals are helping to advance ESG reporting," 2022. https://assets.ey.com/content/dam/ey-sites/ey-com/en_us/news/2022/ey-esg-report-may-2022.pdf (accessed Jun. 16, 2022).
- [74] M. Segal, "More than Half of Public Companies Still Housing ESG Data in Spreadsheets: EY Survey," <https://www.esgtoday.com/more-than-half-of-public-companies-still-housing-esg-data-in-spreadsheets-ey-survey/> (accessed Jun. 15, 2022).
- [75] "Recommendations," Task Force on Climate-Related Financial Disclosures, Sep. 22, 2020. <https://www.fsb-tcfd.org/recommendations/> (accessed Mar. 19, 2022).
- [76] "The Use of Scenario Analysis in Disclosure of Climate-related Risks and Opportunities," TCFD Knowledge Hub, May 24, 2019. <https://www.tcfdhub.org/scenario-analysis/> (accessed Mar. 19, 2022).
- [77] "Why do some people call climate change an 'existential threat'?", MIT Climate Portal. <https://climate.mit.edu/ask-mit/why-do-some-people-call-climate-change-existential-threat> (accessed Mar. 19, 2022).
- [78] E. Dimson, P. Marsh, and M. Staunton, "Divergent ESG ratings," *J. Portf. Manag.*, vol. 47, no. 1, pp. 75–87, Oct. 2020.
- [79] "Economy & Finance," Generation IM: Trends Report. <https://str2021.generationim.com/>

- [chapters/economy-and-finance](#) (accessed Mar. 23, 2022).
- [80] J. Dyke, R. Watson, and W. Knorr, "Climate scientists: concept of net zero is a dangerous trap," *The Conversation*, Apr. 22, 2021. Accessed: Mar. 31, 2022. [Online]. Available: https://theconversation-com.cdn.ampproject.org/v/s/theconversation.com/amp/climate-scientists-concept-of-net-zero-is-a-dangerous-trap-157368?amp_gsa=1&_js_v=a9&usqp=mq331AQIKAGwASCAAgM%3D
- [81] "EU proposes world's first carbon border tax for some imports," Reuters, Reuters, Jul. 14, 2021. Accessed: Mar. 24, 2022. [Online]. Available: <https://www.reuters.com/business/sustainable-business/eu-proposes-worlds-first-carbon-border-tax-some-imports-2021-07-14/>
- [82] A. Whitmore, "The emperors new clothes: Sustainable mining?," *J. Clean. Prod.*, vol. 14, no. 3, pp. 309–314, Jan. 2006.
- [83] "The Next Frontier of Carbon Accounting," RMI, Jun. 09, 2020. <https://rmi.org/insight/the-next-frontier-of-carbon-accounting/> (accessed Mar. 18, 2022).
- [84] "Corporate Standard." <https://ghgprotocol.org/corporate-standard> (accessed Mar. 14, 2022).
- [85] G. J. Miller, K. Novan, and A. Jenn, "Hourly accounting of carbon emissions from electricity consumption," *Environ. Res. Lett.*, vol. 17, no. 4, p. 044073, Apr. 2022.
- [86] R. Gray and M. J. Milne, "Sustainability Reporting: Who's Kidding Whom?," pp. 66–70, Jul. 2002.
- [87] C. Perdeli Demirkan, N. M. Smith, H. S. Duzgun, and A. Waclawski, "A Data-Driven Approach to Evaluation of Sustainability Reporting Practices in Extractive Industries," *Sustain. Sci. Pract. Policy*, vol. 13, no. 16, p. 8716, Aug. 2021.
- [88] E. D. F. Blogs, "A year of data and one clear message: Permian flaring remains a major problem." <https://blogs.edf.org/energyexchange/2021/02/11/a-year-of-data-and-one-clear-message-permian-flaring-remains-a-major-problem/> (accessed Mar. 25, 2022).
- [89] B. Hmiel et al., "Preindustrial 14CH₄ indicates greater anthropogenic fossil CH₄ emissions," *Nature*, vol. 578, no. 7795, pp. 409–412, Feb. 2020.
- [90] "Methane from oil and gas," Environmental Defense Fund. <https://www.edf.org/issue/climate-pollution/methane-oil-and-gas> (accessed Jun. 26, 2022).
- [91] A. Clark and N. S. Malik, "No One Is Owning Up to Releasing Cloud of Methane in Florida," *Bloomberg News*, Jul. 27, 2020. Accessed: Jan. 11, 2021. [Online]. Available: <https://www.bloomberg.com/news/articles/2020-07-27/no-one-is-owning-up-to-releasing-cloud-of-methane-in-florida>
- [92] "Summary for Policymakers." <https://www.ipcc.ch/sr15/chapter/spm/> (accessed Mar. 18, 2022).
- [93] "Sixth Assessment Report." <https://www.ipcc.ch/assessment-report/ar6/> (accessed Mar. 18, 2022).
- [94] "Lancet Countdown," *Lancet Countdown*, Sep. 27, 2019. <https://www.lancetcountdown.org/> (accessed Mar. 18, 2022).

The work included in this article is for educational purposes only.

The Colorado School of Mines, Columbia University, and RMI do not vouch for the accuracy, currency, or completeness of the data or information contained in the article and exclude all liability for any loss or damage arising (including through negligence) in connection with and as a result of any reliance on the data and information contained in the article and/or its use. Questions concerning the analysis and views expressed in the article shall be addressed to the authors.

The content of this chapter has no relationship with the UNFCCC process or the work of the secretariat. The secretariat does not vouch for the accuracy, currency, or completeness of the data or information contained in the article and excludes all liability for any loss or damage arising (including through negligence) in connection with and as a result of any reliance on the data and information contained in the article and/or its use. Questions concerning the analysis and views expressed in the article shall be addressed to the authors.

The authors encourage dissemination of this work, and it may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Any queries on rights and licenses, including subsidiary rights, should be addressed to:

Jordy Lee Calderon

jorlee@mines.edu

© 2020 Jordy Lee Calderon
Colorado School of Mines
1500 Illinois St | Golden, CO 80401