EMISSIONS OMISSIONS: GREENHOUSE GAS ACCOUNTING GAPS

*Leehi Yona**

To act on climate change, many governments and corporations have pledged to reduce their greenhouse gas (GHG) emissions. Any climate law that aims to reduce GHGs—such as the United Nations Paris Agreement—must include a way of counting those emissions in the first place. Yet how that accounting takes place is hardly ever scrutinized, and to date, an analysis of how inadequate GHG accounting practices impact climate laws and policies has been largely absent from legal literature.

This Article tackles that gap, calling attention to and describing the consequential role of GHG accounting in environmental law. It describes how entities such as governments and corporations produce GHG "ledgers"—inventories of their GHG emissions over time—to substantiate claims of emissions reductions related to their pledges. The Article argues that whether such pledges (and the laws and policies governing them) effectively address climate change depends on GHG ledgers being accurate and complete. Its central thesis is two-pronged: First, it claims that climate laws and policies which establish GHG emissions reductions rely on entity-level "ledgers," or accounts, of GHG emissions to set goals and assess progress. Second, it argues that entities often undercount emissions in their ledgers, leading to insufficient or misallocated reductions which undermine those laws and policies.

The Article begins by first discussing the normative underpinnings of GHG accounting, followed by the history and current landscape of GHG accounting laws and systems. It then introduces "unaccounted-for" GHGs—emissions that entities exclude from their

---

* Assistant Professor, Cornell Law School. For invaluable comments on various iterations of this Article, I thank Michelle Wilde Anderson, Shirin Bakhshay, William Boyd, Robin Craig, Danny Cullenward, Holly Doremus, Monika Ehrman, Barbara Fried, Michael Gerrard, Colleen Honigsberg, Shi-Ling Hsu, Rob B. Jackson, Sharon Jacobs, Christine Jolls, Anne Joseph O'Connell, Alice Kaswan, Richard J. Lazarus, Mark Lemley, Andrew Mergen, Julian Nyarko, Jeff Rachlinski, David L. Schwartz, Norman Spaulding, Buzz Thompson, Rebecca Tushnet, Michael Vandenbergh, Diego Zambrano, participants at the Harvard-Yale-Stanford Junior Faculty Forum, the Sabin Colloquium for Innovative Environmental Law Scholarship at Columbia Law School, the Northwestern-Penn-Stanford Junior Faculty Workshop in Law and STEM, the Vermont Law and Graduate School Environmental Law Colloquium, the Natural Resources Law Teachers Workshop, and faculty at Boston College School of Law, Cornell Law School, the Elisabeth Haub School of Law at Pace University, Florida State University School of Law, Fordham Law School, Georgetown University Law Center, Southern Methodist University Dedman School of Law, Stanford Law School, the University of Houston Law Center, the University of Kentucky J. David Rosenberg College of Law, and the University of Maryland Francis King Carey School of Law. I thank the *Harvard Environmental Law Review* for editorial feedback, and Cheyenne Joshua for research assistance. I am grateful to Cornell Law School, the Knight-Hennessy Scholars Program, the Emmett Interdisciplinary Program in Environment and Resources at Stanford University, and the Pierre Elliott Trudeau Foundation Doctoral Scholarship for supporting this research.

ledgers, undercounting the total GHG emissions to which they are held accountable—and explains their legal and policy implications. Entities that undercount their emissions may insufficiently reduce their overall emissions as well as underprioritize reducing emissions from the GHG sources they exclude from their ledgers. Finally, the Article explores recommendations to remedy these accounting deficits, applying concepts from information disclosure and financial reporting to describe principles for effective GHG accounting. Ultimately, the Article argues that GHG accounting shortfalls compromise laws and policies that require accurate and complete emissions information, and that these shortfalls must be addressed for these laws to effectively tackle climate change.

Table of Contents

Introduction 599
I. Normative Underpinnings of Greenhouse Gas Accounting 604
A. The Purpose of Greenhouse Gas Accounting in Law and Policy 604
1. Differences Between Greenhouse Gas Accounting for Knowledge and Science Compared to Law and Policy 605
2. Aims of Greenhouse Gas Accounting in Legal Systems 606
B. Principles for Greenhouse Gas Accounting 609
1. Consistency and Comparability 609
2. Standardization 610
3. Accuracy and Completeness 610
II. The Legal and Policy Landscape of Greenhouse Gas Accounting 611
A. Greenhouse Gas Accounting Laws and Policies 611
1. Paris Agreement and National Inventory Reports 612
2. Mandatory Facility-Level Reporting 613
3. Subnational, Local, and Corporate Reporting 613
B. Different Terminologies (and Their Context-Dependent Implications) 614
III. Greenhouse Gas Accounting Gaps 618
A. Unaccounted-for Greenhouse Gas Emissions 618
1. Knowledge and Governance Causes of Unaccounted-for Greenhouse Gases 620
B. Existing Systems Are Poorly Equipped to Address Unaccounted-for Greenhouse Gas Emissions 623
1. Historical Greenhouse Gas Accounting Factors 623
2. Structural Factors 625
3. Oversight and Enforcement Factors 629
IV. Implications of Unaccounted-for Greenhouse Gas Emissions 633
A. Unaccounted-for Greenhouse Gas Emissions Undercount Emitters' Total Emissions, Leading Them to Insufficiently Reduce Overall Emissions 633

B. Unaccounted-for Greenhouse Gas Emissions Distort How Emitters Prioritize Their Mitigation Efforts 636
C. Impacts on the Applicability of Carbon Pricing Mechanisms. 638
V. Getting Greenhouse Gas Accounting Right 640
A. Accountability in Greenhouse Gas Accounting. 640
B. Consistency and Comparability Through Interoperability 642
1. Greenhouse Gas Accounting Standard Setter 644
C. Discretion and How to Address It 645
1. Oversight to Enforce Compliance with Accounting Standards 647
2. Transparency (and Transparency About Transparency) 649
D. Sufficiently Reliable, Decision-Useful Accounting 651
1. Integrating Best Available Scientific Evidence and Technology 651
2. Balancing Costs with Information Needs. 652
Conclusion 653

Introduction

"If we had to [correct our greenhouse gas emissions accounting methods], we wouldn't be clear-cutting old growth rainforest."[1]

On September 9, 2020, the San Francisco Bay Area awoke to an amber sky which evoked an apocalyptic world. In what would become one of the worst wildfire seasons in California history, the overwhelming smoke from a nearby fire "turn[ed] day into an eerie twilight."[2] To say that 2020 was a big year for California's wildfires[3] would be an understatement: five of the top seven largest wildfires in the state's history burned in 2020 (the other two, the Mendocino Complex and Dixie fires, burned in 2018 and 2021, respectively).[4] California

1. Interview with British Columbia Official [name and affiliation withheld in accordance with Institutional Board Review research protocol], in Victoria, Can. (June 20, 2017). This quote was given in response to a question about the impacts of greenhouse gas accounting methods on policy on Vancouver Island, where Indigenous groups are campaigning against logging. *See, e.g.*, *B.C. Timber Sales Clearcutting Old-Growth Rainforest in Tsitika Valley, Schmidt Creek Region*, Wilderness Comm. (Jan. 28, 2025), https://perma.cc/3ZF8-PTYR. This Article draws on semi-structured research interviews (N = 54) approved under Yale University IRB Protocol 2000020397 and Stanford University IRB Protocols 47751 and 61253.
2. Thomas Fuller, *Wildfires Blot Out Sun in the Bay Area*, N.Y. Times (Sept. 9, 2020), https://perma.cc/TUL7-3L2G.
3. Many states similarly experienced the effects of large Canadian wildfires in 2023. *See, e.g.*, Christine Hauser & Claire Moses, *Smoke Pollution from Canadian Wildfires Blankets U.S. Cities, Again*, N.Y. Times (July 17, 2023), https://perma.cc/7K3N-XZ86.
4. Cal. Dep't of Forestry & Fire Prot., Top 20 Largest California Wildfires (2024), https://perma.cc/XQ3N-LNEP.

wildfires are devastating, causing hundreds of billions of dollars in damage, impacting human health and costing lives.[5]

Another important, yet less recognized, impact of these fires is the greenhouse gas (GHG) emissions they release into the atmosphere. At first blush, the GHG emissions from wildfires may seem to be natural disasters, or at least unavoidable. But in California, most wildfires are sparked by human activity and infrastructure that can indeed be managed.[6] Moreover, wildfire GHG emissions are substantial: average emissions from California's wildfires over the last two decades are roughly equivalent to the state's annual emissions from all diesel vehicles.[7]

Strikingly, however, the California Air Resources Board excluded these emissions from the GHG inventory that the state uses to ascertain progress toward emissions reduction goals.[8] As a result, the state's wildfire GHGs were effectively "unaccounted for" in reports documenting California's adherence to statutory GHG reduction pledges. In other words, the state abdicated responsibility for these emissions even though they are large, measurable, reducible, and overwhelmingly caused by human activity.

Why? This Article tackles the question by scrutinizing a critical (albeit technical) foundation of climate law that has not received enough attention in legal scholarship: GHG accounting, and how gaps in accounting undermine climate progress. It argues that climate law must be poised to intervene and address accounting problems that risk undermining efforts to address climate change.

Greenhouse gas accounting is core to climate law and policy. Human emissions of GHGs into the atmosphere fuel climate change, causing floods, sea level rise, droughts, and extreme weather events, which exacerbate existing racial, gender, and socioeconomic disparities worldwide.[9] In response to this crisis, many actors who emit large quantities of GHGs, such as corporations and governments, have committed to reducing their emissions. Various national and multilateral initiatives, such as the United Nations Framework Convention on

5. Daoping Wang et al., *Economic Footprint of California Wildfires in 2018*, 4 Nat. Sustainability 252, 252 (2021).

6. Cal. Dep't of Forestry & Fire Prot., *supra* note 4. For example, an investigation found that utility actions (poorly managed vegetation near powerlines and delayed responses to infrastructure damage) caused a 2021 fire. Cal. Dep't of Forestry & Fire Prot., Investigation Rep. No. 21CABTU009205-58 (July 13, 2021).

7. Cal. Air Res. Bd., Greenhouse Gas Emissions of Contemporary Wildfire, Prescribed Fire, and Forest Management Activities i. fig.E-1 (Dec. 2020), https://perma.cc/9UER-L76Z [hereinafter Wildfire Emissions]; Cal. Air Res. Bd., California Greenhouse Gas Emissions for 2000 to 2018: Trends of Emissions and Other Indicators 8 fig.7 (2020), https://perma.cc/EC7R-VHPH [hereinafter California Inventory].

8. California Inventory, *supra* note 7, at 8 fig.7.

9. *See generally* Intergovernmental Panel on Climate Change [hereinafter IPCC], Climate Change 2013: The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Thomas Stocker et al. eds., 2014).

Climate Change (UNFCCC) Paris Agreement,[10] aim to spur emissions reduction pledges. Responsible actors can make progress toward these commitments by reducing their emissions and/or removing GHGs from the air through "sinks" (e.g., by planting trees or through other so-called "natural climate solutions").[11] To claim successful climate mitigation, they must demonstrate net GHG emissions reductions[12] by producing GHG "ledgers,"[13] the GHG inventories used to assess entity GHG emissions (and climate responsibilities) over time.[14]

Greenhouse gas accounting is a complex, dry, technical, crucial, and powerful pillar of climate law. It can and does affect present-day policies: in one example, the Biden Administration used GHG accounting to support claims that the Inflation Reduction Act ("IRA"),[15] dubbed "the greatest climate action in [U.S.] history,"[16] would reduce national GHG emissions by 40% compared to 2005.[17] The Paris Agreement similarly requires that countries produce GHG ledgers for "clarity and tracking of progress towards achieving Parties' individual nationally determined contributions."[18] Accounting influences decision-making in the corporate sector as much as in government, sometimes leading to adverse behaviors: in a phenomenon known as "carbon leakage," corporations may evade stricter climate policies by relocating to jurisdictions with fewer regulations.[19] Like governments, corporations also allocate resources to GHG accounting to support emissions reductions pledges.[20] With 91% of the global economy committing

10. Paris Agreement to the U.N. Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104 [hereinafter Paris Agreement].
11. *See generally* Bronson W. Griscom et al., *Natural Climate Solutions*, 114 Proc. Nat'l Acad. Sci. 11645 (2017) (outlining challenges and benefits of land-based climate mitigation).
12. *See, e.g.*, Leehi Yona et al., *Refining National Greenhouse Gas Inventories*, 49 Ambio 1581 (2020) [hereinafter *Refining Inventories*]; Rob Swart et al., *Are National Greenhouse Gas Emissions Reports Scientifically Valid?*, 7 Climate Pol'y 535 (2007); Tinus Pulles, *Did the UNFCCC Review Process Improve the National GHG Inventory Submissions?*, 8 Carbon Mgmt. 19 (2017); Tinus Pulles, *Twenty-Five Years of Emission Inventorying*, 9 Carbon Mgmt. 1 (2018) [hereinafter Pulles, *Twenty-Five Years*].
13. Amy Luers et al., *Make Greenhouse-Gas Accounting Reliable — Build Interoperable Systems*, 607 Nat. 653, 653–56 (2022).
14. Jerome Whitington, *Carbon as a Metric of the Human*, 39 Pol. & Legal Anthropology Rev. 46, 46 (2016) ("[A]lmost all climate change policy presumes and requires the ability to systematically quantify carbon emissions.").
15. Inflation Reduction Act of 2022, Pub. L. No. 117–169, 136 Stat. 1818 (2022).
16. Shelley Welton, *Neutralizing the Atmosphere*, 132 Yale L.J. 171, 213 (2022).
17. U.S. Dep't of Energy, DOE/OP-0018, The Inflation Reduction Act Drives Significant Emissions Reductions and Positions America to Reach Our Climate Goals 1 (2022) (claiming the IRA reduces U.S. GHG emissions by 40% compared to 2005, using methods in U.S. Dep't of Energy, Methodological Appendix, https://perma.cc/6t6u-223v).
18. Paris Agreement, *supra* note 10, at 10–11.
19. Intergovernmental Panel on Climate Change, Climate Change 2022: Mitigation of Climate Change 166–67 (Priyadarshi R. Shukla et al. eds., 2022).
20. *See, e.g.*, *Introducing the Carbon Call*, The Carbon Call, https://perma.cc/4MNE-HES9 (a corporate coalition to "better discover, understand, and share GHG emissions data");

to net zero emissions by mid-century[21]—which will have to be accounted for in some way—GHG accounting has become and will remain a powerful force in climate law and policy.[22]

Greenhouse gas accounting is also embedded within legal institutions. Many statutes such as the Greenhouse Gas Reporting Program[23]—a mandatory national reporting program for large stationary sources—explicitly rely on GHG accounting. Carbon pricing mechanisms such as cap-and-trade policies implicitly rely on it to effectively reduce emissions.[24] Furthermore, GHG accounting speaks to longstanding issues in monitoring, a cornerstone of environmental statutes such as the Clean Air Act, the National Environmental Policy Act, the Toxics Release Inventory, and the Clean Water Act.[25]

Beyond environmental law, GHG accounting is in conversation with literature in financial reporting and information disclosure systems.[26] The Securities and Exchange Commission relies on financial accounting principles of relevance, reliability, and comparability.[27] Similarly, information disclosure systems, whether domestically with the U.S. Patent and Trademark Office[28] or internationally with Rule of Law assessments,[29] struggle with information quality challenges. GHG accounting shares many of the underlying goals

Companies, We Mean Business Coalition, https://perma.cc/93K4-XVHF (listing global corporate efforts to reduce GHG emissions).

21. Welton, *supra* note 16, at 174.
22. *See generally* Lauren Gifford, *"You Can't Value What You Can't Measure": A Critical Look at Forest Carbon Accounting*, 161 Climatic Change 291 (2020) (describing political and social motivations surrounding forest carbon accounting from a geographic lens); Francisco Ascui & Heather Lovell, *As Frames Collide: Making Sense of Carbon Accounting*, 24 Acct., Auditing & Accountability J. 978 (2011) (highlighting differing scientific and political logics and worldviews influencing carbon accounting).
23. *Learn About the Greenhouse Gas Reporting Program (GHGRP)*, U.S. Env't Prot. Agency, https://perma.cc/A3RS-ZBDX; 40 C.F.R. § 98 (2009).
24. Daniel Cole, *Origins of Emissions Trading in Theory and Early Practice*, *in* Research Handbook on Emissions Trading 9, 15–18 (Stefan E. Weishaar ed., 2016).
25. Bradley Karkkainen, *Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?*, 89 Geo. L.J. 257, 263–66 (2000); 42 U.S.C. § 7401; 42 U.S.C. §§ 4321–4370; 33 U.S.C. § 1314.
26. *See, e.g.*, The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 C.F.R. pts. 210, 229, 232, 239, 249; Wesley Magat & W. Kip Viscusi, Informational Approaches to Regulation 4–5 (1992) (illustrating how agencies facing difficult choices between inaction or technological controls use information as a compromise); Richard L. Revesz, Environmental Law and Policy: Problems, Cases, and Readings 792–95 (2008) (highlighting informational regulations in environmental law).
27. Leopold A. Bernstein & John J. Wild, Financial Statement Analysis: Theory, Application, and Interpretation 76–80 (6th ed. 1998).
28. Janet Freilich, *Government Misinformation Platforms*, 172 U. Pa. L. Rev. 1537, 1540–41 (2024).
29. The Quiet Power of Indicators: Measuring Governance, Corruption, and Rule of Law (Sally E. Merry et al. eds., 2015).

(transparency and information disclosure for public benefit) and challenges (misinformation) as these systems.

And yet GHG accounting has not attracted much, if any, attention in the legal literature.[30] Some may attribute this relative obscurity to GHG accounting's technical and banal reputation.[31] This Article argues that the pedantic mundaneness of GHG accounting is what makes it so worthy of attention in legal scholarship: it quietly forms the bedrock of climate law by guiding the rules governing mitigation policies.

Moreover, the impacts of GHG accounting shortfalls are staggering: scientific estimates of global GHG emissions are *at least 30% higher* than what national governments account for.[32] Deficits between emitters' accounted-for and actual GHGs impact climate progress. Unaccounted-for emissions dispel the illusion that climate laws and policy regimes are based on complete and accurate GHG footprints. The perceived technical "neutrality"[33] of GHG accounting processes deflects attention from them precisely when they should be scrutinized.

California's wildfires validate this hard look: they illustrate how GHG accounting practices exclude measurable, reducible, human-caused emissions. Wildfire emissions are an example of what this Article calls "unaccounted-for" GHG emissions, emissions that otherwise responsible actors exclude from their ledgers. Unaccounted-for GHGs are ubiquitous. Sometimes actors use

30. Notable exceptions include Taotao Yue & Marjan Peeters, *Better Greenhouse Gas Emissions Accounting for Biofuels: A Key to Biofuels Sustainability*, 6 Climate L. 279 (2016) (highlighting how proper accounting is essential for biofuels to be effective for climate mitigation); Michael P. Vandenbergh & Sharon Shewmake, *The Pandemic Legacy: Accounting for Working-from-Home Emissions*, 48 Ecology L.Q. 767 (2021) (outlining challenges for companies to measure employees' remote work GHG emissions and summarizing corporate GHG accounting methods); Clint Wallace & Shelley Welton, *Taxing Luxury Emissions*, 109 Cornell L. Rev. 1153 (2024) (proposing a carbon tax on luxury goods); Jonathan Rosenbloom, *Outsourced Emissions: Why Local Governments Should Track and Measure Consumption-Based Greenhouse Gases*, 92 U. Colo. L. Rev. 451 (2021) (arguing for consumption-based municipal GHG accounting over current geographical-based accounting methods); Welton, *supra* note 16 (accounting risks in the context of net-zero pledges). Notably, these articles only examine a subset of GHG accounting: biofuels, work-from-home, luxury, city-level, and net-zero emissions, respectively.

31. *See, e.g.*, Leehi Yona et al., *Factors Influencing the Development and Implementation of National Greenhouse Gas Inventories*, 5 Pol'y Design & Prac. 197, 213–14 (2022) [hereinafter *National Inventories*].

32. In 2019, scientific analyses calculated 58 $GTCO_2$ (± 6.1) total GHG emissions. *See* Jan C. Minx et al., *A Comprehensive and Synthetic Dataset for Global, Regional, and National Greenhouse Gas Emissions by Sector 1970–2018 with an Extension to 2019*, 13 Earth Sys. Sci. Data 5213, 5234 (2021). In contrast, combined country National Inventory Reports were 44.2 $GTCO_2$. *See* Chris Mooney et al., *Countries' Climate Pledges Built on Flawed Data, Post Investigation Finds*, Wash. Post (Nov. 8, 2021), https://perma.cc/WML6-DEYR; *see also* John Muyskens et al., *Measuring the Invisible: How the Post Did Its Global Emissions Analysis*, Wash. Post (Nov. 8, 2021), https://perma.cc/6WVZ-RNZQ.

33. A play on words. *See, e.g.*, Shelley Welton's "neutrality mirage" when referring to the problems of net-zero emissions pledges. Welton, *supra* note 16.

methodologies that produce unaccounted-for GHGs, as does Canada, whose national ledger undercounts Alberta oilsands emissions by at least 30%.[34] Other unaccounted-for GHGs may result from misrepresentation, such as when corporations deliberately exclude whole sectors from their ledgers. Technology companies, whose emissions occur mostly in their supply chains, create unaccounted-for GHGs particularly often.[35] For example, IBM excluded emissions from standardized industry reporting forms, explaining that it does not believe there is a "rational basis" to account for some GHG sources, even though doing so is industry best practice.[36] As a result of their magnitude and their pervasiveness, unaccounted-for GHGs impact climate progress.

This Article documents and analyzes the existence and extent of unaccounted-for GHGs and discusses their legal and normative implications. It begins with a normative discussion of the goals of GHG accounting in law, outlining frameworks to achieve those aims. From there, it describes the history and current legal landscape of GHG accounting and introduces unaccounted-for GHGs, a problem heretofore overlooked in legal literature. It then explains the implications of this problem for environmental law. Finally, the Article concludes with recommendations to address accounting deficits, considering these normative underpinnings and the current landscape. It argues that GHG accounting deserves more attention in climate law, aiming to introduce "emissions omissions" and pave the way for research, scholarly discussions, and recommendations to confront them.

I. Normative Underpinnings of Greenhouse Gas Accounting

A. The Purpose of Greenhouse Gas Accounting in Law and Policy

To analyze and evaluate the current GHG accounting landscape, it is important to first establish a normative baseline that details what GHG accounting systems *ought* to do.[37] This Part establishes such a baseline.

---

34. *See* John Liggio et al., *Measured Canadian Oil Sands CO_2 Emissions are Higher than Estimates Made Using Internationally Recommended Methods*, 10 Nat. Commc'ns 1, 5 (2019).
35. *See generally* Lena Klaaßen & Christian Stoll, *Harmonizing Corporate Carbon Footprints*, 12 Nat. Commc'ns 1 (2021).
36. Int'l Bus. Machs. (IBM), Climate Change 2021 CDP Questionnaire 70–71 (2021).
37. Principles of effective GHG accounting parallel those found in other disclosure systems and environmental regulations. Disclosure systems are central to many bodies of law, from intellectual property, to the Rule of Law, to public health. They prominently feature in environmental statutes such as the National Environmental Policy Act (NEPA) and international frameworks such as the Paris Agreement. *See* Wolfgang Merkel, *Measuring the Quality of Rule of Law: Virtues, Perils, Results*, *in* Rule of Law Dynamics: In an Era of International and Transnational Governance 46–47 (Michael Zürn et al. eds., 2012); Daniel E. Ho, *Fudging the Nudge: Information Disclosure and Restaurant Grading*, 122 Yale L.J. 574,

1. Differences Between Greenhouse Gas Accounting for Knowledge and Science Compared to Law and Policy

Greenhouse gas accounting can serve different purposes depending on the systems to which it is applied. In some cases, GHG accounting can provide a *sum total* of global GHG emissions; in others, it can serve to assign *responsibility* for those emissions and track emitters' progress in reducing them. To clarify this distinction, this Article refers to the former as "global" GHG accounting, and the latter as "entity" GHG accounting.

Global GHG accounting aims to determine the *sum* of GHG emissions using scientific estimates and models. This global total, calculated by researchers and peer reviewed, then serves as a benchmark to determine the emissions reductions which are needed to mitigate global average temperature rise. For example, the Global Carbon Project, a scientific (non-governmental) body, produces a report called the "Global Carbon Budget", which calculates global annual GHG emissions through atmospheric data and modelling of ecosystem processes.[38] Similarly, the Intergovernmental Panel on Climate Change (IPCC) produces scientific assessments of the state of climate change, which decision-makers may then use as references that guide policy negotiations.[39] Though these assessments inform policy, they do not constitute policy, but rather are reference documents that decision-makers developing climate laws and policies can use as benchmarks.[40]

In contrast, entity GHG accounting aims to determine *accountability* and *responsibility* for emitters' contributions to climate change. Rather than yield one comprehensive sum of global emissions, in entity accounting, emitting actors produce GHG "ledgers": inventories that comprise their emissions (and, therefore, their climate responsibilities).

---

650 (2012); 42 U.S.C. § 4332. *See generally* Janet Freilich, *Ignoring Information Quality*, 89 Fordham L. Rev. 2113 (2021) (discussing disclosure systems in the patent context).

38. *See generally* Pierre Friedlingstein et al., *Global Carbon Budget 2019*, 11 Earth Sys. Sci. Data 1783 (2019); *see also The Global Carbon Budget: FAQs*, Global Carbon Budget, https://perma.cc/EZZ7-G9PR ("Since 2006, the Global Carbon Budget has summed up all anthropogenic emissions of carbon dioxide (CO_2) to the atmosphere, and all the carbon removed from the atmosphere by land and ocean, to account for the rise in atmospheric CO_2, as this drives climate warming. It brings together many independent sources of data, including systematic observations and state-of-the-art model ensembles, to provide a robust, independent scientific assessment of CO_2 sources and sinks each year and their associated uncertainties. It tracks changes over time in CO_2 emissions from burning and other uses of fossil fuels and from land use change. It also assesses how the Earth's carbon sinks on the land and oceans are changing in response to human activities and climate change.").
39. *See, e.g.*, Welton, *supra* note 16, at 181–82.
40. *See, e.g.*, IPCC, *supra* note 9; *see also The Global Carbon Budget: FAQs*, Global Carbon Budget, https://perma.cc/EZZ7-G9PR ("[emissions] data are integrated at global, regional, and national levels, providing a benchmark against which UNFCCC negotiations can take place.").

Greenhouse gas ledgers are entity-specific, produced by actors such as national and state governments as well as corporations, generally as part of mitigation commitments.[41] They serve as the basis for those actors' climate pledges by tracking their progress toward emissions reductions, comparing current GHG ledgers to historical ones. Table 1 highlights the distinction between global and entity GHG accounting.

Table 1: Global Versus Entity Greenhouse Gas Emissions Accounting.

Accounting Type	**Global**	**Entity**
Goal	Determining actual GHG emissions; producing scientific knowledge and information concerning the state of climate change.	Determining and assigning responsibility/accountability for contributions to climate change; actors also use GHG accounting to inform their climate mitigation decisions.
Scale	Ecosystem or process level (e.g., industrial activities, permafrost thaw, worldwide emissions).	Individual actors and institutions (e.g., national, subnational, and local governments; corporations; educational institutions).
Illustrative Outputs	Scientific assessments (e.g., Global Carbon Budget); GHG emissions modelling in peer-reviewed literature.	National Inventory Reports submitted to United Nations Framework Convention on Climate Change; corporate GHG reports.

By virtue of their goals of climate mitigation, laws and policies rely on entity GHG accounting, as Part II.A will demonstrate.[42] Because this Article concerns the *legal* dimensions of GHG accounting, it will focus on entity accounting rather than global accounting.

2. Aims of Greenhouse Gas Accounting in Legal Systems

A common misconception about entity GHG accounting is that actors' ledgers are used to calculate global emissions. In distinguishing between global and entity GHG accounting, this Article disproves such a myth. In reality,

41. Of course, while these entities all produce GHG ledgers, there are meaningful differences in how one might hold a national government responsible for their emissions compared to a small company. *See infra* Part V, which will address some of those distinctions; however, it is critical to emphasize that entity-level GHG accounting is about assigning *responsibility* for producing GHG emissions rather than simply scientifically calculating the sum of global emissions without attribution or accountability for those emissions. This distinction also makes the case for including seemingly different forms of GHG accounting—at different government scales, for corporations, etc.—under one category.

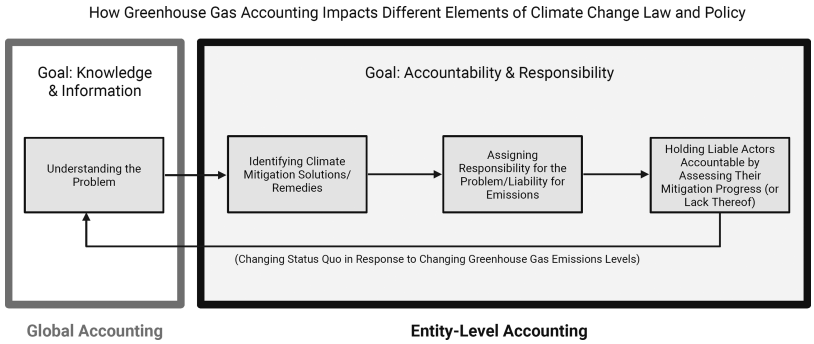
42. *See infra* Part II.A.

scientific bodies have several methods for measuring, estimating, and predicting global GHG emissions levels[43] which are more trustworthy than sums of hundreds of segmented, self-reported ledgers that this Article will demonstrate are error-prone and incomplete.[44] If GHG ledgers are not used to ascertain a global emissions total, then what *are* the goals of GHG accounting in climate law?

At its core, GHG accounting advances transparent accountability for climate change. Climate change is a global crisis which requires collaborative governance, often consisting of individual mitigation pledges. GHG accounting must therefore inform the public and institutions[45] about the progress that emitters are making toward this mitigation. These are all ways that GHG accounting impacts climate law.

Addressing climate change requires GHG accounting in multiple ways, as Figure 1 demonstrates. On a global level, accounting helps the world understand the current state of global warming; at the entity level, accounting helps determine responsibility for emitters' climate change contributions, as well as assess the action those emitters are taking to reduce their emissions.

Figure 1: Why Climate Change Action Needs Greenhouse Gas Accounting.



The figure above demonstrates the different ways GHG accounting impacts climate law and the respective goals that accounting may serve.

43. *See generally* Friedlingstein et al., *supra* note 38.
44. *See infra* Part III.
45. It thus bears similarities with other disclosure systems that assume transparency benefits the public good and improves market efficiency. *See, e.g.*, The Obama Administration's Memorandum on Transparency and Open Government, 74 Fed. Reg. 4685 (Jan. 21, 2009); Jehan El-Jourbagy & Philip P. Gura, *In Space, No One Can Hear You're Green: Standardization of Environmental Reporting, the SEC's Proposed Climate Change Disclosure Rules, and Remote Sensing Technology*, 59 Am. Bus. L.J. 773, 785 (2022). Specifically, these systems assume that, where "a bridgeable information gap contributes substantially to risks or public service failures," information disclosers can reduce those risks, and as a result, information users can and will use the information to make better choices. *See* Archon Fung et al., Full Disclosure: The Perils and Promise of Transparency 174–75 (2007); *see also* Cynthia Giles, Next Generation Compliance 43 (2023) (arguing the Greenhouse Gas Reporting Program reduces GHG emissions despite only mandating disclosures). In environmental law, effective disclosure can also motivate positive behavior change, even if not mandating it. *Id.* Similarly, accounting for their GHGs may pressure emitters to reduce them, and/or inform the sectors or behaviors they may target for emissions reductions.

This Article argues that legal GHG accounting systems strive to determine each actor's specific *responsibility* and *contributions* to climate change as well as to hold them accountable for emissions reductions. Two idealized GHG accounting system designs could serve these goals, according to two differing worldviews of responsibility. The first approach assigns responsibility for each emissions source to one and only one actor. The second approach assigns responsibility for all emissions within each actor's *zone of influence*, representing the sources they would be well-positioned to play a role in reducing. This distinction is critical because it affects system design: the former would have a hierarchy of mutually exclusive ledgers (where unique GHG emissions appear on only one ledger) that partition a known global total, whereas the latter would have ledgers that encompass *all* emissions within each actor's zone of influence.

To illustrate, imagine GHG accounting for petroleum: emissions are released at every step, from extraction to refinement, transportation, and combustion. In a mutually exclusive approach, emissions at each stage would be counted only once, assigned to only one actor, and collectively added up to calculate total emissions. In other words, the petroleum company would account for GHG emissions from refining and extraction, the separate transport company would account for transportation emissions, and the consumer would account for combustion emissions. In contrast, a zone of influence approach would have the petroleum company, the transporter, and the consumer each account for all of these emissions, because ostensibly each can influence the behavior of other actors within the supply chain.[46]

Both mutually exclusive and zone of influence approaches serve the broader goal of decreasing GHG emissions to address climate change, by declaring

46. Some critics argue that zone of influence ledgers create "double counted" emissions. The double (or multiple) counting argument is that if everyone accounted for supply chain emissions, total aggregated emissions across all actors would be higher than true emissions. For example, if Apple accounted for iPhone supply chain emissions, it would include emissions from its supplier (Foxconn) and end users (consumers who purchase and use iPhones). Double counting presumes that Foxconn would also account for GHGs it generates to produce iPhone components and that national governments would include iPhone-related citizen activity in their UNFCCC ledgers. *See generally* Manfred Lenzen, *Double-Counting in Life Cycle Calculations*, 12 J. Indus. Ecology 583 (2008) (describing life cycle GHG emissions). However, double counting emissions sources is an issue only if the goal of GHG accounting regimes is to *measure global* emissions. If systems aim to determine and assess *actor or entity responsibility* for emissions, then double counting becomes "a feature, not a flaw," because GHG accounting would capture an actor's *entire* contribution to climate change. Allison Herren Lee, Former Securities and Exchange Commissioner, Remarks at Stanford Law School (Jan. 25, 2023). As a note, double counting GHG *reductions* undermines GHG accounting goals because it overestimates climate mitigation; double counting emissions *sources* does not. *See* Lambert Schneider et al., *Double Counting and the Paris Agreement Rulebook*, 366 Sci. 180, 181 (2019). In fact, double counting GHG emissions could even increase mitigation, because actors would be incentivized to pressure other entities across supply chains to reduce their emissions, potentially creating market incentives to decarbonize.

which emissions each actor may get credit for reducing over time. Both could rely on the existing scientific quantifications of emissions measured at the global level to inform amounts of reductions necessary. They differ however in the narrowness or breadth of the set of emissions an actor (1) has attributed to them; (2) is required to account for in ledgers; (3) is declared responsible for; and (4) may get credit for reducing. Below, this Article outlines features of ideal GHG accounting systems which may apply to either approach.

B. Principles for Greenhouse Gas Accounting Law

Certain principles for GHG accounting in law impact whether these pledges (and the laws and policies governing them) effectively address climate change. The following Part will describe those principles.

1. Consistency and Comparability

To further accountability, GHG ledgers must be consistent and comparable. This Article defines consistency as the *internal* coherence of actors' ledgers over time and comparability as the *external* congruence between different actors' ledgers. For instance, an actor should use consistent methods to calculate land-based emissions from year to year; ledgers should also be comparable between different companies and countries. Both consistency and comparability create the regularity that makes it possible to hold emitters accountable and assess their adherence to science-based standards. They thus inform decision-making, increase public understanding, and foster collaboration and trust among emitters.[47]

Entities must produce consistent and comparable ledgers for their mitigation efforts to be appropriately scrutinized. California offers an example: in 2018, the state changed accounting methods to exclude on-road transportation emissions from biofuels, resulting in reductions in accounted-for transportation sector emissions when they otherwise would have increased.[48] This lack of consistency hampers the public's ability to understand (and scrutinize) California's progress in reducing transportation sector GHG emissions. Similarly, UNFCCC parties generally account for emissions in both common reporting format (CRF) tables and National Inventory Reports (NIRs). While CRF tables are standardized and contain limited quantitative data, NIRs contain detailed GHG ledgers and include information such as the methods and data sources

47. *Cf.* Edward Fields, The Essentials of Finance and Accounting for Nonfinancial Managers 85 (3d ed. 2016) ("[E]ach successive set of financial statements must employ the same methodology. . . . Only then can comparative analysis and trends be valid"); El-Jourbagy & Gura, *supra* note 45, at 787 ("Comparability . . . leads to more informed decision-making.").

48. California Inventory, *supra* note 7, at 8.

used.[49] As a result, CRF tables are comparable across countries, while NIRs are not. But because country GHG ledgers are based on NIRs, misreporting becomes harder to identify.[50] Absent consistency and comparability, it is harder to identify reporting in bad faith, and it is harder to determine progress being made to address climate change, because it becomes harder to assess collective mitigation efforts. Consequently, integrity and public trust in GHG accounting will be diminished if the public cannot understand ledgers, or if important discrepancies exist within and between ledgers.

2. Standardization

To be consistent and comparable, GHG accounting systems ought to have rigorous, scientifically-based standards. Here, other areas of law, such as financial reporting, are informative.[51] Standardization—"a process of self-imposed or government-derived regulation by which actors develop consensus-based norms"—creates comparable reference points in financial reports.[52] For example, Generally Accepted Accounting Principles (GAAP) outline standardized balance sheet formats for investors to compare corporations' financial statements,[53] and forms such as 10-Ks are meant to make reports accessible to an informed public. GHG accounting regimes similarly ought to mandate the use of standards based on rigorous science so that ledgers serve to reduce emissions by accurately reflecting reality.

3. Accuracy and Completeness

Similarly, GHG ledgers ought to emphasize high information quality. Indeed, the *rigor* and *quality* of accounting standards matter just as much as their existence.[54] Some climate laws explicitly contain statutory language affirming the importance of robust GHG accounting methods,[55] emphasizing

49. *See generally Reporting Requirements*, U.N. Climate Change, https://perma.cc/T4RG-ELVY.

50. Muyskens et al., *supra* note 32.

51. By "financial reporting," this Article refers specifically to corporate financial reporting systems rather than other financial accounting systems (e.g., income tax accounting).

52. El-Jourbagy & Gura, *supra* note 45, at 783–84.

53. *Id.* at 787.

54. *Id.* at 811 ("Using a standard method of reporting without oversight is no guarantee of rigor.").

55. *See, e.g.*, Oregon Dep't of Env't Quality, Oregon's Greenhouse Gas Emissions through 2015: An Assessment of Oregon's Sector-Based and Consumption-Based Greenhouse Gas Emissions 5 (2018), https://perma.cc/W428-L335 ("In order to incorporate best available data and methodology, DEQ periodically updates these inventories. . . . These updates also allow Oregon to better understand changes in emissions relative to different drivers like policy, the economy and changes in population. This data is also the basis

that "[i]naccurate inventories that do not reflect the actual emissions […] can lead to misdirected air quality control measures, resulting in delayed attainment of standards and unnecessary and significant costs."[56] Finally, to maintain their rigor, GHG accounting methods ought to be dynamic and incorporate emerging available scientific evidence.

II. The Legal and Policy Landscape of Greenhouse Gas Accounting

A. Greenhouse Gas Accounting Laws and Policies

Greenhouse gas accounting impacts climate progress in several ways. First, by providing the basis upon which mitigation pledges are implemented, it creates incentives for actors to reduce their overall footprint,[57] which leads to GHG emissions reductions. Second, by illustrating trends in emissions from different industries and sources, GHG accounting informs the policies governments and institutions may take, including which economic sectors they might choose to prioritize for emissions reductions.[58] In these ways, GHG accounting influences climate law and policy, subsequently impacting the overall progress being made to address climate change.

---

for statewide greenhouse gas emission projections. These projections create a foundation to better understand how policy and programs implemented now might affect emissions in the future.").

56. Cal. Health & Safety Code § 39607.3(d).

57. *See, e.g.*, Del. Code Ann. tit. 7, § 10003(e) (2024) ("The reductions required by subsections (a) and (b) of this section shall be determined by reference to Delaware's Greenhouse Gas Inventory prepared by the Department."); *see also* Del. Code Ann. tit. 7, § 10003(a)–(b) (2024) ("The State shall implement greenhouse gas emissions reduction strategies to ensure that, no later than January 1, 2030, Statewide greenhouse gas emissions on a net basis shall be reduced by not less than 50% from a 2005 baseline (the '2030 target'). The State shall implement greenhouse gas emissions reduction strategies to ensure that, no later than January 1, 2050, greenhouse gas emissions in the State shall be stabilized at or below net zero emissions (the '2050 target') and shall not exceed that level thereafter.").

58. *See, e.g.*, Oregon Dep't of Env't Quality, *supra* note 55, at 5 ("Emissions estimates inform strategies and help the Oregon Global Warming Commission track progress toward goals in emission reductions. . . . In order to incorporate best available data and methodology, DEQ periodically updates these inventories so that the most up-to-date information is provided to Oregon's residents, businesses and policy-makers. These updates also allow Oregon to better understand changes in emissions relative to different drivers like policy, the economy and changes in population. This data is also the basis for statewide greenhouse gas emission projections. These projections create a foundation to better understand how policy and programs implemented now might affect emissions in the future.").

There are many reasons why an emitter may report GHG emissions. At the national or subnational levels, GHG accounting may be required by statute or regulation.[59] In rarer cases, GHG accounting may be part of a settlement agreement or writ of mandate pursuant to climate litigation.[60] The following Part outlines three of the most prominent such examples: national GHG reports under the Paris Agreement, mandatory facility-level reporting, and subnational, local, and corporate GHG emissions reporting. It highlights distinctions in GHG inventorying that can influence how these laws and policies are applied.

1. Paris Agreement and National Inventory Reports

The United Nations Paris Agreement, perhaps the most widely known climate treaty, requires that national governments report their GHG emissions.[61] Parties to the Paris Agreement are required to develop and share regular National Inventory Reports (NIRs) as an accountability mechanism for their Nationally Determined Contributions (NDCs).[62] In the United States, the EPA produces a National Inventory Report[63] annually (typically making it available for public comment).[64]

59. *See, e.g.*, Del. Code Ann. tit. 7, § 10003(e) (2024) ("The reductions required by subsections (a) and (b) of this section shall be determined by reference to Delaware's Greenhouse Gas Inventory prepared by the Department."); *see also* Del. Code Ann. tit. 7, § 10003(a)–(b) (2024), *supra* note 57 ("The State shall implement greenhouse gas emissions reduction strategies to ensure that, no later than January 1, 2030, Statewide greenhouse gas emissions on a net basis shall be reduced by not less than 50% from a 2005 baseline (the '2030 target'). The State shall implement greenhouse gas emissions reduction strategies to ensure that, no later than January 1, 2050, greenhouse gas emissions in the State shall be stabilized at or below net zero emissions (the '2050 target') and shall not exceed that level thereafter.").
60. *See, e.g.*, Leehi Yona, *Democracy in the Air: Uncounted Emissions, Discounted Communities* 34 Cornell J. L. Pub. Pol'y (forthcoming 2025); Memorandum of Agreement Between Sierra Club & City of Stockton and Cal. Att'y Gen. (Sept. 10, 2008), https://perma.cc/WH58-M7XA.
61. *Reporting Requirements*, U.N. Climate Change, https://perma.cc/T4RG-ELVY.
62. U.N. Climate Change, U.N. Framework Convention on Climate Change, Draft Handbook for the Review of National Greenhouse Gas Inventories 6 (2021); Paris Agreement, *supra* note 10.
63. U.S. Env't Prot. Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 ES-1-ES-2 (2023), https://perma.cc/A8A8-LDMN.
64. Notice of and Request for Comment on Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022, 89 Fed. Reg. 11275 (Feb. 14, 2024).

2. Mandatory Facility-Level Reporting

Programs for mandatory facility-level GHG emissions reporting exist at the national level as well as at some state levels.[65] Nationally, the Environmental Protection Agency implements the Greenhouse Gas Reporting Program (GHGRP) for individual facilities emitting at least 25,000 metric tonnes of carbon dioxide equivalent ($MTCO_2$) annually.[66] The GHGRP is the result of a 2009 EPA rule for GHG reporting under the Clean Air Act.[67] Similarly, the California Air Resources Board (CARB) has required certain individual facilities to report their GHG emissions over 10,000 $MTCO_2$ since 2006 as part of the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR).[68] While California's MRR may be the most well-known state-level mandatory facility reporting program, there are similar programs in other states, such as Colorado, Iowa, Massachusetts, and Oregon.[69]

3. Subnational, Local, and Corporate Reporting

Greenhouse gas accounting can take place at a variety of subnational scales, from state to local and municipal agencies as well as among corporations. There are often statutory GHG reporting requirements for statewide emissions.[70] Additionally, some local governments produce GHG inventories. Cities may do so as part of voluntarily adopting a Climate Action Plan.[71] Alternatively, municipalities may be mandated to produce GHG ledgers as part of a state-level environmental assessment requirement. For example, the California

65. There have also been increasing mandates for corporate GHG reporting. For example, the California Data Corporate Accountability Act will require all corporations operating in California with total annual revenues above one billion dollars to report their GHG emissions to the state Air Resources Board. Cal. Health & Safety Code § 38532. At the federal level, the Securities and Exchange Commission released a long-awaited final rule on mandatory corporate GHG emissions disclosures in March 2024. The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 C.F.R. pts. 210, 229, 232, 239, 249 (2024). Notably, both the SEC rule and the California law are still evolving.
66. GHGRP, *supra* note 23; 40 C.F.R. § 98 (2009).
67. *See, e.g.*, Vandenbergh & Shewmake, *supra* note 30, at 787–90.
68. Cal. Code Regs. tit. 17,§ 95101.
69. Or. Admin. R. 340-215; Mass. Ann. Laws ch. 21N, § 2(a) (LexisNexis 2021); Iowa Code § 455B.152 (2007); Colo. Rev. Stat. § 25-7-140.
70. *See, e.g.*, W. Va. Code § 22-5-19 (2023); Or. Rev. Stat. Ann. § 468A.260 (2024); Mass. Ann. Laws ch. 21N, § 2(c) (LexisNexis 2021); Vt. Stat. Ann. tit. 10, § 582 (2023); Md. Code Ann., Env't § 2-1203 (LexisNexis 2024); Conn. Gen. Stat. §§ 22a–200b (2022).
71. *Mapped: Cities with a Climate Action Plan*, C40 Cities Climate Leadership Group (Jan. 2022), https://perma.cc/S4T4-W48F.

Environmental Quality Act (CEQA) requires that all public agencies[72] proposing a project evaluate those projects' GHG emissions impacts.[73] County General Plans, which serve as the blueprint for local governments in the state, are subject to these CEQA requirements.[74]

At the corporate level, a drive to encourage voluntary climate pledges from non-state actors emerged to compensate for nations' insufficient plans to meet Paris Agreement targets.[75] This effort triggered a flurry of GHG accounting start-ups and initiatives[76] aiming to provide repositories for companies to report their emissions and benefit from promoting those disclosures. One such firm, CDP (formerly Carbon Disclosure Project), is widely used to report corporate GHG emissions.[77] CDP is one of a true "alphabet soup of acronyms"—TCFD, CSRD, IFRS, GRI, and SASB, to name a few—in this space.[78] In the U.S., under the Biden Administration, the Securities and Exchange Commission (SEC) sought to standardize GHG ledgers as part of its financial disclosure mandates for publicly traded companies.[79]

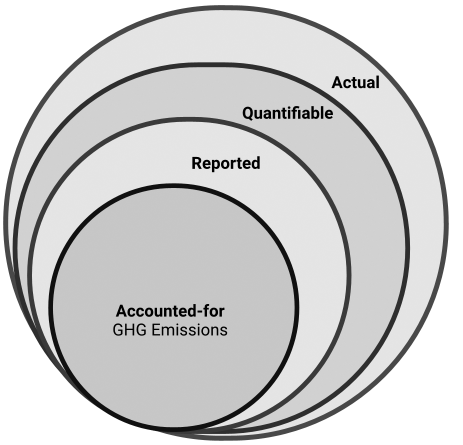
B. Different Terminologies (and Their Context-Dependent Implications)

Not all GHG "counting" is equal. This Article claims that differing levels of disclosure in GHG accounting systems allow actors to document some emissions while abdicating responsibility for them. As Figure 2 below illustrates, a consequential distinction emerges between "measured," "reported," and "accounted-for" emissions in governmental GHG ledgers, where emitters are not held liable for GHGs they measure or report but do not otherwise account for.[80]

---

72. Cal. Pub. Res. Code tit. 13, § 21063 ("'Public agency' includes any state agency, board, or commission, any county, city and county, city, regional agency, public district, redevelopment agency, or other political subdivision.").
73. Cal. Code Regs. tit. 14, §§ 15000–15387; *see, e.g.*, Cal. Code Regs. tit. 14, § 15064.4.
74. *See generally* Ass'n of Env't Pros., 2024 California Environmental Quality Act (CEQA): Statutes & Guidelines (2024), https://perma.cc/2J9G-6Q3W.
75. Press Release, United Nations Framework Convention on Climate Change, Climate Plans Remain Insufficient: More Ambitious Action Needed Now (Oct. 26, 2022), https://perma.cc/VL3N-98TJ; We Mean Business Coalition, *supra* note 20; *Cooperative Initiatives*, Global Climate Action Portal, https://perma.cc/L8S7-T55U; Albert Lin, *Making Net Zero Matter*, 79 Wash. & Lee L. Rev. 679 (2022).
76. El-Jourbagy & Gura, *supra* note 45, at 797 (describing how entities such as SASB and GRI end up "cluttering . . . [GHG emissions] reporting.").
77. *Guidance for Companies*, *infra* note 182.
78. El-Jourbagy & Gura, *supra* note 45, at 795.
79. The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 C.F.R. pts. 210, 229, 232, 239, 249 (2024). For an overview, *see* El-Jourbagy & Gura, *supra* note 45, at 819–20.
80. GHG ledgers are used for effectively *every* climate law which concerns GHG reductions, including, but certainly not limited to, carbon taxes. GHG accounting is therefore still critical in countries without national carbon taxes. For example, in the United States, GHG

Figure 2: Different Categories of Greenhouse Gas (GHG) Emissions.[81]



The concentric circles, in order from largest to smallest, represent GHGs that: are emitted into the atmosphere (outermost circle); are quantified or quantifiable (second outermost); are reported by the emitting actor (second innermost); or for which the actor is responsible in a GHG ledger (innermost circle).

First, *measurable* GHG emissions are scientifically quantifiable. With measurable emissions, the process by which GHGs are emitted is known and informed by peer-reviewed evidence. Measurable GHGs emitted by a particular activity are generally quantifiable or estimated with a reasonable degree of scientific confidence. Indeed, many measurable emissions are also *measured* (or estimated). For example, emissions from forest fires are quantified globally[82] and many scientific bodies measure annual global GHG emissions.[83] However, just because GHG emissions are measured does not ensure that an actor or institution will be liable for them.

Second, measured GHG emissions can be *reported*, meaning that they are documented by governments or other responsible actors in some form. Actors list these *reported* emissions in their aggregated GHG data. In the UNFCCC context, for example, countries may include international aviation and maritime shipping emissions in their GHG ledgers as "memo items."[84] In a subnational

accounting is still used for the EPA's facility-level GHG reporting, for Paris Agreement compliance, and more. *See supra* Part II.A.

81. This Figure was created with Biorender.com (publication permissions granted).

82. Global Fire Assimilation System, Copernicus Atmosphere Monitoring Service (2023), https://perma.cc/4HZL-Z2UP.

83. *See generally* Friedlingstein et al., *supra* note 38.

84. Accounting for Carbon: Monitoring, Reporting and Verifying Emissions in the Climate Economy 46 (Valentin Bellassen & Nicolas Stephan eds., 2015).

example, the State of Hawaii reports (but does not account for) aviation emissions in its GHG inventory.[85] Once again, however, reporting does not indicate liability. The UNFCCC memo items and Hawaii's aviation emissions are examples of emissions governments measure and *report*, but do not *account for*.

Third, only *accounted-for* GHG emissions determine responsibility for emissions reductions (and thus, assess progress toward those pledged reductions). These are an actor's formally recorded emissions for which they are liable. Internationally, the Paris Agreement and Kyoto Protocol determine country responsibilities and contributions toward climate mitigation based only on accounted-for GHGs, even if countries report additional "memo items" in their official UNFCCC submissions.[86] Countries' "memo items" are an "unaccounted-for" category, meaning those emissions are excluded from GHG *accounting* even though they are *reported*.[87] Any emissions that are reported but are not accounted for are not tallied in government National Inventory Reports and thus do not bear on governments' progress toward meeting their respective climate pledges, such as Nationally Determined Contributions[88] under the Paris Agreement. Categorizing GHG emissions sources as "unaccounted-for" allows parties to exempt themselves from obligations to reduce them.

Fourth, subnational and corporate settings have differing GHG accounting scales. For example, the State of California *reports* emissions from international and interstate aviation but does not *account for* them.[89] Additionally, those different terms may carry different meanings depending on the systems in which they are applied. As Table 2 describes, different types of "counted" emissions are treated differently in policy settings: many GHG "reports" are not used for accountability purposes. In governmental contexts, actors are only held responsible for the GHG emissions included in their GHG "*accounts*," whereas in corporate settings, companies may produce multiple "GHG *reports*" but only refer to *one report in particular* to attest to their mitigation responsibility and progress. For example, a corporation may refer to its more public-facing corporate reports for stakeholders as their "GHG report" for accountability purposes, even though they may also submit a separate report to a CDP database[90] that usually has relatively higher overall emissions.[91]

85. ICF & Univ. Haw. Econ. Rsch. Org., Hawaii Greenhouse Gas Emissions Report for 2017, Prepared for Hawaii State Dept. of Health ES-4 (2021).
86. U.N. Framework Convention on Climate Change, *supra* note 62, at 93.
87. *Id*.
88. Romain Weikmans et al., *Transparency Requirements Under the Paris Agreement and Their (Un)Likely Impact on Strengthening the Ambition of Nationally Determined Contributions (NDCs)*, 20 Climate Pol'y 511, 514 (2019).
89. California Inventory, *supra* note 7, at 7.
90. *See supra* Part II.A.3. *See also* Klaaßen & Stoll, *supra* note 35, at 2 (highlighting the difference between corporations' public GHG reports and the reports submitted to CDP).
91. *See* Klaaßen & Stoll, *supra* note 35, at 2.

Table 2: Distinctions Between Different Greenhouse Gas Accounting Terminologies Across Emitting Entities.

<table>
<tr><th>Term</th><th>Actual Emissions</th><th>Quantified (or Measured) Emissions</th><th>Reported Emissions</th><th>Accounted-for Emissions</th></tr>
<tr><td>Government contexts[92]</td><td rowspan="2">True GHG emissions and sinks (includes scientifically measured and estimated emissions as well as known and unknown scientific unknowns).</td><td rowspan="2">Emissions that are either:
(1) Scientifically measured through primary data (“measured emissions”); or
(2) Scientifically estimated, e.g., through models developed based on primary data and measurements (“estimated emissions”).</td><td>GHG emissions that are documented but which may include additional “unaccounted-for” emissions that are excluded from GHG ledgers (e.g., UNFCCC Memo Items).</td><td><u>GHG emissions that an actor is held accountable for generating</u> and is responsible for mitigating (e.g., through an emissions reduction pledge).</td></tr>
<tr><td>Corporate or private actor contexts</td><td colspan="2">Emissions which are documented in some way but which the actor may not necessarily be held accountable for generating. For example, companies may produce multiple GHG reports but then point to <u>one specific report for accountability purposes.</u> This specific report may potentially exclude additional “unaccounted-for” emissions for which they do not claim responsibility.</td></tr>
</table>

The ledgers used to assess an actor’s climate responsibility and mitigation progress are underlined for each respective entity.

Corporations, while they may not use the same “measuring, reporting, and accounting” terminology distinctions, nonetheless also have different levels of reporting. Absent official mandatory disclosure standards, corporations often report different overall GHG ledgers but use one specific ledger to claim and track their emissions reductions toward a public pledge.[93] Notably, however, non-state entities are not bound by UNFCCC conditions, meaning that corporations can and should fully account for their emissions.[94] Because GHG ledgers

92. The interpretation for governments presented here is true for all UNFCCC parties and *generally* the case for subnational governments, though UNFCCC treaties are not legally binding for subnational governments.
93. *See generally* Klaaßen & Stoll, *supra* note 35.
94. *Reporting Requirements*, *supra* note 61.

are the GHG inventories used to hold actors accountable for their emissions and to measure/attest to their mitigation progress, both government GHG *accounts* and *specific* corporate GHG *reports* are GHG ledgers.[95]

Finally, mandatory facility-level GHG reporting also illustrates accounting distinctions. Notably, governments do not necessarily *account* for individual facility-level emissions that are *reported* to them in programs such as the EPA GHGRP and CARB MRR.[96] In just one local example, the City of Stockton, California, excludes from its ledger many Stockton-based GHG emissions sources that are reported to CARB.[97] These individual facility-level data, while nonetheless important sources of information and monitoring, may be *reported*, but not *accounted for*, in government GHG ledgers.[98] If no government is liable for certain categories of GHG emissions, mitigating them becomes nearly impossible without a global regulatory framework.[99]

III. Greenhouse Gas Accounting Gaps

This Article now introduces and explains a substantial but under-recognized problem in climate law: unaccounted-for GHG emissions.

A. Unaccounted-for Greenhouse Gas Emissions

Current GHG accounting systems create what this Article calls unaccounted-for, or omitted, GHGs: human GHG emissions that may be *measurable*, *quantified*, or *reported*, but not *accounted for* in actors' ledgers.[100] Picture the following: a chain-smoker promises their physician that they will quit smoking. To show their progress, the smoker keeps a log of every single cigarette they smoke—but only records cigarettes that they themselves purchased. They exclude cigars, e-cigarettes, cigarettes a partner had at home, cigarettes that

95. *See supra* Table 2.

96. *See, e.g.*, U.S. Env't Prot. Agency, Greenhouse Gas Reporting Program (GHGRP), GHGRP and the U.S. Inventory of Greenhouse Gas Emissions and Sinks, https://perma.cc/Q63V-G3Q4. *See also supra* Part II.A.2.

97. *See generally* Yona, *supra* note 60.

98. Moreover, they illustrate the political implications that this Article highlights: while there is greater agreement and political palatability about disclosure and reporting, there is relatively more pushback to *regulating* disclosure.

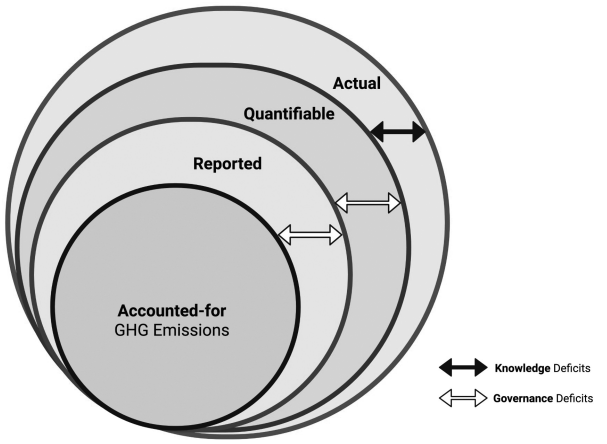
99. Of note, actors could suffer reputational sanctions (or be the target of public advocacy campaigns) for emissions that were reported but not accounted for. Indeed, corporations often are the target of reputational sanctions, including through shareholder activism. *See generally* Madison Condon, *Externalities and the Common Owner*, 95 Wash. L. Rev. 1, 18–26 (2020). Nonetheless, those sanctions depend on public awareness and political campaigning rather than systematic or universal enforcement. Actors may be held responsible for some of these emissions, but nonetheless that responsibility would occur outside existing regimes to assign liability, such as the Paris Agreement.

100. This Article defines GHG ledgers as documents which include *accounted-for* GHGs.

coworkers offered them, etc., from their logs. The patient might be able to tell their physician they smoked zero cigarettes based on their log, but their lungs will say otherwise. Those missing cigarettes are still tobacco that the smoker consumed. Similarly, unaccounted-for GHGs may be excluded from actors' ledgers, but they nonetheless contribute to climate change.

Some unaccounted-for GHGs are measurable—in fact, many are often measured—and caused by human activity, but emitters are not held accountable for them.[101] They thus create shortfalls between true GHG emissions and the emissions that entities, namely governments and corporations, account for. Critically, incentives to reduce unaccounted-for GHGs are weaker than if those same emissions were accounted for.[102] Absent accountability, unaccounted-for GHG sources are likely to go unmitigated. In the following section, the Article describes two different types of unaccounted-for GHGs: knowledge- and governance-based omissions.

Figure 3: Unaccounted-for GHG Emissions.[103]



This diagram describes unaccounted-for GHGs[104] *and their two types: knowledge deficits and governance deficits. This Article will focus on governance deficits, since they are deficits which law and policy systems are poised to address.*

101. There are arguably two types of mismatches where accounted-for GHGs don't reflect actual GHGs: Type I (when accounted-for GHGs are higher than actual GHGs) and Type II (when accounted-for GHGs are lower than actual GHGs) errors. Some "measured" GHGs are estimates using scientific methodologies that could theoretically produce both types of errors; however, in practice, GHG ledgers systematically undercount actual GHGs. Thus, this Article will focus on unaccounted-for GHGs resulting from Type II, not Type I, errors.
102. *See generally* Gifford, *supra* note 22 (demonstrating how carbon accounting influences policy).
103. This Figure was created with Biorender.com (publication permissions granted).
104. *See supra* Figure 2.

1. Knowledge and Governance Causes of Unaccounted-for Greenhouse Gases

This Article posits that both knowledge and governance challenges produce unaccounted-for GHGs, each with different remedies. Knowledge-based unaccounted-for GHGs require increased research and information-building, whereas governance-based unaccounted-for GHGs require better laws and policies. Knowledge-based unaccounted-for GHGs occur in sectors where key data or information about the mechanisms or quantities of emissions are missing or limited. This missing information leaves unknowns which contribute to uncertainties that materially impact decision-making. In these instances, more information is needed to appropriately quantify GHG sources or sinks.

The land use sector suffers from compounded knowledge-based challenges because ecosystem dynamics include a larger variety of carbon sources and sinks than relatively straightforward human activities such as fossil fuel combustion.[105] Whereas it is conceptually straightforward to measure the emissions generated by burning a gallon of crude oil, more complex variables are at play for the carbon sequestered by planting a tree.[106] Examples of knowledge-driven unaccounted-for GHGs include many land- and ecosystem-based GHGs, such as emissions from forests and soils, as well as "feedback loop", or escalating, emissions in areas such as the Arctic, where scientists are still determining the full extent of GHG emissions.[107] These knowledge-based unaccounted-for GHGs have governance components only insofar that they may be addressed by allocating more financial and human resources to increase research capacity.[108]

By contrast, governance-driven unaccounted-for GHGs occur *despite* ample and sufficient scientific information. They are unaccounted-for GHGs that are measurable—in fact, many are already measured and estimated—but excluded from actors' ledgers. Take, for example, wildfire GHG emissions, which are substantial, totaling 1.5 billion $MTCO_2$ globally in 2022,[109] more than the *total* national carbon dioxide emissions reported by Brazil and Canada *combined*.[110] Put differently, if global wildfire emissions were considered a UNFCCC country, they would rank sixth worldwide, larger than the *total accounted-for* GHG

105. *See* Gifford, *supra* note 22, at 295–96.

106. *See, e.g.*, *National Inventories*, *supra* note 31, at 211.

107. *See generally, e.g.*, Timothy Searchinger et al., *Fixing a Critical Climate Accounting Error*, 326 Sci. 527 (2009); Gifford, *supra* note 22, at 295–96; Sonja Vermeulen et al., *A Global Agenda for Collective Action on Soil Carbon*, 2 Nat. Sustainability 2 (2019); Carly Phillips et al., *Escalating Carbon Emissions from North American Boreal Forest Wildfires and the Climate Mitigation Potential of Fire Management*, 8 Sci. Advances 7161 (2022).

108. *See generally Refining Inventories*, *supra* note 12.

109. Global Fire Assimilation System, *supra* note 82.

110. Using data from Zhu Deng et al., GHG Data from Inverse Models and UNFCCC National Inventories V0.1 (July 10, 2021), https://perma.cc/YCR2-5V8C (measuring carbon dioxide emissions from both Brazil and Canada for 2016, the most recent year for which Brazilian reported emissions are available).

emissions in every country except China, the United States, India, Russia, and Indonesia.[111] As one research interviewee, an employee of the Canadian Forest Service, underscored: "I mean, for sure forest fire emissions in Canada […] can be as much as 250 to 300 megatons in a year […] that would add another 40 or 50% to our emissions," adding that "fundamentally, it's not politically feasible" to account for these emissions.[112] Indeed, the barriers to accounting for those emissions are governance, not knowledge, based.

California is a compelling case. The state's wildfire emissions are high and quantified.[113] Most wildfire sources are identified and reducible; human activities, such as poorly maintained powerlines and unattended campfires, cause the majority of them.[114] Yet the state excludes wildfire emissions from its GHG inventory. These unaccounted-for GHGs are governance—not knowledge—based. California serves as an example of those pressures and political motivations, priding itself on being a climate leader,[115] an image which relies on reducing GHG emissions for credibility and thus may create perverse accounting incentives. Unaccounted-for GHGs are rooted in political frictions: institutions are inclined to include as many GHG "sinks" (such as carbon offsets)[116] as possible in ledgers while excluding as many GHG "sources" as possible.[117] Doing so fosters perceptions of those actors being climate leaders, even if they those perceptions do not reflect reality.

This Article defines governance-based unaccounted-for GHGs as GHGs that are unaccounted for because they are (1) excluded as part of GHG accounting methodology (i.e., a structural or systemic problem with guidelines), or (2) excluded from a given GHG ledger independent of methodology (i.e., individual noncompliance). In the first case, emissions are unaccounted for because the accounting methodology that was used excludes them, such as fugitive emissions from fossil fuel sources,[118] or the statement from a Canadian government

111. *ClimateDeck Country Rankings*, Rhodium Group & Breakthrough Energy (on file with the author).

112. Telephone Interview with Canadian Forest Service Official [name and affiliation withheld in accordance with Institutional Review Board protocol] (Aug. 3, 2017).

113. *See generally* Wildfire Emissions, *supra* note 7. Moreover, while wildfire impacts are discussed in legal scholarship, this Article is the first to examine their unaccounted-for GHGs.

114. *See generally* Off. State Fire Marshal, Cal. Dep't Forestry & Fire Prot., 2019 Wildfire Activity Statistics (2020) (illustrating that, of the wildfires in 2019 whose sources were identified, over 90% were caused by human activity).

115. *See, e.g.*, *California Moves to Prevent New Oil Drilling Near Communities, Expand Health Protections*, Off. Governor Gavin Newsom (Oct. 21, 2021), https://perma.cc/FY2K-BZUG.

116. Shelley Welton provides an excellent analysis of the "fungibility" problem in carbon offsets, illustrating how the concept of interchangeable carbon offsets is flawed and leads to accounting risks in climate policy. *See* Welton, *supra* note 16, at 202–07.

117. *National Inventories*, *supra* note 31, at 217; *see also* Leehi Yona, *Climate Injustice, Off the Books*, 73 UCLA L. Rev. (forthcoming 2026), at 21–23, 29–30, 35–37.

118. *See, e.g.*, Michael Gillenwater, *Forgotten Carbon: Indirect CO_2 in Greenhouse Gas Emission Inventories*, 11 Env't Sci. & Pol'y 195, 197 (2008).

official regarding forest soil carbon inventorying.[119] In the second case, an institution or inventory compiler may deliberately exclude a specific emissions source, despite guidelines indicating that it should have been included. For example, many corporations have drastically different GHG ledgers compared to generally agreed-upon methodologies.[120] Finally, both types of governance-based unaccounted-for GHGs can co-occur within the same ledger, with an inventory compiler using methods that exclude substantial emissions sources by design while also making arbitrary individual exclusions.

International aviation and maritime shipping illustrate both structural and individual governance-based unaccounted-for GHGs. Both are excluded from national ledgers at the UNFCCC, an exclusion dating to the Kyoto Protocol.[121] As a result, these GHG emissions sources are rarely included in ledgers, even sub-nationally.[122] These unaccounted-for GHG deficits are structural.

Concurrently, some air and seaports, as well as commercial airlines, voluntarily produce their own ledgers.[123] Yet the methods and quality of ports' GHG ledgers vary widely. For example, most U.S. seaports hire the same consulting company, Starcrest Consulting LLC, which almost always excludes Scope 3 emissions, to produce their GHG ledgers.[124] In an interesting inconsistency, one port—the New York and New Jersey Port Authority—excluded Scope 3 emissions from shipping in its seaport GHG ledger developed by Starcrest,[125] but reported Scope 3 emissions in its other airport GHG ledger for the same reporting year.[126] Especially notable, however, is that Scope 3 maritime shipping emissions are indeed quantifiable. For example, the Port of Seattle has accounted for Scope 3 emissions—which are between 30 and 43 times the port's combined

119. Notably, structural unaccounted-for GHGs can result from *wholesale exclusions* of a GHG source as well as from the use of a methodology which does include the source but *undercounts* it.

120. *See, e.g.*, Klaaßen & Stoll, *supra* note 35, at 8.

121. *See infra* Part II.B.1.

122. *See generally* California Inventory, *supra* note 7.

123. *See, e.g.*, *Ports and Goods Movement Emissions Inventory*, U.S. Env't Prot. Agency, https://perma.cc/4ZVL-ZSMA; *see generally* Michael P. Vandenbergh & Daniel J. Metzger, *Private Governance Responses to Climate Change: The Case of Global Civil Aviation*, 30 Fordham Env't L. Rev. 62 (2018) (highlighting role of private governance in reducing aviation GHGs, including an effort led by Virgin Atlantic to evaluate the company's carbon footprint).

124. *See, e.g.*, Starcrest Consulting Grp., Inventory of Air Emissions for Calendar Year 2018: Port of Stockton, California (Feb. 2021) [hereinafter Starcrest, Port of Stockton]; Starcrest Consulting Grp., Inventory of Air Emissions for Calendar Year 2021: Port of Long Beach, California (Aug. 2022) [hereinafter Starcrest, Port of Long Beach]. For a ledger including Scope 3 emissions, *see* Starcrest Consulting Grp., Inventory of Air Emissions for Calendar Year 2020: Port of Los Angeles, California (Jan. 2021).

125. Starcrest Consulting Grp., The Port Authority of New York & New Jersey Port Department: 2019 Multi-Facility Emissions Inventory (Dec. 2020).

126. SC&A, Inc., Greenhouse Gas and Criteria Air Pollutant Emissions Inventory for the Port Authority of New York & New Jersey (Oct. 2021).

Scope 1 and 2 emissions—for years, and is one of the few ports that does not produce its GHG ledgers through Starcrest.[127] These gaps, sometimes occurring within the same institution's ledgers, exemplify individual governance-based unaccounted-for GHGs.

Regardless of whether the underlying driver is systemic or individualized in nature, that institutions both know how to and already do measure (but exclude) many of these emissions is important: it means that many unaccounted-for GHGs exist not because of insufficient knowledge, but deficient governance.[128] Hence, remedies to poor GHG accounting practices exist and cannot be dismissed. Governance-based unaccounted-for GHGs undermine the legal systems that rely on GHG emissions reductions to mitigate climate change.

B. Existing Systems Are Poorly Equipped to Address Unaccounted-for Greenhouse Gas Emissions

1. Historical Greenhouse Gas Accounting Factors

Many problems stem from how GHG accounting first emerged in climate law. Early GHG accounting systems had different goals and audiences than today, yet they dictate the boundaries of current regimes.[129] Understanding this context is necessary to address unaccounted-for GHGs.

First, GHG accounting systems initially and substantially emerged to produce ledgers for a subset of emissions sources in a subset of countries in response to the UNFCCC Kyoto Protocol.[130] The first international GHG emissions reduction treaty, the Kyoto Protocol, included six GHGs—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6)—as part of mitigation commitments from wealthier economies, so-called "Annex I" countries.[131] Under the Protocol, Annex I nations compile GHG inventories using guidelines produced by the IPCC Task Force on National Greenhouse Gas Inventories ("IPCC guidelines") to demonstrate fulfillment of their emissions reductions pledges.[132] Early GHG accounting guidelines were thus designed for wealthy

127. *Measuring Greenhouse Gas Emissions at the Port of Seattle*, Port of Seattle, https://perma.cc/5XLZ-9EBD.

128. *See generally Refining Inventories*, *supra* note 12.

129. *National Inventories*, *supra* note 31, at 215.

130. Kyoto Protocol to the U.N. Framework Convention on Climate Change, Dec. 10, 1997, Dec. 1/CP.3, U.N.Doc.FCCC/CP/1997/L.7/Add.1 ¶ 22 [hereinafter Kyoto Protocol]; *National Inventories*, *supra* note 31, at 210.

131. Kyoto Protocol, *supra* note 130, at Annex A, B; *Parties and Observers*, U.N. Climate Change, https://perma.cc/6DCM-ALW7.

132. IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 5 (Simon Eggleston et al. eds., 2006) [hereinafter Greenhouse Gas Inventories]; Kyoto Protocol, *supra* note 130, at 8.

countries which presumably possessed substantial primary and national emissions data.[133] This context is consequential: many ensuing GHG accounting methods relied on these first guidelines[134] that were not designed for all countries, let alone for corporate or other non-state actors.[135]

Second, initial IPCC guidelines primarily addressed energy sector emissions,[136] expanding to agriculture, forestry, and land use in 2006, when countries began to use forest and land management to meet their Kyoto pledges.[137] GHG accounting methods evolved with this political shift,[138] becoming more complex and abstract, and consequently expanding opportunities to exercise discretion.[139] In turn, scrutinizing ledgers became more difficult.[140]

Finally, the Paris Agreement marked a new era of GHG accounting in the decades since the Kyoto Protocol. It required UNFCCC parties—expanding to all nations, not just the Annex I subset, for the first time—to submit National Inventory Reports of GHG emissions and sinks.[141] It also catalyzed a

133. *National Inventories*, *supra* note 31, at 210.

134. Luers et al., *supra* note 13, at 654.

135. Notably, these initial systems also did not aim to produce a global ledger.

136. Pulles, *Twenty-Five Years*, *supra* note 12, at 2.

137. *See generally, e.g.*, Gifford, *supra* note 22; *National Inventories*, *supra* note 31; Molly Macauley & Nathan Richardson, *Seeing the Forests and the Trees: Technological and Regulatory Impediments for Global Carbon Monitoring*, 26 Berkeley Tech. L.J. 1387 (2011).

138. As one IPCC author states: "The first [GHG] inventories concentrated on CO_2 and did not need more than well-developed energy statistics and understanding of high school chemistry. [Emissions] [s]ources here were defined along lines of economic or social end users such as industrial branches. When . . . non-CO_2 gases became more of interest, both in science and for the national experts negotiating [GHG] reduction targets, . . . the guidance [became] more complex." Pulles, *Twenty-Five Years*, *supra* note 12, at 2.

139. What's more, a norm of "carbon dioxide equivalence" emerged, where all GHGs are represented as carbon dioxide emissions relative to their estimated global warming impacts. This approach inherently relies on comparing gases that are different in their Global Warming Potential, or how they impact climate change. Yet the negative effects of non-CO_2 GHGs—such as methane, which impacts warming on a different timescale than carbon dioxide—can be lost when those gases are treated as carbon dioxide equivalents. *See, e.g.*, Michael R. Boswell et al., Climate Action Planning: A Guide to Creating Low-Carbon, Resilient Communities 96–97 (2019) (outlining common CO_2 equivalencies); Kathleen A. Mar et al., *Beyond CO_2 Equivalence: The Impacts of Methane on Climate, Ecosystems, and Health*, 134 Env't Sci. & Pol'y 127, 128 (2022); *see also, e.g.*, Kyoto Protocol, *supra* note 130, at 7; Scott C. Neubauer, *Global Warming Potential is Not an Ecosystem Property*, 24 Ecosystems 2079, 2079 (2021). For a discussion of alternative models for weighting the climate impacts of different greenhouse gases, *see generally* Keith P. Shine et al., *Alternatives to the Global Warming Potential for Comparing Climate Impacts of Emissions of Greenhouse Gases*, 68 Climatic Change 281 (2005).

140. El-Jourbagy & Gura, *supra* note 45, at 814 ("The more complicated the data is . . . the more difficult it is to deem credible.").

141. Paris Agreement, *supra* note 10, at 10–11.

flurry of corporate and subnational mitigation pledges.[142] Hence, many institutions outside UNFCCC purview now produce GHG ledgers to ascertain progress toward these commitments. An oversight vacuum emerged, where many voluntary ledgers, such as the corporate reports highlighted below, are subject to less scrutiny.

2. Structural Factors

The structures of GHG accounting regimes contribute to unaccounted-for GHGs. In some cases, reporting requirements themselves produce unaccounted-for GHGs by design. Two such approaches are commonly used by governments and non-state actors: the IPCC guidelines and the World Resources Institute Greenhouse Gas Protocol ("GHG Protocol"), respectively.[143] Each approach has a structure that may create unaccounted-for GHGs: IPCC guidelines' Tiers and the GHG Protocol's Scopes.

The IPCC guidelines form the foundation of GHG accounting. They were first produced in 1996, revised in 2006 and underwent a subsequent non-comprehensive "Refinement" in 2019.[144] The IPCC produces guidelines using an "expert synthesis" approach that brings together government-nominated coauthors in a collaborative global writing effort.[145] This process echoes the IPCC's procedures for its Assessment Reports,[146] which summarize the best available scientific evidence on climate change.[147] Yet unlike with Assessment Reports,

142. *See, e.g.*, We Mean Business Coalition, *supra* note 20. It also catalyzed sub-national pledges that many U.S. states and cities made following the country's withdrawal from the Agreement. Craig Holt Segall, *Networked Federalism: Subnational Governments in the Biden Era*, 48 Ecology L.Q. 1, 2–7 (2021) (illustrating how states and subnational governments can push forward climate action agendas in the U.S.); Vicki Arroyo et al., *State Innovation on Climate Change: Reducing Emissions from Key Sectors While Preparing for a New Normal*, 10 Harv. L. & Pol'y Rev. 385, 385 (2016).

143. World Res. Inst. & World Bus. Council for Sustainable Dev., Greenhouse Gas Protocol, Technical Guidance for Calculating Scope 3 Emissions 39–48 (2013) (outlining emissions accounting for nonstate actors such as corporations and municipalities).

144. Of note: the "2019 Refinement" of the IPCC guidelines was not a full revision, but a refinement of some aspects of the guidelines, meaning that the most recent fully updated set of guidelines is the 2006 version. Some of the decision-making around which elements of the guidelines to review in the 2019 Refinement was likely driven by both science as well as policy. However, IPCC officials stated that the reasoning behind a refinement and not a full revision in 2019 was grounded in what the IPCC believed to be the willingness, or "political mood," of the UNFCCC to accept substantially revised GHG accounting guidelines. *National Inventories*, *supra* note 31, at 201–02, 210, 215.

145. *See, e.g.*, *id.* at 207–09.

146. An important distinction: the IPCC guidelines are actual methodologies applied to produce ledgers, whereas the Assessment Reports are policy reference documents. *Id.*

147. The group received the Nobel Peace Prize for their report. *The Nobel Peace Prize 2007*, Nobel Prize Found., https://perma.cc/92VB-2KSH.

the IPCC does not regularly update its GHG accounting guidelines.[148] As a result, the most recently revised guidelines (and the benchmarks accepted by the UNFCCC) are nearly two decades old.[149]

Furthermore, IPCC guidelines were first developed under bygone constraints in the 1990s. The expert synthesis process was born out of necessity: data were much more limited when the first IPCC guidelines were written than they are today.[150] Expert synthesis made sense considering this large-scale data scarcity and the fact that the guidelines were intended for wealthy, well-resourced countries that presumably could produce primary data for their ledgers.[151] Conversely, today there are abundant remote sensing and computing resources available to estimate emissions,[152] and the Paris Agreement stipulates that *all* parties use IPCC guidelines to compile ledgers.[153] It is thus all the more surprising that the IPCC guidelines have only been updated a handful of times since they were first written, despite substantial increases in scientific knowledge in the intervening decades.[154]

Nonetheless, IPCC guidelines have become the prevailing GHG accounting methodology,[155] a common occurrence for indicators that are sponsored by influential multilateral organizations[156] such as the United Nations. As such, they have become an entrenched part of the system, locking in a methodological approach that has been sporadically updated.[157] The absence of updates leaves accounting standards trailing behind emerging science and creates unaccounted-for GHGs.

The UNFCCC relies on countries' National Inventory Reports, produced using IPCC guidelines, to determine progress toward Paris Agreement commitments.[158] IPCC guidelines are thus critical to holding governments accountable to their emissions reduction pledges, yet they are inflexible and outdated. While they aimed to be the foundation for GHG accounting, in practice they have also become a rigid, constraining ceiling, since they dictate the bounds within

148. *Id.*
149. Greenhouse Gas Inventories, *supra* note 132.
150. Scientific journals were not easily searchable nor online in the 1990s, nor did big data exist, and computers were nowhere near being the common research tool they are today.
151. *Refining Inventories*, *supra* note 12, at 1582–83; *National Inventories*, *supra* note 31, at 209–10.
152. *See generally* Climate TRACE, Bringing Radical Transparency to Global Emissions (2021).
153. *National Inventories*, *supra* note 31, at 201.
154. *Refining Inventories*, *supra* note 12, at 1582.
155. For example, many states and municipalities use IPCC guidelines, though sub-national governments are not formal UNFCCC parties and therefore not required to do so. *See, e.g.*, California Inventory, *supra* note 7.
156. The Quiet Power of Indicators, *supra* note 29, at 21.
157. *National Inventories*, *supra* note 31, at 213.
158. *Id.* at 201.

which GHG ledgers are produced.[159] Many sectors that were initially excluded from the first IPCC guidelines are still excluded today, even by non-state actors who are not bound to use them.[160] Thus, IPCC guidelines "lock in" structural unaccounted-for GHGs in sectors such as international aviation and maritime shipping.[161] The UNFCCC "memo items" category allows whole industries to effectively receive accounting *carte blanche*,[162] not to mention that using updated IPCC guidelines is voluntary.[163] Moreover, since countries have relied on those same guidelines for decades, deviating from them becomes politically challenging.[164]

Perhaps the most important IPCC guideline element is the tiered approach used to calculate GHG emissions. Under this approach, an institution could use one of three methods to estimate emissions, categorized by available data. A national government lacking any primary data would use a "Tier 1" approach, which provides default reference values through which to approximate emissions; if some national-level data are available, a "Tier 2" approach is used; and if granular data are available, a "Tier 3" approach applies.[165] For example, a government agency trying to account for forest soil carbon using a Tier 1 approach would consult a table that, based on forest soil type (e.g. "sandy"), and climate type (e.g., "tropical dry"), lists a default carbon value (31 tonnes of carbon per hectare), which they would then multiply by their total forested area.[166] A Tier 2 approach would require the government agency to have some national-level data (e.g., forest management practices)[167] while still using default values to calculate forest soil carbon. Finally, a Tier 3 approach would involve calculating forest soil carbon using models that require certain inputs (e.g., field data collected from benchmark forest sites).[168] The tiered approach dates to the first 1996 IPCC guidelines (which were geared towards Annex I nations' energy sector emissions).[169]

159. *Id.* at 209; *National Inventories*, *supra* note 31, at 209–10; *Refining Inventories*, *supra* note 12, at 1582–83 (highlighting how the tiered approach initially was designed to offer flexibility for all reporting countries but that it now also constrains the structure governing GHG accounting, even in the presence of improved or preferable systems).

160. *See generally* Yona, *supra* note 117.

161. *National Inventories*, *supra* note 31, at 213.

162. *See supra* Part II.B.

163. This is per official guidance—the Paris Agreement Enhanced Transparency Framework—which allows countries to use different guideline editions. *Id.* ¶ 28.

164. *Id.*

165. *Refining Inventories*, *supra* note 12, at 1582–83.

166. *National Inventories*, *supra* note 31, at 203.

167. Harald Aalde et al., Chapter 2: Generic Methodologies Applicable to Multiple Land-use Categories, *in* 2006 IPCC Guidelines for National Greenhouse Gas Inventories 2.37 (2006).

168. *Id.* at 2.39.

169. *National Inventories*, *supra* note 31, at 210.

The IPCC guidelines' tiered approach is both lauded and criticized. Proponents argue that it allows all countries, regardless of how much primary data they possess, to produce GHG ledgers,[170] a necessary compromise to creating any kind of international GHG accounting system. They emphasize that the tier approach sets a floor for GHG accounting, "not […] a roof."[171] But Tier 1 approaches rely on default reference values that, in at least one case, may be educated guesses.[172] These kinds of informed estimates may have been appropriate for the limited information available thirty years ago, but are suboptimal compared to the technological tools and scientific information that exist today.[173] As a twenty-five-year veteran scientist working on GHG inventories put it, the tiered method is on the one hand "a quick and dirty approach" which enables all countries to produce *some* kind of GHG ledger, while also being "the 'worst method' a country can apply" because it relies on default reference values, ultimately serving as a reasonable approach that is "good enough for unimportant sources and sinks."[174] In other words, IPCC guidelines are an imperfect first GHG accounting step. Yet even well-resourced countries such as Canada and the United States use Tier 1 methods in their ledgers, and the flexibility for all countries to choose which tier to apply can incentivize "tier shopping."[175] The nuanced purpose (and unintended consequences) of IPCC guidelines provides context for the challenges of GHG accounting in a present-day legal and policy landscape which grew out of this initial IPCC groundwork.[176]

The second well-known GHG accounting method, the GHG Protocol, is one such offshoot.[177] Often used by non-state actors—such as corporations and other private actors—to produce voluntary GHG ledgers, the GHG Protocol provides guidance but does not verify or enforce specific GHG accounting

170. *National Inventories*, *supra* note 31, at 209 ("A government scientist and IPCC author argued that, while imprecise, Tier 1 approaches serve an important purpose: 'Let's say we want you to get on a bicycle from A to B. Well, first we build a bicycle. Then we add a motor. You don't start with a Ferrari. . . . It's more important for people to understand how the system works before specificity is applied.'").

171. *Id.* at 209.

172. *Id.* at 208 (quoting IPCC author saying, "Some [IPCC guideline methodology values] just come because someone said, 'Oh, this one paper said they're about 25, so let's just do that,' and it becomes 25.").

173. Look no further than the scientific analyses, using technology such as remote sensing, that compare country GHG ledgers with more rigorously collected data. *See generally, e.g.*, Zhu Deng et al., *Comparing National Greenhouse Gas Budgets Reported in UNFCCC Inventories Against Atmospheric Inversions*, 14 Earth Sys. Sci. Data 1639 (2022).

174. Pulles, *Twenty-Five Years*, *supra* note 12, at 3.

175. *National Inventories*, *supra* note 31, at 209.

176. One might argue that the initial structure of the IPCC inventories was a necessary compromise to at least set a *basis* for GHG accounting policies. The result, however, was nonetheless a system that can be exploited with discretionary misreporting. *See infra* Part IV.

177. *See generally* World Res. Ins. & World Bus. Council for Sustainable Development, The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (2015) [hereinafter GHG Protocol Standard].

standards.[178] It has quickly become the unofficial practice for corporate GHG emissions reporting, even so far as becoming the methodology that the SEC incorporated by reference in its Rule for Climate-Related Disclosure.[179] However, as with IPCC guidelines, its present-day use—both insofar as the number of users, as well as its scale and scope of analysis—has eclipsed its initial design and intended audience.[180]

A main GHG Protocol feature is how it measures emissions at different levels (so-called "Scopes" 1, 2, and 3) of corporate activity. Under this approach, Scope 1 emissions include an actor's direct GHG emissions within its immediate geography; Scope 2 emissions include indirect GHG emissions resulting from the actor's electricity use; and Scope 3 emissions include "all other indirect emissions," or GHG emissions outside a product's geographical jurisdiction but within its supply chain,[181] also referred to as "upstream" and "downstream" emissions.[182] Scope 3 emissions form an ever-larger portion of actors' GHG footprint as globalization increases, and many stationary facilities—such as fossil fuel production, refinery, and manufacturing operations—produce them.[183] Finally, national governments typically exclude upstream and downstream Scope 3 emissions, since IPCC guidelines exclude them as well.[184]

3. Oversight and Enforcement Factors

Much corporate and non-state GHG accounting is voluntary: actors opt to disclose or reduce emissions and produce ledgers subject to little, if any, oversight.[185] These voluntary corporate accounting practices are unregulated and disjointed.[186]

The current GHG accounting landscape for non-state actors (outside of UNFCCC parties) is largely unregulated[187] and lacks standardization or

178. Gifford, *supra* note 22, at 298.

179. The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 C.F.R. pts. 210, 229, 232, 239, 249 (2024).

180. *See, e.g.*, *About Us*, Greenhouse Gas Protocol, https://perma.cc/KAZ5-23HX (outlining how the GHG Protocol's use expanded over the years and how revised editions have included additional GHG sectors such as electricity use).

181. GHG Protocol Standard, *supra* note 177, at 25.

182. *See, e.g.*, *Guidance for Companies*, Climate Disclosure Project, https://perma.cc/3M6C-6ZZJ.

183. *See generally* GHG Protocol Standard, *supra* note 177.

184. *See generally* Greenhouse Gas Inventories, *supra* note 132.

185. El-Jourbagy & Gura, *supra* note 45, at 792.

186. *Id.* at 818 (corporate GHG reporting "is currently voluntary in the United States and disclosures are variable.").

187. *See, e.g.*, U.N.'s High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities, Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions (2022) [hereinafter Integrity Matters]; Lily Hsueh, *Do Businesses that Disclose Climate Change Information Emit Less*

consensus.[188] Private GHG accounting actors and standard setters such as CDP and GHG Protocol—and the ledgers that companies produce using them—effectively allow corporations to "claim scientific authority, affirm legal values such as transparency and accountability, and assert their legitimacy to govern."[189] At the same time, the "global patchwork" of GHG accounting systems make it hard to compare GHG ledgers, in addition to making it challenging to assess the validity, completeness, and rigor of an individual GHG ledger, creating a fuzzy GHG accounting ecosystem that is difficult to scrutinize.[190]

Some corporations arbitrarily exclude GHGs from their ledgers. For example, Alphabet claims in its voluntary GHG ledger that its Google Maps navigation software, by virtue of finding efficient driving routes for users, reduces emissions by 500,000 to 1,000,000 $MTCO_2$.[191] These claimed emissions reductions are substantial when put into context: in the same GHG ledger, Alphabet lists total Scope 1 emissions of 45,073 $MTCO_2$.[192] That Google Maps reduces Alphabet's GHG footprint simply by providing its users with fuel-efficient routes raises eyebrows, because the company excludes the *emissions* from those routes.[193] Alphabet is claiming GHG emissions *reductions* from an activity that it *excludes* as a GHG *source*.[194]

Moreover, voluntary corporate GHG accounting methodologies suffer from the same growing pains as national ones. And as with the IPCC guidelines, the GHG Protocol's scale, reach, and use has far eclipsed the initial expectations

Carbon? Evidence from S&P 500 Firms, 18 Climate Change Econ. 2250003-1, 2250003-13 (2022).

188. U.S. Gov't Accountability Off., GAO-20-530, Public Companies: Disclosures of Environmental, Social, and Governance Factors and Options to Enhance Them 41 (July 2, 2020); El-Jourbagy & Gura, *supra* note 45, at 792.

189. The Quiet Power of Indicators, *supra* note 29, at 105.

190. Luers et al., *supra* note 13, at 653–54.

191. Alphabet, CDP Climate Change Response 2022 27 (2022), https://perma.cc/2PSV-V9UX; Google, Google Maps Eco-Friendly Routing: Accelerating the Journey to Sustainability for One Billion People 6 (2021), https://perma.cc/6ZH4-PV66.

192. Alphabet, *supra* note 191, at 23. Total emissions at all scopes is 11,371,205 $MTCO_2$. *Id.*

193. *Id.*

194. Alphabet published its research on how it calculated emissions reductions online, highlighting the methodologies it used to develop its "eco-friendly routing." *See generally* Neha Arora et al., *Quantifying the Sustainability Impact of Google Maps: A Case Study of Salt Lake City* 1 (2021), https://perma.cc/9SZV-QLAN. While Alphabet's claim of avoided emissions through Google Maps may have merit—if indeed Google Maps reduces user vehicle emissions—the company's purported emissions reductions rely on internal research and aren't currently used in other corporate accounting contexts. Alphabet could in theory have a defensible claim to these reductions by including the emissions from these routes *as well as* the purported Google Maps GHG reductions, but critically, it accounts for emissions reductions from a *source* it otherwise *excludes*.

upon which it was designed.[195] The GHG Protocol has arguably evolved in ways that echo other examples of indicators whose "technical role is essential to its credibility but at the same time […] is inevitably political, possibly in ways that differ from what the creators intended."[196] These tensions undermine corporate GHG ledgers.

The lack of oversight in corporate GHG accounting creates incentives for "cheap talk"[197] where corporations may abuse their discretion and exclude GHGs from their ledgers to curate an image of environmental stewardship. "Questionable, wonky, and often blatantly dishonest carbon accounting is rampant" because of such a vacuum,[198] particularly in corporate ledgers, which often deliberately exclude Scope 3 emissions.[199] Some attempts to remedy these enforcement and compliance issues are emerging, though they are facing an uphill battle. During the Biden Administration, the SEC's Final Rule on GHG disclosures was whittled down to omit Scope 3 reporting requirements (likely in an effort to preemptively mitigate expected legal challenges);[200] under the second Trump Administration, the SEC withdrew its defense of the rule in litigation in 2025.[201] A few months later, the Supreme Court's decision in *Seven County Infrastructure Coalition v. Eagle County, Colorado* further dealt a blow to incorporating supply chain GHG emissions in National Environmental Policy Act (NEPA) analyses.[202] In an international example, a report from the United Nations High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities outlined potential recommendations to address

195. *See, e.g.*, *About Us*, GHG Protocol, https://perma.cc/KAZ5-23HX (outlining how the GHG Protocol's use expanded over the years and how revised editions have included additional GHG sectors such as electricity use).

196. The Quiet Power of Indicators, *supra* note 29, at 7.

197. *See generally* Hsueh, *supra* note 187.

198. Gifford, *supra* note 22, at 296.

199. *See generally* Klaaßen & Stoll, *supra* note 35.

200. Jacqueline Vallette & Kathryne Gray, *SEC's Climate Risk Disclosure Proposal Likely to Face Legal Challenges*, Harv. L. Sch. F. on Corp. Governance (2022), https://perma.cc/T6UC-CNNK; The Enhancement and Standardization of Climate-Related Disclosures for Investors, 17 C.F.R. pts. 210, 229, 232, 239, 249 (2024).

201. *See* Press Release, U.S. Securities and Exchange Commission, SEC Votes to End Defense of Climate Disclosure Rules (Mar. 27, 2025), https://perma.cc/S4YP-4LHD (outlining a vote by the Securities and Exchange Commission to withdraw its defense of the climate disclosure rule in ongoing litigation and ceding any oral argument time to the Court); *see also* Letter from Respondent SEC (Mar. 27, 2025) at 1, National Center for Public Policy Research v. SEC, No. 24-2173 (8th Cir. June 10, 2024).

202. *Seven Cnty. Infrastructure Coalition v. Eagle Cnty., Colo.*, No. 23975, 605 U.S. ___, slip op. at 3 (May 29, 2025) (holding that the National Environmental Policy Act does not require that agencies consider any "upstream" and "downstream" GHG emissions and climate change impacts in their Environmental Impact Statements).

greenwashing and "dishonest climate accounting" in corporate GHG ledgers,[203] though the group itself does not wield the power to actually implement its own recommendations. Inconsistent (and sometimes conflicting) taxonomies in different GHG accounting regimes only further obscure these efforts.[204] Indeed, the lack of consistent, rigorous, transparent, and mandatory GHG accounting standards for non-state actors is a challenge to climate progress.

States can also drive statutory failures to account for GHGs. Such emissions omissions are sometimes intentional: for example, a Hawaii statute explicitly excludes all aviation emissions (even from domestic sources, which are generally accounted for) from the state GHG ledger.[205] The State of California provides a contrasting example with its accounting of on-road transportation emissions from biofuels. In California, the state legislature explicitly included overall biofuel GHG inventorying in its statutory language[206] and affirmed the importance of accurate ledgers.[207] Legislative history arguably suggests an intent to account for transportation-based biofuel emissions, since the Low Carbon Fuel Standard explicitly advocates for life cycle emissions accounting.[208] CARB used to account for on-road transportation biofuel GHGs but changed and excluded (though reported) them in 2016, treating them as zero, ostensibly by claiming that biofuels are net-zero fuels[209]—a claim disputed in scientific literature.[210] Perhaps unsurprisingly, the exclusion benefitted California's public image: if biofuel GHGs were accounted for, California's 2018 transportation sector emissions would have reported an increase, rather than a decrease, compared to the prior year.[211]

---

203. Integrity Matters, *supra* note 187, at 8.

204. Luers et al., *supra* note 13, at 656.

205. 2007 Haw. Sess. Laws 234, at 12.

206. Cal. Health & Safety Code § 39607.3(b)(1) ("Each inventory update shall include all of the following: (1) The state board's and each district's best estimates of emissions from all sources, including, but not limited to . . . biogenic sources.").

207. Cal. Health & Safety Code § 39607.3(d) ("The Legislature hereby finds and declares that it is in the interests of the state that air quality plans be based on accurate emission inventories. Inaccurate inventories that do not reflect the actual emissions into the air can lead to misdirected air quality control measures, resulting in delayed attainment of standards and unnecessary and significant costs.").

208. 17 Cal. Code Regs. § 95480.

209. California Inventory, *supra* note 7, at 8; Cal. Air Res. Bd., California's 2000-2014 Greenhouse Gas Emissions Inventory: Inventory Updates Since the 2015 Edition of the Inventory 10 (2016), https://perma.cc/G9Z7-WW5H.

210. *See generally* Eric Johnson, *Goodbye to Carbon Neutral: Getting Biomass Footprints Right*, 29 Env't Impact Assessment Rev. 165 (2009); Searchinger et al., *supra* note 107.

211. California Inventory, *supra* note 7, at 8.

Interestingly, CARB announced the biofuel emissions accounting change in a technical document,[212] presumably implying that the change was not substantial enough to constitute regulatory action.[213] Had CARB treated the change as so—arguably more appropriate, considering the impacts of the omission—it would have had to go through public comment and a more transparent approval process per the California Administrative Procedure Act.[214] In this case, broad statutory language—leading to CARB's ability to interpret the biofuel GHG exclusion as a methodological change which bypasses public scrutiny—creates discretion for government agencies to interpret accounting methodologies to their benefit, potentially resulting in undercounted GHG ledgers.

IV. Implications of Unaccounted-for Greenhouse Gas Emissions

Assessing the efficacy of climate solutions is essential to addressing climate change. Knowing *who* emits GHGs (and *how much*) is core to GHG accounting theory and climate law, necessary for understanding the status quo and attributing responsibility for the climate crisis.[215] Regulatory decisions based on poor or incorrect information can lead to perverse incentives and even harmful policy.[216]

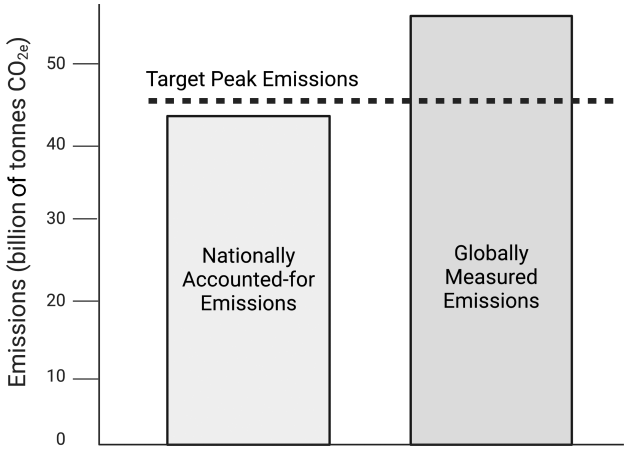
Entities who undercount their emissions may insufficiently reduce their overall emissions as well as underprioritize reducing emissions from the GHG sources they exclude from their ledgers. These accounting shortfalls thus compromise laws and policies that require accurate and complete emissions information to effectively address climate change. The following Part will describe the implications of unaccounted-for GHGs for climate and environmental law. Climate laws are weakened so long as unaccounted-for GHGs remain unaddressed.

A. Unaccounted-for Greenhouse Gas Emissions Undercount Emitters' Total Emissions, Leading Them to Insufficiently Reduce Overall Emissions

Perceptions of progress toward emissions reductions are likely to be overstated if there are substantial unaccounted-for GHGs, because the world would be missing the full picture when assessing climate responsibility (see Figure 4).

212. *Id.*; Cal. Air Res. Bd., *supra* note 209.
213. Cal. Gov. Code § 11342.600.
214. Cal. Gov. Code §§ 11340–11361 (§ 11346 in particular).
215. *See supra* Part I.
216. Freilich highlights how similarly poor information quality in patent applications may undermine the goals and values of patent law. *See* Freilich, *supra* note 37, at 2116, 2138.

Figure 4: The Deficit Between Nationally Accounted-for Greenhouse Gas Emissions Submitted to the United Nations Framework Convention on Climate Change Relative to Calculated Global Emissions in 2019.[217]



The dashed line represents the threshold for peak global emissions for the same year, according to a separate report by the IPCC outlining trajectories to limit global average temperature rise to 1.5 degrees Celsius, a threshold to avoid many of the most catastrophic climate impacts.[218]

Unaccounted-for GHGs also distort benchmarks that measure progress toward climate mitigation. Much of the UNFCCC process relies on accurately assessing the collective emissions of national governments against the world's remaining available GHG emissions limit (also known as a "carbon budget").[219] And international treaties such as the Paris Agreement require accurate and complete national GHG ledgers to be effective.[220] Indeed, the Paris Agreement harkens back to theories of indicators as sources of diplomacy: countries that submit inaccurate, misleading, or incomplete GHG ledgers erode the trust

217. Scientific analyses estimated 59 $GTCO_2$ total global GHG emissions in 2019. *See* Jan C. Minx et al., *supra* note 32, at 5213. In contrast, combined country National Inventory Reports were 44.2 $GTCO_2$. *See* Chris Mooney et al., *Countries' Climate Pledges Built on Flawed Data, Post Investigation Finds*, Wash. Post (Nov. 7, 2021), https://perma.cc/WML6-DEYR; *see also* John Muyskens et al., *Measuring the Invisible: How the Post Did Its Global Emissions Analysis*, Wash. Post (Nov. 7, 2021), https://perma.cc/6WVZ-RNZQ.

218. Intergovernmental Panel on Climate Change (IPCC), Special Report: Global Warming of 1.5°C, Summary for Policymakers 14 (Valérie Masson-Delmotte et al. eds., 2018).

219. *See generally* Friedlingstein et al., *supra* note 38.

220. Weikmans et al., *supra* note 88, at 4.

necessary for successful international governance.[221] Accordingly, unaccounted-for GHGs limit the credibility of UNFCCC mechanisms: it is harder to ascertain parties' successful climate mitigation if unaccounted-for GHGs remain unaccounted for. If national GHG ledgers consistently undercount emissions,[222] unaccounted-for GHG shortfalls will distort perceptions of progress and undermine the integrity of global climate agreements.

The Inflation Reduction Act ("IRA") illustrates how unaccounted-for GHGs can undermine current and future policymaking efforts to reduce GHGs. The IRA is widely touted as a transformative and historic climate law,[223] ostensibly reducing U.S. GHG emissions by 40% based on 2005 levels.[224] Many of the IRA's climate benefits rely on incentivizing "clean" energy sources that emit few or no GHGs.[225] For example, the IRA provides a Sustainable Aviation Fuel Credit for businesses using biomass-based jet fuel alternatives,[226] known as Sustainable Aviation Fuels (SAFs). Yet scientific evidence has called into question the net GHG reductions gained by using SAFs compared to conventional jet fuels.[227] Furthermore, the IRA created a methane emissions monitoring and reduction program under the EPA.[228] In response to this IRA provision, the EPA posted a Request for Information seeking input on how to revise methane emissions reporting methodologies.[229] How the EPA decides to account for methane emissions, and whether unaccounted-for GHGs will increase or decrease as a result, may impact the effectiveness of the IRA to curb methane oil and gas emissions. Aviation and methane are but two areas where unaccounted-for GHGs may impact the success of the IRA, though there are others, such as hydrogen fuels, "zero-emissions electricity generation facilities," and carbon removal and sequestration.[230] GHG accounting in these industries thus

221. *See supra* Part I.A.

222. *See generally* Deng et al., *supra* note 173 (illustrating patterns of undercounting in country National Inventory Reports compared to global atmospheric data).

223. *See generally, e.g.*, Don C. Smith, *Historic Climate Change Legislation Becomes Law: The United States Becomes Serious (At Least for Now) on Combatting Climate Change*, 40 J. Energy & Nat. Res. L. 403 (2022).

224. Based on the methodology in Methodological Appendix, *supra* note 17.

225. *See generally* Mark A. Luscombe, *Green Energy Credits and the Inflation Reduction Act Tax Trends*, 100 Taxes 3 (2022).

226. 26 U.S.C. §§ 40B, 6426(k); Inflation Reduction Act of 2022, Pub. L. 117-169, 136 Stat. 1818.

227. *See generally* Fabio Caiazzo et al., *Impact of Biofuels on Contrail Warming*, 12 Env't Rsch. Letters 1 (2017) (examining impacts of different SAF water contents on contrails and their contribution to overall atmospheric warming compared to fossil fuels).

228. Inflation Reduction Act § 60113.

229. U.S. Env't Prot. Agency, Request for Information, Methane Emissions Reduction Program, Docket No. EPA-HQ-OAR-2022-0875-0002 (2022), https://perma.cc/9REX-NJZY.

230. Jonathan L. Ramseur, Cong. Rsch. Serv., R47262, Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change 1, 6 (Oct. 26, 2023); *see* Inflation Reduction Act §§ 13104, 13204, 13702.

can influence incentives to invest in them.[231] Drawing on accounting concepts from Part II, the faithful representation and verifiability of GHG accounting for sources such as SAFs—particularly when these industries' "accounted-for" GHGs are lower than true emissions—will impact how effective climate laws will be in reducing actual GHG emissions. Finally, unaccounted-for GHGs weaken pathways to hold emitters accountable. Taken to an extreme, institutions could claim carbon neutrality while being net sources of carbon, depending on how they account for (and exclude) GHGs, perpetuating a "neutrality mirage."[232]

B. Unaccounted-for Greenhouse Gas Emissions Distort How Emitters Prioritize Their Mitigation Efforts

A common-sense implication of unaccounted-for GHGs is that they impact the climate mitigation policies that decisionmakers choose to implement. GHG accounting methods influence governance by outlining the bounds within which GHG emissions reductions strategies should take place, highlighting the sectors which deserve attention (accounted-for sectors) and those which do not (unaccounted-for sectors).[233] Jurisdictional responsibility drives emissions reductions.[234] Simply put, emitters are not motivated to invest resources in emissions reductions that they do not receive credit for in their GHG ledgers. Accounting methodologies affect political possibilities. The opening quote from a British Columbia government official explaining that the province would not be clear-cutting old growth rainforest on traditional Indigenous territory if GHG accounting methods changed underscores this point.[235] As another example, the

231. *See generally, e.g.*, Lin, *supra* note 75, at 703–05 (illustrating some of the motivations for companies to develop net zero emissions targets, including that "investing in companies that are implementing net zero strategies can benefit investors' bottom line by focusing on companies best positioned for the long term").

232. Shelley Welton coined the term "neutrality mirage" in reference to "accounting risks" in actors' net-zero pledges. *See generally* Welton, *supra* note 16.

233. Davis et al. illustrate how indicators and metrics can have governance impacts: "Indicators have knowledge effects by increasing awareness and specificity of standards. They smuggle theories of corruption, rule of law, and development into apparently neutral systems of measurement. . . . The underlying theories affect how decisions are made: indicators that become dominant persuade decision makers to follow their models. Indicators also affect governance when they specify a standard such that decision making becomes an assessment of performance with relation to the metrics of that standard." *See* The Quiet Power of Indicators, *supra* note 29, at 21.

234. *See generally* Michael P. Vandenbergh & Mark A. Cohen, *Climate Change Governance: Boundaries and Leakage*, 18 N.Y.U. Env't L.J. 221 (2010) (evaluating boundary-setting as a strategy to incentivize non-Kyoto Protocol countries to reduce their emissions).

235. Interview with British Columbia Official, *supra* note 1. *See also* William Boyd, *Ways of Seeing in Environmental Law: How Deforestation Became an Object of Climate Governance*, 37 Ecology L.Q. 843, 898–915 (2010) (describing how scientific paradigms impact forest governance).

entire socio-political regime of Reducing Emissions from Deforestation and Forest Degradation (REDD+) programs rests on wealthy countries investing in developing nations' forest projects so that wealthy nations can claim GHG reductions.[236] At the same time, empirical studies suggest that countries may be overestimating the potential of land to sequester carbon.[237] If properly accounting for these projects' GHGs means that they sequester less carbon than current ledgers claim, the projects could cease to be economically or politically desirable.

California's state-level GHG accounting illustrates how unaccounted-for GHGs impact policy decisions. In California's case, unaccounted-for GHG sectors include fugitive emissions from natural gas operations as well as emissions from international transportation (e.g., airports and maritime shipping).[238] The California biofuel transportation emissions case evokes the argument that incentives to "game" GHG ledgers exist when accounting rules allow for it, regardless of whether actors actually intended to mislead or misreport.[239] It also illustrates how unaccounted-for GHGs contradict principles of climate accountability: biofuel unaccounted-for GHGs had material impacts on the trend of the state's transportation sector emissions.[240] Had the state government publicly acknowledged this trend, it may have been motivated to implement additional good faith emissions reductions, or invested less in biofuels.

Wildfires are another illustrative example. There are fewer incentives to reduce wildfire unaccounted-for GHGs than if they were accounted for. Typically, fires that don't impact or directly threaten communities are not controlled or managed,[241] and wildfires themselves are rarely mitigated for GHG emissions, even though it is possible to reduce them by mitigating wildfire frequency and severity.[242] The motivations and incentives to reduce wildfire emissions are

236. Gifford, *supra* note 22, at 294.

237. *See generally* Giacomo Grassi et al., *Critical Adjustment of Land Mitigation Pathways for Assessing Countries' Climate Progress*, 11 Nat. Climate Change 425 (2021); Ana Meijide et al., *Measured Greenhouse Gas Budgets Challenge Emission Savings from Palm-Oil Biodiesel*, 11 Nat. Commc'ns 1 (2020).

238. *See, e.g.*, Cal. Air Res. Bd., California's Greenhouse Gas Inventory by IPCC Category (11th ed.), https://perma.cc/75J3-DWSW.

239. *See, e.g.*, Axel Michaelowa, *Joint Implementation—The Baseline Issue: Economic and Political Aspects*, 8 Glob. Env't Change 81, 82 (1998); Axel Michaelowa et al., *Additionality Revisited: Guarding the Integrity of Market Mechanisms Under the Paris Agreement*, 19 Climate Pol'y 1211, 1214 (2019).

240. California Inventory, *supra* note 7, at 8.

241. Phillips et al., *supra* note 107, at 3.

242. Governments can minimize wildfire damage through approaches such as: effective forest management, regular thinning to avoid buildup of vegetative matter (also known as "fuel"), limiting human population growth in forested areas, or reducing greenhouse gas emissions and fighting climate change. As one example, wind energy may reduce the transmission failures which frequently spark wildfires (with an added benefit of transitioning to renewable energy, mitigating climate change and thus also indirectly mitigating wildfire frequency and severity). *See generally* Rebecca Miller et al., *Barriers and Enablers for Prescribed Burns for Wildfire Management in California*, 3 Nat. Sustainability 101 (2020) (examining

distorted because they are unaccounted for: an analysis in Alaska and Northern Canada found that mitigating wildfire emissions is a cost-effective climate policy, but one that is seldom used because "limiting boreal wildfires has not been explicitly considered as a climate mitigation strategy."[243] Because wildfire emissions are unaccounted for, reducing them is not rewarded as climate mitigation, leading to adverse policy motivations.[244] Incentives to mitigate wildfire emissions are weak at best, if not entirely nonexistent.[245] Indeed, unaccounted-for GHGs affect real-life climate policy decisions.

C. Impacts on the Applicability of Carbon Pricing Mechanisms

Unaccounted-for GHGs could undermine the effectiveness of carbon pricing.[246] A frequently discussed climate policy,[247] carbon pricing typically consists of a carbon tax or a cap-and-trade scheme.[248] Carbon taxes aim to internalize

prescribed burns as a means of limiting wildfires in California); Christopher French, *America on Fire: Climate Change, Wildfires & Insuring Natural Catastrophes*, 54 U.C. Davis L. Rev. 817, 841–46 (2020); Anna Bernstein, *An Introduction to Joint Powers Authorities, Their Funding Mechanisms, and Why California Should Utilize One in Order to Create an Effective Forest Management System to Prevent Wildfires*, 16 Hastings Bus. L.J. 231 (2020) (arguing for a Joint Powers Authorities approach to wildfire management in California); Francisco Haces-Fernandez, *Wind Energy Implementation to Mitigate Wildfire Risk and Preemptive Blackouts*, 13 Energies 1 (2020) (illustrating how large-scale wind energy may reduce wildfire impacts and risks).

243. Phillips et al., *supra* note 107, at 3.

244. These emissions would be especially impactful if accounting for wildfire "knock-on" emissions which contribute to climate change, leading to more wildfires. *Id.*

245. As another example, British Columbia reports but does not account for wildfire emissions, measuring them but abdicating responsibility for them. Between 2012 and 2021, the province reported average annual wildfire emissions of 55.3 $MTCO_2e$, while its *entire* annual accounted-for emissions for the same period totaled 62.7 $MTCO_2e$. 1990-2021 Provincial Inventory: Province of British Columbia, https://www2.gov.bc.ca/assets/download/9CF9539647EF4CF2B584EEC3DEC061A7. Wildfire management is also absent from the province's list of climate mitigation priorities, and fires far from human communities are typically left to burn out. Gov't of British Columbia, Provincial Inventory of Greenhouse Gas Emissions, https://perma.cc/7RCG-YVQG; Gov't of British Columbia, Climate Action and Accountability, https://perma.cc/9PD5-8ZWK. Since the provincial government has been motivated to enact climate policies to reduce emissions that it does currently account for, wildfire emissions, substantial as they are, would more likely be mitigated if they were accounted for.

246. While a full assessment of the impacts of unaccounted-for GHGs on carbon pricing mechanisms is beyond the scope of this Article, it is worth briefly mentioning here.

247. *See* Frank Jotzo, *Australia's Carbon Price*, 2 Nat. Climate Change 475 (2012); Boqiang Lin & Zhijie Jia, *Impacts of Carbon Price Level in Carbon Emission Trading Market*, 239 Applied Energy 157 (2019); Yan Hao et al., *Modelling of Carbon Price in Two Real Carbon Trading Markets*, 244 J. Cleaner Prod. 118556 (2020).

248. *See generally* Reuven Avi-Yonah & David Uhlmann, *Combating Global Climate Change: Why a Carbon Tax is a Better Response to Global Warming than Cap and Trade*, 28 Stan. Env't L.J. 3 (2009) (assessing carbon tax and cap and trade mechanisms to limit GHGs).

climate harms within a product's price.[249] They thus build sociopolitical feedbacks[250] between actors and their behaviors to reduce GHG emissions. While the concept of a carbon tax is hardly new, GHG accounting practices have been relatively absent from tax analyses.[251]

Yet GHG accounting impacts fundamental tenets of carbon taxes, such as setting the tax rate, determining who is taxed, and dealing with international trade.[252] Set at the appropriate rate and targeted toward the right consumer base, a carbon tax can "[force] individuals to consider the full set of consequences from [GHG] emissions."[253] Unaccounted-for GHGs hinder lawmakers' ability to set the appropriate tax rate. When GHGs are unaccounted for, tax policies underestimate actual emissions, leading to missing information in the current tax price. This deficit could lead to a detrimentally low carbon tax that does not accurately reflect the cost of carbon. Adequately and completely accounting for GHG emissions is a prerequisite for carbon taxes to work in support of these principles.[254] The implications of unaccounted-for GHGs also extend beyond carbon taxes and into pricing schemes such as cap-and-trade systems. As with carbon taxes, if unaccounted-for GHGs are *unaccounted for*, the carbon price will be set at a lower price than what it ought to be.[255]

249. *See generally* N. Gregory Mankiw, *Smart Taxes: An Open Invitation to Join the Pigou Club*, 35 E. Econ. J. 14 (2009) (making the case for a carbon tax as a climate policy solution).

250. Peter Howard & Michael A. Livermore, *Sociopolitical Feedbacks and Climate Change*, 43 Harv. Envtl. L. Rev. 119, 136–38 (2019).

251. For example, a report by the U.S. Department of the Treasury Office of Tax Analysis, outlining methodologies to analyze carbon taxes, presumed that the Internal Revenue Service could adopt EPA GHG accounting guidelines without critically evaluating differences in accounting methodologies. John Horowitz et al., *Methodology for Analyzing a Carbon Tax* 8 (Treas. Off. Tax Analysis, Working Paper No. 115, 2017).

252. *See generally, e.g.*, Gilbert E. Metcalf & David Weisbach, *The Design of a Carbon Tax*, 33 Harv. Envtl. L. Rev. 499 (2009).

253. *Id.* at 500.

254. Furthermore, determining the appropriate tax base is challenging for many unaccounted-for GHG sectors. The tax base might not be easily determined, or the most reasonable tax base may not actually be the individuals or institutions in positions of decision-making power. The aviation sector is such an example: taxes levied on the aviation industry will likely be passed on to consumers who may not wield the power to overhaul the aviation industry's activities to be less carbon intensive. What is needed in the case of aviation emissions is government regulation of the industry that accelerates a renewable energy transition, and less so a tax on consumers who often do not have alternative means of transportation available to them. Herein lies an implication that unaccounted-for GHGs have for carbon taxes: they may disrupt this actor-behavior-emissions relationship that underpins carbon tax policy.

255. Conversely, if unaccounted-for GHGs *were* subsequently accounted for, the flood of emissions could lead to dysfunctions within carbon markets, potentially driving prices so high that the markets become untenable. *See, e.g.*, Lesley K. McAllister, *The Overallocation Problem in Cap-and-Trade: Moving Toward Stringency*, 34 Colum. J. Env't L. 395, 426–27 (2009) (emphasizing feasibility as a standard when designing cap-and-trade systems).

V. Getting Greenhouse Gas Accounting Right

Unaccounted-for emissions undermine accounting goals by obstructing the assignment of responsibility and impeding perceptions of progress towards emissions reductions pledges. Emissions omissions could plausibly be the result of a mere failure to understand GHG emissions science and mitigation, or of a deliberate policy choice. Arguably, both causes have contributed to the problem: the perceived apolitical and technical nature of GHG accounting made it easier to create (and maintain) a system that excluded emissions, and the political economy of GHG accounting and climate policy made exclusions a convenient loophole in a policy compromise. This Part outlines recommendations to improve GHG accounting, informed by these dual causes as well as the aims and principles outlined in Part II, in addition to drawing on other areas of law such as financial reporting. To fulfill their goal of stymying atmospheric concentrations of GHGs, climate laws and policies need entity-level accountability for emissions. GHG ledgers which are accurate, complete, consistent, comparable, and standardized drive this accountability. While each recommendation outlined below will not address unaccounted-for GHGs alone, they collectively tackle different components of the problem, ultimately moving GHG accounting closer to the ideal.

A. Accountability in Greenhouse Gas Accounting

In this section, the Article returns to the normative discussion in Part II to argue that GHG accounting systems ought to embrace a *zone of influence* approach, bearing in mind the current GHG accounting landscape described in Part III and the unaccounted-for GHG problems highlighted in Part IV.[256] GHG accounting systems must: (1) fully and accurately account for actors' emissions (including omitted emissions); (2) hold actors responsible for their contributions to climate change; (3) incentivize emissions reductions; and (4) acknowledge and respond to ledgers' political nature. Considering these needs, ledgers ought to embody emitters' *complete* climate responsibility, which this Article argues cannot be achieved with a mutually exclusive approach. Notably,

256. An important distinction that zone of influence is not the same as Scope 3—the former represents a *worldview*, while the latter represents a *category* of emissions. "Zone of influence" is a philosophy or a belief about what emissions an actor ought to be responsible for, while Scope 3 represents a list or category of different emissions sources that could be included in a ledger. Scope 3 emissions are mutually exclusive from Scope 1 as well as Scope 2 emissions. Zone of influence is the belief system about what an actor should be responsible for (i.e., what should be accounted for in their ledger) and a conception of responsibility which *includes* Scope 1, Scope 2, and Scope 3 emissions—and perhaps even emissions which aren't usually included in Scope 3, such as work-from-home emissions. *See, e.g.*, Vandenbergh & Shewmake, *supra* note 30, at 783–84, 794. Zone of influence is the worldview that *all* those scopes ought to be accounted for in a ledger.

producing complete GHG ledgers may in and of itself drive behavior change, since merely disclosing emissions may encourage emitters to reduce them.[257]

The zone of influence approach is appropriate for a few reasons. First, GHG accounting in the context of law and policy is entity-based rather than global in nature. This Article dispels the myth that global emissions measurements are obtained by tallying actors' GHG ledgers.[258] Nor is such a global value used to mandate specific actors' emissions reductions: in fact, national pledges do *not* currently match global mitigation benchmarks.[259] Instead, legal and socio-political systems (and stakeholders such as advocates, emitters, and decisionmakers) *refer to* the global emissions data that scientific bodies produce, including information outlining the required collective reductions in GHG emissions needed, to drive climate laws and policies. The zone of influence approach thus still can (and does) incorporate global emissions data.

Second, while GHG ledgers do not exist to provide a global emissions total, they *must* hold emitters accountable to their contributions to climate change through entity-level accounting. Herein lies another drawback of the mutually exclusive approach: truly dividing all emissions among emitters requires extensive political capital, and consensus on any single responsible actor for a given emissions source—let alone all emissions sources—may be impracticable. Even if reaching such an agreement were possible, the mutually exclusive approach also ignores offshoring risks, where both governments as well as corporations may offshore emissions outside their geographic boundaries to falsely claim emissions reductions. Here is where the "double counting"[260] of the zone of influence system is beneficial: it acknowledges the fact that multiple actors contribute to emissions sources. GHG accounting systems aim to know not just the number of GHGs emitted into the atmosphere, but *all who are responsible* for them. For example, if an actor consumes imported goods, the GHG emissions associated with the production of that good should be part of that actor's

257. *See, e.g.*, Katrina Fischer Kuh, *Informational Regulation, the Environment, and the Public*, 105 Marq. L. Rev. 603, 660 (2022) ("Disclosure may shape behavior as regulated entities and agencies respond substantively to public input. . . . Regulated entities and agencies may also change behavior preemptively because they anticipate that the disclosure of environmental information will harm their reputation, generate civic opposition, give rise to legislative or regulatory obstacles or tort suits, or occasion bad market effects as individuals (or investors) shun their services or products. Interestingly, public disclosure appears to exert a powerful influence despite the fact that individuals typically remain largely unaware of or fail to understand the information subject to disclosure. These laws generate public disclosure without widespread public comprehension . . . disclosure nonetheless prompts significant upstream catalyst effects").

258. *See supra* Part I.A.

259. *See generally* U.N. Env't Programme, Broken Record: Temperatures Hit New Highs, Yet World Fails to Cut Emissions (Again) (2023) (highlighting that national governments' collective Paris Agreement commitments fall well below the necessary reductions to limit global warming to below 2 degrees Celsius).

260. *See supra* note 46.

ledger.[261] Because of the need to assign responsibility for emissions in this manner, this Article argues that GHG accounting should capture actors' *complete* GHG emissions contributions through a zone of influence approach, rather than to produce a single hierarchy of mutually exclusive ledgers with emissions assigned to only one actor.[262]

Third, an added benefit of zone of influence ledgers is that they motivate actors to reduce emissions across their supply chains. For example, because they stand to also benefit from supply chain emissions reductions, companies may seek out suppliers with lesser GHG footprints, creating a market for decarbonization within GHG accounting itself. And accounting for contentious unaccounted-for GHG sectors may help foster the collaboration needed to decarbonize those industries. For example, a zone of influence approach in UNFCCC ledgers takes contentious industries like international aviation and makes all parties accountable for them, rather than the more likely outcome under a mutually exclusive approach: parties blaming one another for those emissions in attempts to shirk responsibility. The zone of influence approach acknowledges that multiple parties cause certain emissions, and that multiple parties can help reduce them.

B. Consistency and Comparability Through Interoperability

As described in Part II, GHG accounting practices should be consistent, comparable, and transparent. Currently, this is not the case. To achieve this outcome, this Article recommends creating interoperable GHG ledger systems. Often referenced in computer science, interoperability is the ability of multiple systems or components "to cooperate despite differences in language, interface, and execution platform."[263] Interoperability in GHG accounting is the ability for ledgers across actors and scales to convey information in ways that match common and agreed-upon standards. Interoperable GHG accounting systems

261. A potential critique of zone of influence accounting is that accounting for supply chain emissions may be onerous and overwhelming to reporting entities or otherwise politically infeasible. Here, the City of New York is an informative example. In 2023, the Department of Environmental Protection of New York City released a consumption-based GHG inventory that provided crucial insights on the City's overall climate contributions and spurred the adoption of new mitigation measures. While the Commissioner noted that producing this ledger took more effort than previous mutually exclusive ledgers, he also noted that such ledgers didn't need to be produced as regularly to still be informative. In this way, New York City can serve as a "second-best" exemplar for zone of influence GHG accounting. N.Y.U. L. Sch., *Counting What We Consume: A Conversation with Rohit Aggarwala and Kate MacKenzie*, Vimeo (May 26, 2023), https://perma.cc/EB9V-63AE.

262. Measuring global emissions is important, but that is rather the aim of knowledge systems (e.g., scientific institutions such as the Global Carbon Project) compared to the legal aims of GHG accounting, which are climate *accountability* and *responsibility*. This different governance goal impacts system design: complete zone of influence ledgers are essential to scrutinizing specific actors' emissions.

263. Peter Wegner, *Interoperability*, 28 ACM Comput. Surv. 285, 285 (1996).

are open, consistent, and possess aligned vocabulary, definition, methods, and validation techniques.

Interoperability means that GHG entity accounting systems can work together despite different contexts. For example, corporate GHG accounting serves different actors and scales (e.g., multinational corporations and local businesses in different countries) compared to the UNFCCC (national governments under a global treaty), but interoperability would enable both systems to exchange and convey information. In other words, the public should be able to understand Alphabet's and Slovenia's ledgers, which are approximately the same size,[264] and hold both actors accountable (though how that accountability takes shape may differ for each).[265] This reviewability is essential for the accountability and responsibility that GHG accounting systems aim to uphold.

GHG accounting systems can be made interoperable in a few ways. First, systems ought to share vocabulary and common definitions for the same terms.[266] "Measured", "reported", and "accounted-for" emissions should be defined equally in both governmental and private sector ledgers. And within corporate GHG accounting, "Scope 3" emissions should embody actors' complete emissions from company to company. In other words, Apple shouldn't be allowed to exclude Scope 3 emissions that Alphabet includes. A second related step to achieve interoperability is to develop a shared and complete list of all GHGs and sectors which ought to be accounted for, so that omissions are more explicit (and thus likely to be recognized). Third, different GHG accounting software and methodologies ought to be able to exchange information.[267] For example, in national accounting, software differences between IPCC guidelines and UNFCCC reporting make it impossible to incorporate parties' GHG ledgers within information-sharing platforms.[268] Finally, GHG accounting systems should use the same time horizons. As one example, all actors should account for forest offsets in their ledgers on the same timelines, to mitigate pre-emptive and inflated carbon sequestration claims.[269] Similarly, GHG ledgers should

264. Alphabet, *supra* note 191, at 23; Greenhouse Gas Inventory Data—Detailed Data by Party, https://perma.cc/675S-4BH8.

265. To be clear, the argument is not that Slovenia and Alphabet should be treated equally, as they belong to different accounting systems (governmental and corporate). However, every emitter ought to be held accountable to their GHG emissions, whether that's through shareholders in Alphabet's case, or civil society and the UNFCCC in Slovenia's.

266. *See generally* Marian Van Pelt et al., Roadmap to More Interoperable Greenhouse Gas Emissions Accounting: The Carbon Call (2022), https://perma.cc/N53X-AB3Q.

267. Luers et al., *supra* note 13, at 656.

268. Paris Agreement to the Glasgow Climate Change Conference ¶ 19, https://perma.cc/4VYJ-B86Q; *Greenhouse Gas Data*, U.N. Climate Change, https://perma.cc/SJ89-ATDH ("Some non-Annex I Parties submitted their GHG inventory data using the format of the 2006 IPCC Guidelines in reporting GHG emissions/removals. For this reason, these data could not be included in the data interface.").

269. Moreover, a replanted forest should be accounted for in ways that both recognize GHG accounting goals (reducing emissions) and discretion (incentives to greenwash): using

limit lags between when emissions take place and when ledgers are released. Doing so increases accountability by providing information about an actor's emissions with enough time to respond and change behaviors to reduce them. These changes, combined with identifying a standard setter, will help make GHG accounting systems interoperable.

1. Greenhouse Gas Accounting Standard Setter

Interoperability requires comparability, which requires standardization. One consideration for achieving standardization is identifying a standard setter (or task force) to mandate universally adopted, rigorous, complete GHG accounting standards that accurately reflect the best available peer-reviewed evidence. A good standard setter would establish publicly accessible GHG accounting standards that national governments as well as subnational and private actors could use.

Although necessary, identifying a GHG accounting standard setter—and implementing those standards—raises challenges. There is a risk that aiming for universally adopted standards creates a "race to the bottom" where the standards only include uncontentious GHG accounting sectors, resulting in unaccounted-for GHGs. Identifying the standard setter among many options may be challenging. And there will certainly be resistance to reforming current GHG accounting processes by adopting new standards, both in terms of the inertia and path dependence of current accounting methods, as well as actors' resistance to accounting changes that would increase their accounted-for emissions. Addressing these challenges will be difficult, but not impossible.

To address "race to the bottom" concerns, providing the standard setter with a non-exhaustive list of required GHG sectors to include in the standards may help (as would public participation in developing that list).[270] As for

standards that integrate factors such as the risk of the forest burning or being sold and logged, as well as the most rigorous scientific information available.

270. A second-best option draws on the materiality threshold used in financial reporting to determine whether a firm should disclose a particular activity in its reports. Amanda Rose, *A Response to Calls for SEC-Mandated ESG Disclosure*, 98 Wash. U. L. Rev. 1821, 1833 (2020) ("The SEC defines material information as information that a 'reasonable investor' would be substantially likely to consider important in making an investment decision."). Financial Accounting Standards Board's definition of materiality is particularly compelling: "Materiality is entity specific. The omission or misstatement of an item in a financial report is material if, in light of surrounding circumstances, the magnitude of the item is such that it is probable that the judgment of a reasonable person relying upon the report would have been changed or influenced by the inclusion or correction of the item." Fin. Acct. Standards Bd., *Chapter 3: Qualitative Characteristics of Useful Financial Information, Conceptual Framework for Financial Reporting*, *in* Statement of Financial Accounting Concepts No. 8 2–3 (2018). At minimum, accounting regimes ought to adopt a similar tenet where as many materially significant unaccounted-for GHGs are included in standards. Ultimately, while accounting for all GHGs is a laudable goal, accounting for *de minimis* unaccounted-for

selecting the right standard setter and political resistance, other areas of law may be instructive. For example, the International Accounting Standards Board is responsible for developing and maintaining International Financial Reporting Standards (IFRS) which have been adopted by most countries.[271] To ensure appropriate standard setting, the IFRS Constitution outlines membership (such as geographic diversity, shared values of integrity and public welfare), an organizational structure that regularly revises standards, and mechanisms for transparency and due process.[272] Similar processes may inform the creation and identification of a GHG accounting standard setter.[273] While establishing global GHG accounting standards requires effort, it is essential for the interoperability that GHG accounting systems require to fulfill their goals.

Interoperability will help address unaccounted-for GHGs by creating consistency and comparability, which will then make it easier to identify omissions. It makes GHG accounting systems more accessible, which enables scrutiny (and therefore accountability). Of course, interoperability alone will not eliminate unaccounted-for GHGs—doing so would also require oversight and reliability, which the next Part outlines.

C. Discretion and How to Address It

Fixing GHG accounting requires acknowledging that it is not a neutral activity, but one rife with discretionary, political choices.[274] It is essential to regulate GHG accounting systems—and constrain actors' discretion—for these regimes to be effective. Dealing with discretion is a key consideration for any accounting system. Accounting systems often navigate discretionary reporting

GHGs (e.g., emissions meeting a stringent threshold such as <1% of an actor's total true GHG footprint) may not be desirable, especially if doing so would divert limited resources that would otherwise be spent on climate mitigation. Michael R. Boswell et al., *Greenhouse Gas Emissions Accounting: With Contributions by Eli Krispi*, *in* Climate Action Planning 94, 112 (2019). *De minimis* concerns notwithstanding, entire unaccounted-for GHG industries such as international aviation and maritime shipping are material unaccounted-for GHG sources that must be accounted for.

271. *Who We Are*, IFRS Found., https://perma.cc/9X6D-NMKG. Of note: the International Accounting Standards Board recently established a sister International Sustainability Standards Board (ISSB), one of the GHG accounting approaches mentioned in Part III. The ISSB is currently focused on corporate sustainability disclosures, however, which is both broader than GHG accounting and limited to corporate ledgers.

272. *See generally* IFRS Found., Constitution (2021), https://perma.cc/2ZND-E2HK.

273. Engaging accredited auditing and accounting firms, as is done in financial reporting, in implementing standards can also create industry support (and private sector incentives to advocate for those standards as a safeguard against future administration changes).

274. GHG accounting illustrates the "soft law" and "quiet power" of indicators and metrics. The Quiet Power of Indicators, *supra* note 29, at 3.

challenges,[275] and GHG accounting is no exception. Disclosed information can be hard to quantify.[276] Take the forestry sector, where everything from the type of soil, the climate, and the diversity and species of vegetation affects how much carbon a forest removes from the atmosphere.[277] This complexity can make misreporting difficult to detect. What's more, flexibility in GHG accounting systems—providing actors with discretion in when, how much, and what to report—creates opportunities for discretionary misreporting. For example, government agencies are given discretion to use different methodologies to account for forest soil carbon, some of which require little input information (crudely and simply estimating emissions using climate and soil types, e.g., "boreal sandy") and others which make extensive use of data.[278] As a result, different government agencies may end up with different GHG ledgers for the same region despite having the same data.[279] While simplifying complex issues through numerical representation is thought to foster informed decision-making,[280] there is a risk that these oversimplifications create opportunities to use discretion in ways that undermine the effectiveness of the disclosure.[281] Different interpretations[282] of GHG accounting principles may lead to incomplete or inadequate ledgers.[283]

275. While transparency and disclosure may be seen as value-neutral, in practice power influences what information is shared, how, and by whom. Freilich, *supra* note 28, at 41; The Quiet Power of Indicators, *supra* note 29, at 4. Disclosure systems, by virtue of how they collect and disseminate data, are interpretive. Richard Rottenburg & Sally Engle Merry, *A World of Indicators: The Making of Governmental Knowledge Through Quantification*, *in* The World of Indicators: The Making of Governmental Knowledge through Quantification 11–13 (Richard Rottenburg et al. eds., 2015). Decisions about "what to measure and what to ignore" are sources of contestation and "establish[] a normative system through quantification." The Quiet Power of Indicators, *supra* note 29, at 7, 17. And contrary to public perception, financial accountants recognize that "[a]ccounting is not an exact science" but a practice "rooted in the value system of our society." Bernstein & Wild, *supra* note 27, at 78.

276. As is the case with Rule of Law indicators. *See generally* The Quiet Power of Indicators, *supra* note 29.

277. Werner Kurz et al., *CBM-CFS3: A Model of Carbon-Dynamics in Forestry and Land-Use Change Implementing IPCC Standards*, 220 Ecological Modelling 480 (2009).

278. *National Inventories*, *supra* note 31, at 203.

279. *Id.* at 211–12 (quoting Canadian officials that federal and provincial agencies end up with different GHG ledgers despite using the same data).

280. Rottenburg & Merry, *supra* note 275, at 7.

281. Daniel Ho examines how such discretion impacts the efficacy of restaurant grading programs. *See generally* Ho, *supra* note 37.

282. The Rule of Law is relevant here in that "thin"—formal or institutional, as opposed to substantive, or "thick"—interpretations undermine its ideals when interpreted in misleading ways. Similarly, current GHG accounting systems allow actors discretion that can artificially minimize their carbon footprint. *See* Frank Schimmelfennig, *A Comparison of the Rule of Law Promotion Policies of Major Western Powers*, *in* Rule of Law Dynamics: In an Era of International and Transnational Governance 113 (Michael Zürn et al. eds., 2012).

283. Luers et al., *supra* note 13, at 654.

Because GHG accounting occurs within the contentious politics of climate change, actors may be motivated to use discretion to abdicate responsibility for their emissions or otherwise "greenwash" their activities.[284] Therefore, it is critical that GHG accounting systems acknowledge and address discretion. The conservatism principle used in securities law is informative here. Used to mitigate discretion in financial reporting, conservatism dictates that actors should report their activities as accurately as possible, and in the absence of accurate data, they should use the approach that yields the most conservative outcome.[285] Here, the conservative approach to GHG accounting would be the one that leads to higher GHG emissions in ledgers. These discretion safeguards should be built into GHG accounting standards.

Moreover, as in financial reporting, GHG accounting systems ought to have ex post verification processes to ensure that ledgers are reliable and that emissions are completely and accurately accounted for. To mitigate discretion, financial reporting systems possess internal and external controls—including internal audits, separation of duties within institutions, and external audits performed by accredited third parties[286]—to ensure rigorous and truthful reporting.[287] GHG accounting regimes ought to have these controls to increase transparency and to treat discretion in accordance with robust accounting standards. The *implementation* of information disclosure systems impacts how effective they will be.[288]

1. Oversight to Enforce Compliance with Accounting Standards

A robust enforcement system is required to address non-compliance with equally robust standards. GHG accounting regimes should therefore be designed to anticipate and manage the monitoring, compliance, and enforcement challenges facing other disclosure systems.[289] In environmental law, firms have incentives to avoid documenting or publicizing environmental pollution, and statutory regimes may enable reporting loopholes.[290] Many environmental compliance systems are weak, such as the National Pollutant Discharge Elimination System (NPDES) permits used in water quality regulation, which lack

284. GHG ledgers, as public declarations of actors' alleged GHG emissions reductions, also lend those actors both credibility as well as influence. *See generally* Hsueh, *supra* note 187.

285. Fields, *supra* note 47, at 84 ("[C]onservatism requires that 'bad news' be recognized when the condition becomes possible and the amount can be estimated, whereas 'good news' is recognized only when the event . . . has actually occurred.").

286. *See generally* Reed Storey & Sylvia Storey, Fin. Acct. Standards Bd., The Framework of Financial Accounting Concepts and Standards (1998).

287. *See, e.g.*, Peter Easton et al., Financial Accounting for MBAs 29–32 (7th ed. 2017).

288. The Quiet Power of Indicators, *supra* note 29, at 14.

289. For example, Janet Freilich has critiqued the failures of the U.S. Patent and Trademark Office to monitor patent applications for incorrect information and enforce sanctions against applicants who submit them. Freilich, *supra* note 28, at 21.

290. *See* Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 Duke L.J. 1619 (2004).

meaningful compliance and make the NPDES less reliable.[291] Conversely, the Resources Conservation and Recovery Act (RCRA)[292] effectively emphasizes strong monitoring, compliance, and enforcement. Core to RCRA is a stringent manifest system that "tracks hazardous wastes from 'cradle to grave.'"[293] The manifest contains both a universal form and instructions for proper waste handling. Additionally, personnel undergo appropriate training, which helps ensure RCRA compliance.[294] RCRA thus has a comprehensive, rigorous, precise monitoring system. GHG accounting ought to incorporate similarly stringent monitoring, compliance, and enforcement mechanisms to adequately hold emitters accountable.

First, an oversight body ought to be created to monitor and enforce adherence to corporate GHG accounting standards.[295] Financial reporting is again instructive here: to increase accountability, securities laws include an intricate set of provisions designed to detect, deter, and punish misreporting.[296] The SEC, then, as the oversight body, enforces violations of financial reporting laws accordingly.[297] Implementing similar accountability mechanisms for "'patently misleading,' 'grossly unreliable,' or 'effectively incomprehensible'"[298] GHG ledgers would substantially improve them. While a full development and analysis of an oversight body is beyond this Article's scope, adequate and effective oversight can mitigate discretionary misreporting in GHG accounting and make ledgers more reliable.

A top-down approach to this oversight is ideal because it would centralize and standardize enforcement, making it more likely to find and address noncompliance. A federal agency would be well-suited for this task, though such an approach may attract potentially insurmountable major questions challenges

---

291. Giles, *supra* note 45, at 51–55.

292. 42 U.S.C. §§ 6901–6992.

293. Revesz, *supra* note 26, at 610.

294. 40 C.F.R. §§ 262.20, 264.16. To be sure, RCRA has its critics. The high cost of the monitoring program is often a political target. *See, e.g.*, Off. Mgmt. & Budget, Report to Congress on the Costs and Benefits of Federal Regulations (1997) (responding to Thomas Hopkins' critiques of RCRA costs).

295. In theory, voters would provide oversight for national or subnational government GHG accounting, or otherwise the UNFCCC at the international level.

296. Sarbanes-Oxley Act of 2002, Pub. L. No. 107-204, § 302, 116 Stat. 745 (2002).

297. To be sure, today's financial reporting and securities laws are imperfect, and misreporting remains an important problem. However, financial accounting systems nonetheless have structures in place that at least aim to minimize discretion and misreporting, structures—such as accredited standard setters, internal and external controls, etc.—that GHG accounting systems currently lack. *See supra* Part V.C.

298. These terms were originally used in the context of chemical regulation but are also applicable here. Wendy Wagner & Will Walker, Incomprehensible: A Study of How Our Legal System Encourages Incomprehensibility, Why it Matters, and What We Can Do About It 153 (2019).

in the aftermath of *West Virginia v. EPA*.[299] Considering this current judicial reality, cross-jurisdictional approaches may hold more promise. For example, potential alternatives may include the European Union's European Sustainable Reporting Standards (ESRS) scheme, which is more stringent than the SEC's Proposed Rule.[300] Similarly, California's recent legislation mandating full supply chain GHG emissions disclosures for all companies (public and private) operating in the state with over one billion dollars in revenue is also promising.[301] Finally, a self-regulating approach may be possible with zone of influence ledgers, which can help create internal checks for misreporting among actors who have overlapping zones of influence. Such a system motivates actors to ensure that their suppliers are reporting emissions in good faith, which could also create incentives for private actors to self-regulate and identify fraudulent ledgers.[302] A full analysis of the benefits and drawbacks of federal, cross-jurisdictional, and self-regulation possibilities merits extensive future research outside the scope of this Article.

2. Transparency (and Transparency About Transparency)

Second, transparency is essential to address discretion. Without access to data, it is much harder for local communities to demand that their governments incorporate unaccounted-for GHGs into climate action plans.[303] Oftentimes, actors themselves produce emissions data, as with California's unaccounted-for GHGs[304] and with many corporate GHG ledgers.[305] Democratizing access to this knowledge could help foster accountability.[306]

---

299. 597 U.S. 697 (2022) (holding that EPA, in its proposed regulation of power plant GHG emissions, overstepped its authority because Congress did not expressly and clearly authorize it to do so under the major questions doctrine). Considering that the Court didn't find that the EPA, whose mandate is environmental protection, had the authority to regulate power plant GHG emissions in *West Virginia*, it seems even more unlikely that it would find that the SEC, tasked with securities regulation, does have such authority. What's more, it is unlikely that any federal agency will prioritize improving GHG emissions accounting under the Trump Administration. *See, e.g., supra* note 201.
300. *See generally* EY, Technical Line No. 2022-08: How the Climate-Related Disclosures Under the SEC Proposal, the ESRS and the ISSB Standards Compare (2023).
301. Cal. Health & Safety Code § 38532.
302. Other actors within the same supply chain may also more easily spot suspiciously low GHG footprints compared to competitors, which may assist monitoring efforts.
303. *See generally* Luers et al., *supra* note 13.
304. *See generally* California Inventory, *supra* note 7; Wildfire Emissions, *supra* note 7, at i.
305. *See, e.g.*, *Guidance for Companies*, *supra* note 182.
306. It also could increase capacity by making the best use of scientific and technical resources. *See, e.g.*, Holly Doremus, *Data Gaps in Natural Resource Management: Sniffing for Leaks along the Information Pipeline*, 83 Ind. L.J. 407, 461–62 (2008).

In this spirit, GHG ledgers ought to be accessible first by expanding the public's ability to *understand* GHG ledgers and methodologies, and second, by providing more opportunities to *engage* in advocacy and comments concerning them. Critically, this information must be presented in a way that is transparent as well as comprehensible.[307] In an ideal world, GHG ledgers would be so well-disclosed that the average individual would be able to read and understand them; in reality, achieving this kind of lay disclosure is notoriously difficult,[308] particularly with a process as complex as GHG accounting.[309] At the very least, however, GHG ledgers ought to be accessible and understandable to so-called "intermediary groups,"[310] the individuals or organizations who already have some familiarity with the disclosing actor or project. For example, a community organization writing a public comment concerning the environmental impacts of a proposed local biofuel refinery ought to be able to both access and understand their municipality's GHG ledger; an investor interested in sustainability investing ought to be able to access, understand, and scrutinize different corporations' GHG ledgers. As Katrina Kuh writes: "[o]rganized interest or community groups can effectively use disclosed information and publicize (or threaten to publicize) the information to a broader public audience and use the resulting public concern (or threat of the same) as currency to pressure commercial entities or agencies."[311] Prioritizing transparency and access for engaged organizations and individuals is essential to assigning accountability for emissions omissions.

To be clear, this recommendation explicitly argues for a public information disclosure system that differs from current ones in consequential ways:[312] it must be easy for (at minimum intermediary) non-experts to critique and discern;[313] it must require comprehensive reporting, clearly listing the GHG accounting method(s) used and why; it must combine ground-truthing (e.g., using remote

307. *See, e.g.*, Cass R. Sunstein, *Nudging: A Very Short Guide*, 37 J. Consumer Pol'y 583, 585–86. (2014) (highlighting the importance of simplification and ease of understanding when it comes to disclosure to drive policy change).

308. *See, e.g.*, Kuh, *supra* note 257, at 604, 659 ("information cannot simply be pumped into the public domain and expected to enlighten individuals" […] Mandated public disclosure often fails to meaningfully inform the lay public as an audience while nonetheless catalyzing sometimes significant responses by upstream actors").

309. Wendy Wagner and Will Walker make the case for data comprehensibility by outlining how an overabundance of information that is challenging to sift through can hamper the public's ability to understand law and policy. *See generally* Wagner & Walker, *supra* note 298.

310. Kuh, *supra* note 257, at 660.

311. *Id*. at 660–661.

312. *See, e.g.*, Omri Ben-Shahar & Carl Schneider, *The Failure of Mandated Disclosure*, 159 U. Pa. L. Rev. 647, 711–26 (2011) (highlighting the different ways in which mandated disclosures fail, such as when there is information overload or when disclosees who lack expertise to read the disclosures misunderstand them).

313. *See, e.g.*, Annie Brett, *Rethinking Environmental Disclosure* 112 Calif. L. Rev. 1535, 1581 (2024) ("For information-based regulation to work, it is essential that collected information is disseminated in ways that make it accessible and understandable for impacted parties").

sensing data to verify ledgers); it must undergo quality assessments to ensure data integrity.[314] Importantly, this disclosure ought to be understandable and as simple[315] as possible—no easy feat, and likely one that will require disclosure systems to be iterated on and improved as needed to ensure that they are effective.[316] With such a system of transparency in place, stakeholders will be able to better understand and proactively engage with GHG ledgers.[317]

Finally, actors should clearly identify any discretion they exercised to produce ledgers. Borrowing from securities regulation, GHG ledgers should include statements about the methods used and the rationale for doing so, including a statement of methods' benefits and drawbacks.[318] The need for "transparency about transparency" underpins legal scholarship in information disclosure.[319] For example, it bears similarities to Freilich's recommendation of including disclaimers that clearly specify the limitations and drawbacks of the information available on government websites.[320] While transparency about transparency alone will not eliminate unaccounted-for GHGs, it is a necessary element.

D. Sufficiently Reliable, Decision-Useful Accounting

1. Integrating Best Available Scientific Evidence and Technology

Scientific evidence and technology can be important controls for mitigating discretionary GHG accounting by enabling external ledger verification and validation and by ensuring that ledgers accurately and completely represent an entity's emissions. Remote sensing, machine learning, and artificial intelligence are all powerful tools that can help increase available data, resource capacity, and ledger reliability.[321] In corporate GHG accounting, El-Jourbagy and Gura highlight how the SEC can include satellite data in mandated climate

314. Janet Freilich highlights how quality assessment and control is critical for effective information disclosure. *See generally* Freilich, *supra* note 28.

315. Ben-Shahar & Schneider, *supra* note 312, at 743–44.

316. Sunstein, *supra* note 308, at 585 ("Bad surprises certainly are possible, including unintended adverse consequences, and sensible policymakers must try to anticipate such surprises in advance (and to fix them if they arise). . . . Experimentation, with careful controls, is a primary goal of the nudge enterprise").

317. *Id.* at 584 ("If properly devised, disclosure of information can save both money and lives").

318. Wagner and Walker call this a "pedigree statement," drawing on Henry Hu's recommendations for securities reform. Wagner & Walker, *supra* note 298, at 96–101.

319. Ho, *supra* note 37, at 650.

320. Freilich, *supra* note 28, at 49–51.

321. *See, e.g.*, David Rolnick et al., *Tackling Climate Change with Machine Learning*, arXiv:1906.05433 1 (2019), https://perma.cc/2M27-PNX4; Miyuki Hino et al., *Machine Learning for Environmental Monitoring*, 1 Nat. Sustainability 583 (2018); Stephan Henne et al., *Validation of the Swiss Methane Emission Inventory by Atmospheric Observations and Inverse Modelling*, Atmospheric Chemistry & Physics 3683 (2016).

disclosures, by offering companies guidance on how to use these data in their reports and/or by using them to verify disclosures.[322] Programs that rely on satellite data and machine learning to develop accurate and global emissions data, such as Climate TRACE,[323] can help fill in any knowledge gaps, especially if these global or national analyses can become more granular to develop county- and city-level data; in fact, dozens of private, nonprofit, and governmental remote sensing programs are already doing so.[324] Similarly, GHG accounting software, much like XBRL in financial settings,[325] can be a source of both internal and external controls (by facilitating audits).

These technologies would help to both reduce the resources actors need to produce GHG ledgers (by outsourcing data collection and quantification) and create means to externally validate and monitor them.[326] As one example, Canadian oilsands' accounted-for GHGs were lower than scientific measurements.[327] Existing systems need restructuring to include unaccounted-for GHG sources; critically, the scientific technologies to do so already exist. Of course, the barriers to making these improvements are political, but the improvements themselves are possible. Indeed, they echo recommendations in other misinformation disclosure systems such as patent law.[328] Additionally, technology such as remote sensing may lessen resistance to mandatory GHG disclosure, if they make disclosure easier and more cost-effective.[329] More broadly, methodologies which are accurate, *comprehensible*, and adaptable—incorporating material feedback, revision, and analysis over time[330]—will help make GHG accounting more effective for governance.[331]

2. Balancing Costs with Information Needs

Fourth, GHG accounting systems ought to minimize costs when possible, balancing resource, capacity, and data limitations with information quality needs. Tensions may arise between the goal of accurate and complete GHG ledgers and the resources needed to produce them. These tensions echo doctrinal questions about how to find "optimal" rules that balance costs and benefits

322. El-Jourbagy & Gura, *supra* note 45, at 803.
323. *See generally* Climate TRACE, Bringing Radical Transparency to Global Emissions (2021), https://perma.cc/4YPC-EPJA.
324. El-Jourbagy & Gura, *supra* note 45, at 803, 805–07 (summarizing current GHG-related satellite programs and their potential use in GHG ledgers).
325. Luers et al., *supra* note 13, at 655–656.
326. El-Jourbagy & Gura, *supra* note 45, at 778, 780.
327. *See generally* Liggio et al., *supra* note 34.
328. Freilich, *supra* note 37, at 21.
329. El-Jourbagy & Gura, *supra* note 45, at 814.
330. *See, e.g.*, Fung et al., *supra* note 45, at 178–79.
331. The processes governing the IPCC guidelines, for example, could evolve to incorporate such technologies.

in the public interest.[332] These limits of disclosure are important, because knowing how to navigate potentially incomplete or inaccurate information is essential to informed decision-making. GHG accounting systems ought to prioritize information quality while navigating these resource tradeoffs.[333] One approach may be to emphasize information quality in specific areas (such as land use and forestry) where quality and accuracy have a material impact on actor outcomes and behaviors.[334] It is critical for GHG accounting systems to produce sufficiently reliable and decision-useful GHG ledgers.

Conclusion

Greenhouse gas emissions omissions permeate climate laws and policies, posing important regulatory and governance challenges. This Article calls attention to unaccounted-for GHG emissions, describing how current regulatory and policy systems contribute to omissions. It highlights how unaccounted-for GHGs compromise many climate laws and policies. Finally, the Article outlines recommendations to address unaccounted-for GHGs, drawing on best practices from information disclosure and financial reporting. While climate mitigation (emissions reductions) has often received more attention in legal literature[335]—and mitigation is indeed critical to addressing climate

332. *See generally* Thomas Merrill & Henry Smith, *Optimal Standardization in the Law of Property: The Numerus Clausus Principle*, 110 Yale L.J. 1 (2000) (arguing for an "optimal standardization" in property law to maximize social welfare and limit costs).

333. Critics argue that, taken to an extreme, the resources needed for unreasonably or needlessly precise GHG measurements (for example, accounting to the fraction of a ton of carbon dioxide) would be better spent elsewhere, such as toward reducing GHG emissions. While in some instances extreme precision may be onerous or impossible, GHG ledgers must be sufficiently accurate for accounting to be effective. Improving the accuracy and precision of some GHG sources, such as the land sector, would materially impact policies as well as climate progress and are thus far from needless. Moreover, the technology to do so often exists, making accuracy reasonable.

334. GHG accounting regimes may thus draw on financial reporting tenets such as relevance, materiality, and faithful representation as guiding criteria for decision-making around resource allocation to produce GHG ledgers. Fin. Acct. Standards Bd., *Chapter 3, Qualitative Characteristics of Useful Financial Information*, *in* Statement of Financial Accounting Concepts No. 8: Conceptual Framework for Financial Reporting 2–4 (2018).

335. The legal literature on this topic is extensive and cannot be comprehensively summarized here. Some illustrative examples include Francesco Sindico, *The UNFCCC: Legal Scholarship in Four Key Areas*, *in* Climate Change Law 217–26 (Daniel A. Farber & Marjan Peeters eds., 2016) (illustrating history of UNFCCC legal research in climate mitigation, adaptation, finance, and technology transfer, with a focus on emissions reductions pledges); Daniel A. Farber & Cinnamon Carlarne, Climate Change Law (2017) (highlighting history of climate regulation in the U.S. and internationally, focusing on regulatory tools to reduce GHG emissions such as carbon pricing); Richard J. Lazarus, The Making of

change—pledges to reduce emissions are undermined[336] unless unaccounted-for GHGs are acknowledged and addressed.

Ideal GHG accounting systems are cognizant of their political underpinnings. They are informed by best principles in other accounting and legal contexts to create robust and effective disclosure regimes that drive down GHG emissions and hold responsible actors accountable for their contributions to climate change. They also must be dynamic and adaptable to expanding scientific information and new technologies that allow for better information quality. GHG accounting in such a way may serve as a source of powerful and effective governance. This Article argues that unaccounted-for GHGs exist; they are a problem; they are important; they are political—and they are addressable.

ENVIRONMENTAL LAW 198–216 (2023) (summarizing climate law issues such as the temporal dimensions to GHG emissions reductions).

336. Welton, *supra* note 16, at 202 (illustrating how improper accounting in net-zero policies undermines climate progress).