Greenhouse Gas Emissions Information for Decision Making

A Framework Going Forward

Climate change, driven by increases in human-produced greenhouse gases and particles such as soot (collectively referred to as GHGs), is the most serious environmental issue facing society. The need to reduce GHGs has become urgent as heat waves, heavy rain events, hurricanes, and other impacts of climate change have become more frequent and severe. Since the Paris Agreement was adopted in 2015, more than 136 countries, accounting for about 80 percent of total global GHG emissions, have committed to achieving net-zero emissions by 2050. Providing decision makers with useful, accurate, and trusted GHG emissions information is a crucial piece of this effort.

Three converging trends motivated this report: (1) the rapidly increasing demand from a range of users for GHG emissions information across multiple sectors and geographic scales; (2) the development of many new approaches that aim to address this increasing demand; and (3) a growing and rapidly evolving institutional landscape, including public, private, and academic entities seeking to provide better GHG emissions information. These trends point to the need for criteria or principles that users and decision makers could use when evaluating different types of GHG emissions information.

This report examines existing and emerging approaches used to generate and evaluate anthropogenic GHG emissions information at global to local scales and identifies their limitations. The report identifies six "pillars" that form a common framework to evaluate individual emissions datasets and approaches as well as to guide improvements in GHG emissions information products.

APPROACHES FOR QUANTIFYING ANTHROPOGENIC GREENHOUSE GAS EMISSIONS

Quantifying emissions of GHGs is challenging because there are many types of emissions sources and countless individual emitters. Some emissions can be measured directly at their source, such as power plants or industrial facilities, whereas other sources are more distributed in space, requiring that emissions be estimated or inferred from other data. GHG inventories are tools that quantify GHG emissions (or removals) often divided into economic and industrial sectors for a specific place and time. GHG inventories allow policy makers to identify key GHG-emitting sectors and make informed decisions by setting emission baselines, tracking emission changes over time,
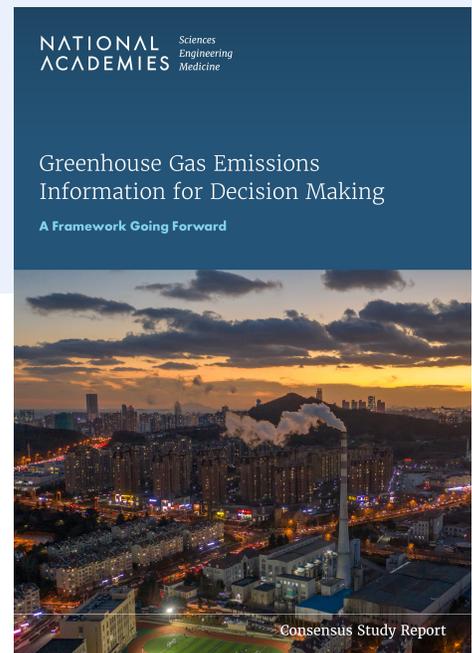
and assessing emission mitigation efforts. GHG inventories are constructed using a wide range of approaches:

Activity-based approaches (often referred to as "bottom-up" approaches) generally utilize activity data such as fuel consumption statistics, traffic counts, population, or land area. These activity measures are transformed using a conversion factor such as the emission or removal of a GHG per unit of activity.

Atmospheric-based approaches (often referred to as "top-down" approaches) use atmospheric measurements of GHGs and an understanding of atmospheric transport and chemical processes to infer information on GHG fluxes (emissions and sinks). Surface-, aircraft-, and space-based observations are combined with analysis approaches and models to transform measurements of atmospheric concentrations into estimates of emissions.

Hybrid approaches generate GHG emissions information through the combination and more complete integration of activity- and atmospheric-based approaches, and/or other data sources, data assimilation, or emerging digital technologies. Hybrid approaches are nascent and hold the possibility of combining multiple measurement streams, atmospheric-, and activity-based approaches to produce more complete and accurate estimates of GHG emissions and sinks.

FRAMEWORK FOR EVALUATING GREENHOUSE GAS EMISSIONS INFORMATION

As more GHG emissions information becomes available and as more decision makers use this information, a common evaluation framework can help users determine what information products best meet their needs and understand the limitations of that information. A common framework can also provide guidance to researchers for designing more useful and trusted data and information. The report identifies six criteria or "pillars" that form a framework to evaluate current and future GHG emissions information:

1. **Usability and Timeliness**: information is comparable and responsive to decision maker needs and available on timescales relevant to decision-making;

2. **Information Transparency**: information is both publicly available and traceable by anyone;

3. **Evaluation and Validation**: review, assessment, and comparison to independent datasets;

4. **Completeness**: coverage of all sources and GHGs for the relevant geographic boundary;

5. **Inclusivity**: who is involved in GHG emissions information creation and who is covered by the information; and

6. **Communication**: methodologies and assumptions are described in understandable forms, well documented, and openly accessible.

Greenhouse gas emissions information development and evaluation should strive to align with the six pillars: usability and timeliness, information transparency, evaluation and validation, completeness, inclusivity, and communication.

The application of the six pillars of the framework to both individual datasets and approaches would advance the current complex GHG emissions information landscape toward one that could more comprehensively meet the needs of users and decision makers. Figure 1 summarizes how the current capabilities of the three

approaches, described above, generally perform relative to the pillars.

ADVANCING GREENHOUSE GAS EMISSIONS INFORMATION CAPABILITIES, TRUST, AND ACCESSIBILITY

Greenhouse gas emissions information should be better coordinated (e.g., through the creation of a coordinated repository or federation of repositories) across the global community, enabling adherence to a set of minimum common pillar attributes.

The pillars above embody the desired attributes for the institutions that develop GHG emissions information. A coordinated repository or federation of repositories where GHG emissions information can be hosted, documented, and clearly characterized would be a critical step forward in maximizing use and understanding of GHG emissions data products. It could establish standards and practices to help users grasp individual characteristics and quality of the wide range of GHG emissions information. Characteristics and functions of a coordinated repository or clearinghouse would operationalize the six pillars, for example, by providing timely, transparent, traceable information; standardized data formats; and governance mechanisms that are coordinated, trusted, and inclusive of the global community.

Greenhouse gas emissions information providers should clearly communicate underlying data, methods, and associated uncertainties.

In the shorter term, data providers can follow many of the guidelines outlined for a clearinghouse to facilitate comparability and verification of their data to foster trust between information providers and users. Resource allocation aimed at bringing data into the public domain with transparency standards could have a substantial impact on the utility of GHG emissions information.

ADDRESSING KEY DATA AND INFORMATION GAPS AND UNCERTAINTIES

Greenhouse gas emissions information (e.g., observations, data analysis, activity data, emission factors) development at more granular temporal and spatial scales with source-level detail should be accelerated to meet the rapidly increasing needs of cities, states, and provinces for managing their emissions.

The accuracy and representativeness of all underlying data used to estimate greenhouse gas emissions (e.g., emission factors, activity data) should be further improved.

Cities, states, provinces, landowners, and the business community, among others, need consistent, standardized, trusted GHG emissions information to enact and evaluate mitigation policies. Currently, data available on granular space and time scales for local and regional decision-making is insufficient. There is a need to expand the necessary data resources to include activity data, emission factors, and atmospheric observations. Further, there is a need to improve the representativeness and resolution across the globe of key underlying data drivers to strengthen the completeness and accuracy of GHG emissions information.

Approaches		Pillars					
		Usability and Timeliness	Information Transparency	Evaluation and Validation	Completeness	Inclusivity	Communication
Activity-based	Methods	Medium	High	Medium	Medium	Low	Medium
Activity-based	Data	Medium	Medium	Low	Medium	Low	Medium
Atmospheric-based	Methods	Low	High	Medium	Medium	Low	Low
Atmospheric-based	Data	Medium	Medium	High	Medium	Low	Medium
Hybrid	Methods & Data	Low	Low	Medium	Medium	Low	Low

FIGURE 1 A qualitative assessment of the current capabilities of three approaches for quantifying GHG emissions information were ranked from low (light green) to high (dark green) against the six evaluation pillars. These rankings are useful to compare the approaches to each other and identify strengths and opportunities for improvement.

OPERATIONALIZING CURRENT CAPABILITIES

Greenhouse gas emissions estimation research efforts should transition with urgency to operational capabilities with institutions to maintain and ensure longevity.

The need to reduce emissions is urgent, but the current timeline and processes to operationalize new data, technologies, or approaches to enable decision-useful strategies is misaligned to meet emissions reduction goals in a timely manner. Accelerating the transition of research to operations will require scientists, research funders, and data users to identify ways to lower existing barriers to that transition and ways to make new data products more immediately usable. The clearinghouse and other coordination mechanisms recommended above, along with alignment with the pillars, should help make new GHG emissions information usable more quickly.

STRIVING FOR HYBRID APPROACHES

Greenhouse gas emissions data collection, modeling, and information development should be designed and implemented to enable a fuller integration and "hybridization" of information and approaches.

Most of the current GHG inventory and information development to date has tended to use single methods or approaches with single-technique observations or data sources. Going forward, a "cross-technique" or hybridization of (traditional) approaches and datasets would provide more accurate and comprehensive GHG emissions information. Some of this work has begun and includes data assimilation and data fusion as well as new machine learning and other techniques. Greater synergy between air quality, meteorology, and GHG data collection and analysis efforts would facilitate the development of these hybrid approaches. To strive for hybridization is to holistically improve GHG monitoring across scales, approaches, and capacity.

ENSURING USABILITY, TIMELINESS AND EFFECTIVE COMMUNICATION OF GHG EMISSIONS INFORMATION

Greenhouse gas emissions information generators, decision makers, and global stakeholders should engage in an iterative process in a timely manner to ensure the information provided is relevant and useful.

Incorporating decision maker input is critical for information developed to respond to the policy needs of stakeholders and decision makers. The time lag to integrate new research findings into GHG emissions information limits the development and execution of sound mitigation policy and can delay necessary investments and technology development. Usability and timeliness of GHG emissions information can be enhanced if data producers and users engage in an iterative process, which the clearinghouse or federated repository could support, to facilitate investments in systems that are focused on providing decision support and responsive to an evolving policy-making landscape.

To read the full report, please visit http://www.nationalacademies.org/basc

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