Greenhouse Gas Emissions Information for Decision Making: A Framework Going Forward

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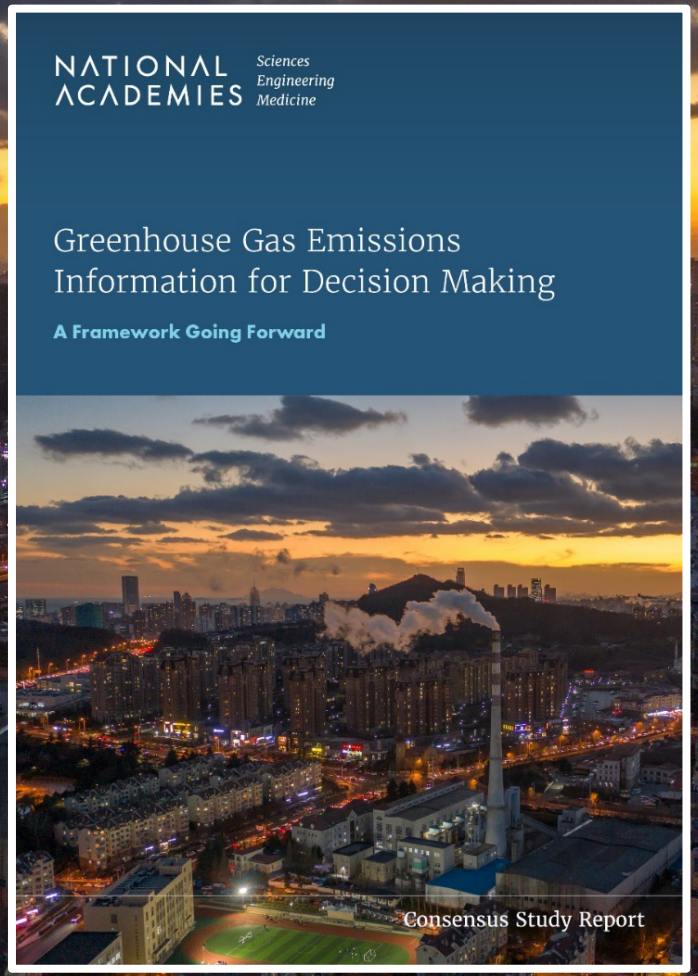
A Framework Going Forward



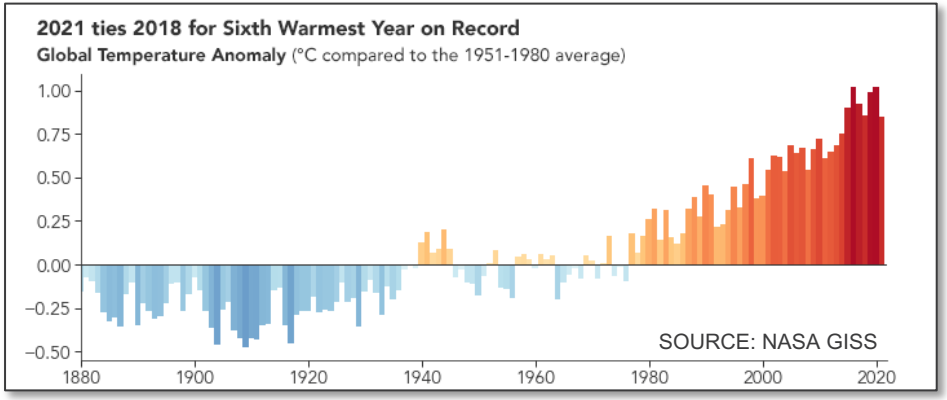
Why is This Important

- Policymakers and other leaders increasingly need to understand and use information about greenhouse gas (GhG) emissions, but it can be difficult to evaluate the relevance, utility, and accuracy of this information.
- Decisions based on high-quality emissions information are critical to meeting targets to reduce GhGs and mitigating the worst effects of climate change.
- Emissions information has already enabled the global community to take monumental steps to address climate change, e.g., reduction targets under the Paris Agreement and tracking progress.
- **Emissions information needs to be as accurate, transparent, and timely as possible to meet the needs of decision-makers needing this information.**
- **Improving not just the quality of emissions information but also the way it's communicated and presented would enable further progress in future.**

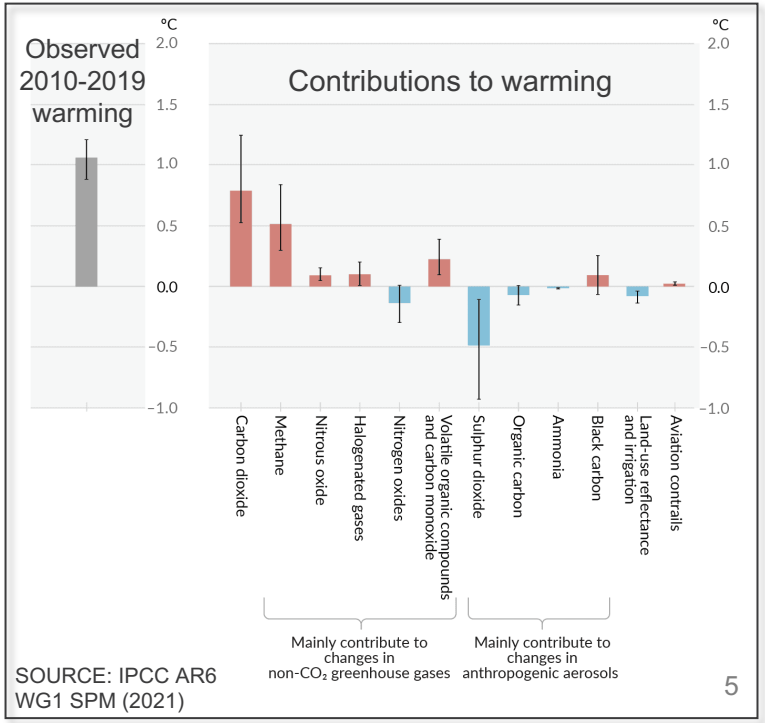
Future Changes in Earth's Climate Depend on Atmospheric Concentrations of Greenhouse Gases (GHGs)

High Quality GHG Emissions Information is Needed for Nations, Cities and Corporations to Reduce GHG Emissions

Climate change and its impacts are accelerating, motivating the need for urgent action



GHG emissions information is needed for mitigation decisions



Motivations to Develop Criteria for Evaluating GHG Information

Three converging trends motivated this report:

1. Rapidly increasing **demand** from a range of users **for trusted information about GHGs** across multiple sectors and geographic scales;
2. Development of many **new approaches for quantifying GHG emissions information** 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.

Charge to Study Committee

- Describe **approaches used to develop anthropogenic greenhouse gas emissions inventories**.
- Discuss the potential uses and **limitations of these approaches**.
- Provide a **framework to evaluate emissions information and inventories**, including guidance for policy makers about their use in decision making.
- Present **several case studies** to demonstrate how the framework could be applied to evaluate emissions information and inventory approaches and identify strengths and opportunities for improvement for each case study.
- To the extent possible, identify **ways to improve** methodological transparency, sustainability and continuity of relevant observations, and product confidence in global anthropogenic greenhouse gas emissions inventories

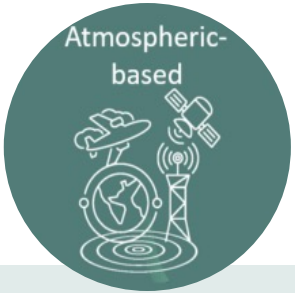
Committee Members

- **Donald J. Wuebbles** *(Chair),* University of Illinois
- **Kamal S. Bawa** *(NAS),* University of Massachusetts Boston and Ashoka Trust for Research in Ecology and the Environment
- **Gabrielle Dreyfus**, Institute for Governance & Sustainable Development
- **Annmarie Eldering**, NASA JPL (Retired)
- **Fiji George**, Cheniere Energy Inc.
- **Heather Graven**, Imperial College London
- **Kevin Gurney**, Northern Arizona University
- **Angel Hsu**, University of North Carolina at Chapel Hill
- **Tomohiro Oda**, Universities Space Research Association
- **Irène Xueref-Remy**, University of Aix-Marseille

Approaches for Quantifying GHG Information

GHG inventories are tools for quantifying **GHG emissions information**, 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.

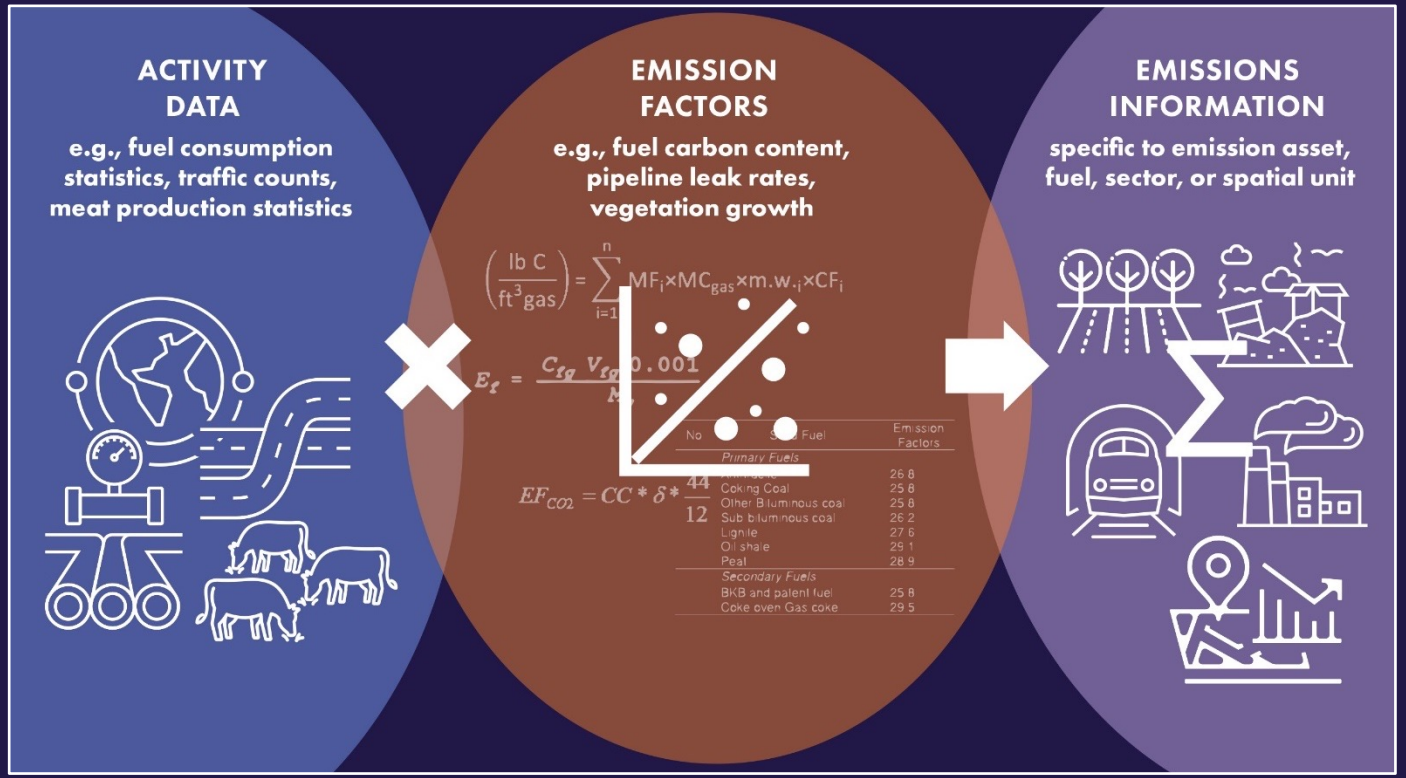
Most familiar to decision makers, most commonly deployed for decision making purposes



Have been extensively developed, less application to decision making

More recent development, offers a promising means to build more relevant and accurate inventories in the future

Activity-based Approach

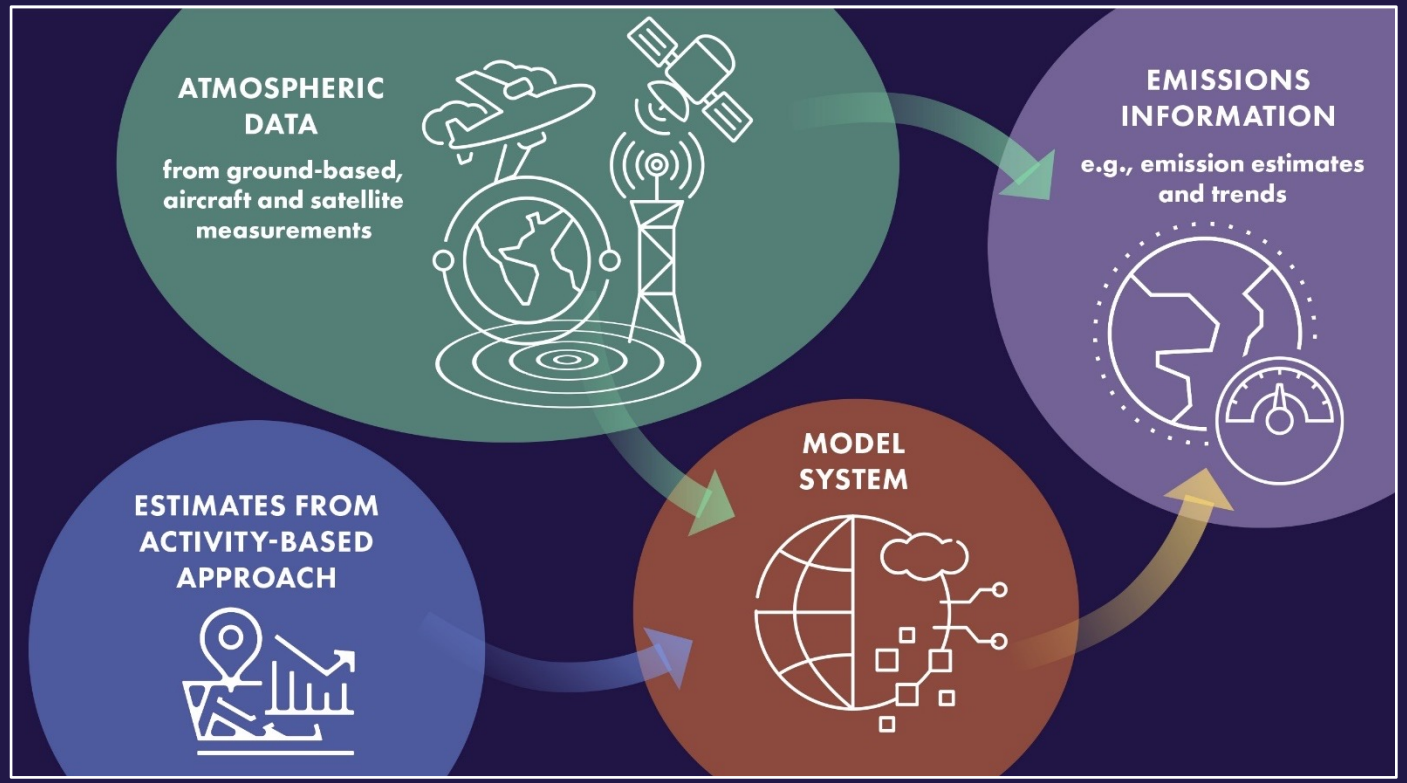


Many Activity-based Approaches are Available

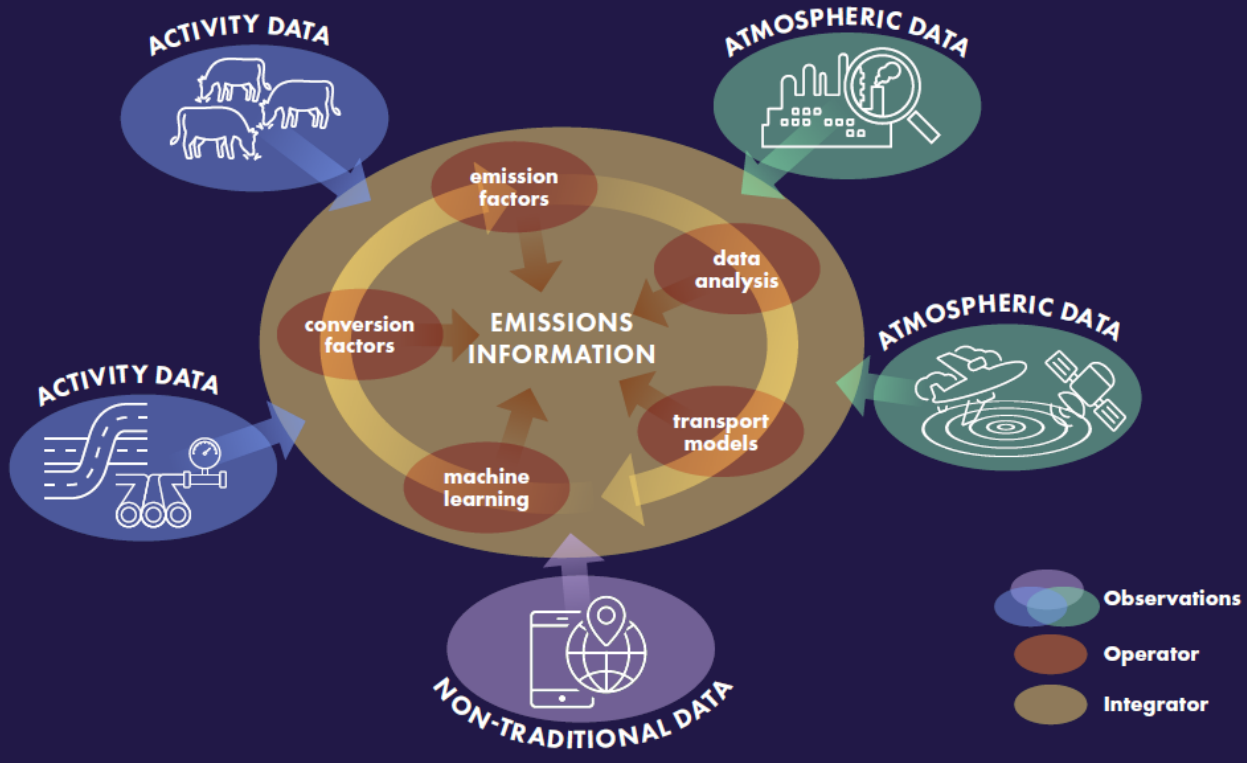
Inventory Name	Gases	Geographic coverage	Resolution (space, time)	Time period (latency)
International Energy Agency (IEA)	Energy, CO_2, CH_4	190 countries	Country, annual	1971-2020, 1960-2020 (OECD)
Energy Information Administration (EIA)	Energy, CO_2	230 countries	Country, annual	1980-2019 (country), 1949-2018 (global)
BP	Energy, CO_2	80 individual countries, 12 regional aggregates	Country/region, annual	1965-2021
UN Statistics (UNSD)	Energy, CO_2	230 countries/territories	Country, annual	1990-2020 (publicly available)
United Nations Framework Convention on Climate Change (UNFCCC)	CO_2, CH_4, N_2O, CO, NMVOC, SO_2, F-gases, HFCs, PFCs, SF_6, NF_3, CO_2-LULUCF	All Parties	Country, Annex I: annual, non-Annex I: biennial	1990-2020 (T-2) (developed) or 1990-various (T-4) (developing)
Emissions Database for Global Atmospheric Research (EDGAR)	CO_2, CH_4, N_2O, F-gases (HFC, PFCs, SF_6, NF_3), Air pollutants (SO_2, NO_x, NMVOC, CO, NH_3, PM2.5, PM10, BC, OC)	228 countries, Global	0.1°×0.1°, monthly	1970-2018 (NA)
Carbon Dioxide Information Analysis Center (CDIAC)	CO_2	259 countries	Country, annual	1751-2017
Fossil Fuel Data Assimilation System (FFDAS)	CO_2	137 countries, 3 regional aggregates	0.1°×0.1°, monthly	1997-2015
Gridded Global Model of City Footprints (GGMCF)	CO_2 (consumption-based footprint)	13,000 cities	Urban area	2013
Global Carbon Project (GCP)	CO_2, CO_2-LULUCF (also consumption-based CO_2)	259 countries ($FFCO_2$ only)	Country, annual	1750-2020 ($FFCO_2$) 1850-2020 (LULUCF)
Community Emissions Data System (CEDS)	SO_2, NO_2, BC, OC, NH_3, NMVOC, CO, CO_2, CH_4, N_2O	221 countries	0.5°× 0.5°, monthly	1750-2019 1970-2019 (CH_4 and N_2O)
Potsdam Real-time Integrated Model for probabilistic Assessment of emissions Paths (Primap-Hist)	CO_2, CH_4, N_2O, F-gases, HFC2, PFCs, SF_6, NF_3	All UNFCCC member states, most non-UNFCCC territories	Country, annual	1750-2019
CAIT/Climate Watch	CO_2, CH_4, F-gases, N_2O	185 countries	Country, annual	1850-2019 (country) 1990-2019 (sectors)
Open-source Data Inventory for Anthropogenic CO_2 (ODIAC)	CO_2	259 countries	1km×1km, monthly	2000-2019
Carbon Monitor	CO_2	6 countries, EU+UK,ROW	Country and region, 0.1°×0.1°, daily	2019-2022
Global Gridded Daily CO2 Emissions Dataset (GRACED)	CO_2	6 countries, EU+UK, ROW	0.1°×0.1°, daily	2019-2020
GCP-GridFED	CO_2	259 countries	0.1°×0.1°, annual	1959-2018
FAOSTAT	CO_2, CH_4, N_2O, CO_2-LULUCF			1961-2019
BLUE	CO_2-LULUCF	Global	0.25°×0.25°, annual	1700-2019
OSCAR	CO_2-LULUCF	10 regions	Regions, annual	1701-2019
H&N	CO_2-LULUCF	187 countries	Country, annual	1850-2019

Table adapted from Andrew (2020) and Minx et al. (2021)

Atmospheric-based Approach



Hybrid Approach



Structural and Technical Limitations of the Current Landscape

A range of challenges have inhibited the usefulness of emissions information to support decision-making, including:

- **Institutional structures**: information is highly distributed and difficult to find
- **Activity-based approaches**: underlying activity data and emission factors may not be accurate or representative
- **Atmospheric-based approaches**: atmospheric measurements may not be continuous or comparable; errors from transport models; difficult to separate emission sources
- **Hybrid approaches**: emerging digital technologies face challenges of interoperability, transparency, data quality, and algorithmic bias

Framework for Evaluating GHG Information

Six criteria or “pillars” form a common framework to evaluate current and future GHG emissions information and inventories:

- **Usability and timeliness**: information is comparable and responsive to decision maker needs on timescales relevant to decision-making;
- **Information transparency**: information that is both publicly available and traceable by anyone;
- **Evaluation and validation**: review, assessment, uncertainty, and comparison to independent datasets;
- **Completeness**: coverage of all GHGs and sectors in space and time;
- **Inclusivity**: who is involved in GHG information creation and who is covered by the information; and
- **Communication**: methodologies and assumptions are described in understandable forms, well-documented, and openly accessible.

Qualitative Evaluation of Current Approaches Relative to the Pillars

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

High: approach consistently addresses the pillar criteria
Medium: approach ranks high in some instances but ranks low in others
Low: pillar criteria are not usually well addressed

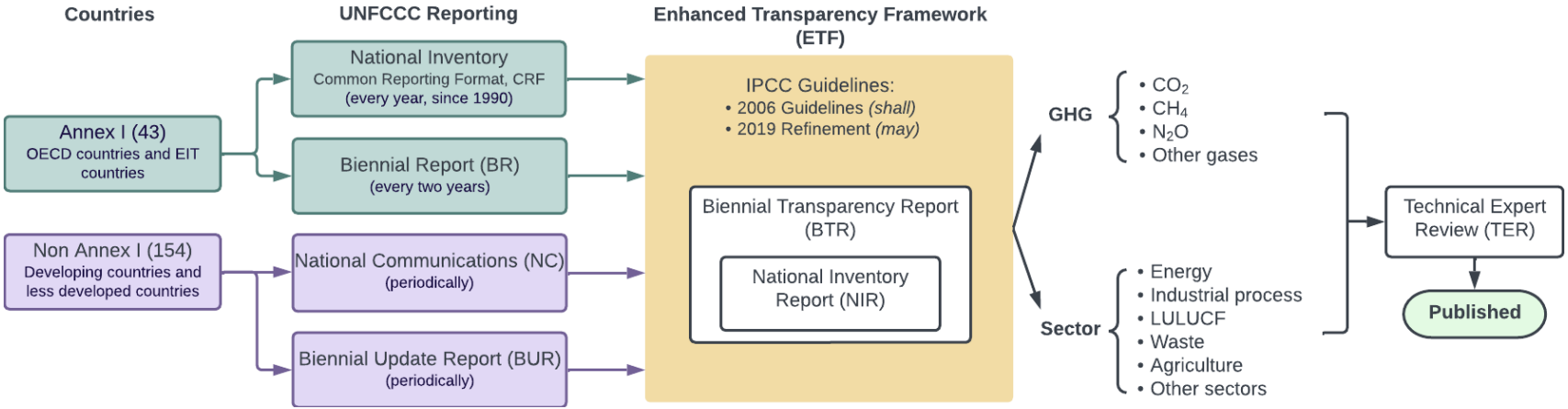
Applying this Framework to Specific GHG Emissions Information Products

- Intention is to evaluate GHG emissions information in the **context of its intended purpose** (e.g., identifying local emissions reduction opportunities, assessing progress in meeting national commitments):
  - Is the intended purpose **clearly described** and **communicated**?
  - Is it **usable** and **timely** for the intended purpose?
  - Does the **quality**, **reliability**, and **accuracy** of the information meet the needs of its intended purpose?

- Report includes several **case studies** that demonstrate how the framework could be applied to evaluate specific GHG emissions information products
  - Case studies illustrate how the framework could be used to help decision makers consider whether an approach is fit for purpose
  - Small sample of GHG emissions information activities are selected to provide a cross-section of the three approaches, across local to global scales, and in a variety of locations

UNFCCC Reporting and Enhanced Transparency Framework

CURRENT APPROACHES FOR QUANTIFYING ANTHROPOGENIC GREENHOUSE GAS EMISSIONS



Case Study: *UNFCCC Enhanced Transparency Framework*

Strengths:

- Adherence to 2006 IPCC guidelines results in high information transparency and completeness

Opportunities for improvement:

- Improve time lag would enhance usability and timeliness
- Undergo separate peer review (in addition to UNFCCC expert review team) to enhance evaluation and validation
- Expand reporting beyond small group of technical experts to improve inclusivity
- Improve communication to general public

	Pillars					
Case Study	Usability and Timeliness	Information Transparency	Evaluation and Validation	Completeness	Inclusivity	Communication
UNFCCC ETF	Medium	High	Medium	High	Medium	Medium

Case Study: *Urban hybrid approach: INFLUX*

Strengths:

- Data and methods documented and freely available
- Extensive evaluation of techniques and comparison of multiple approaches
- CO_2 and methane emissions include majority of Indianapolis emissions and all sectors were included in emission estimates

Opportunities for improvement:

- Engage with local policy makers and the public from the beginning to improve usability and inclusivity
- Improve policymaker's and the public's understanding of data available

	Pillars					
Case Study	Usability and Timeliness	Information Transparency	Evaluation and Validation	Completeness	Inclusivity	Communication
INFLUX	Low	High	High	High	Low	Low

Case Study: *Methane emissions estimates from the U.S. oil and gas supply chain – EPA estimates*

Strengths:

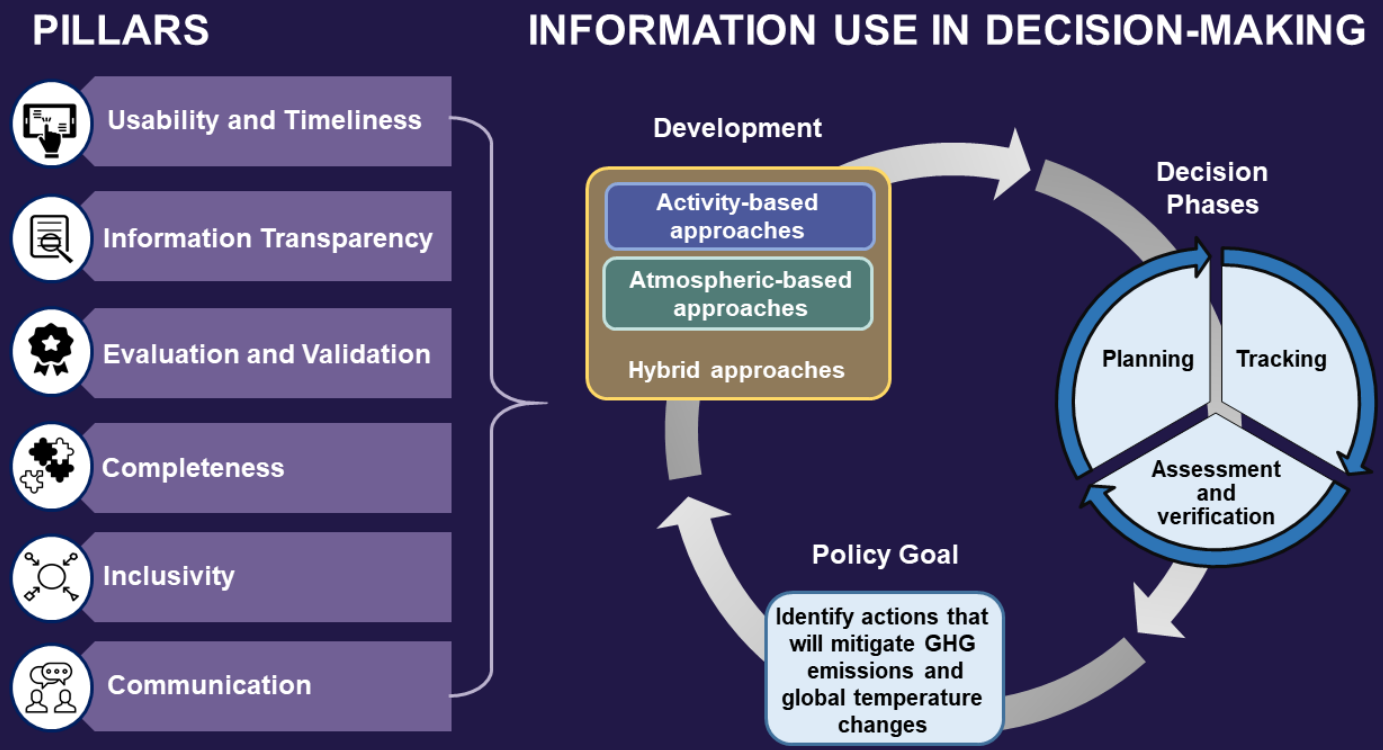
- Methods and data available and in understandable language
- 30-day public review process for GHGI
- Communication with non-expert audiences via public website with explanatory information

Opportunities for improvement:

- Improve time lag and make regional or gridded data available to enhance usability
- Improve evaluation and validation by reconciling differences between inventories
- Expand coverage beyond high-emitting facilities

	Pillars					
Case Study	Usability and Timeliness	Information Transparency	Evaluation and Validation	Completeness	Inclusivity	Communication
EPA GHGRP and GHGI	Medium	High	Medium	Low	Medium	High
PermianMAP	High	High	High	Medium	Low	Medium

Pillars Underlie Iterative Information Development and Decision-making Process



Overview of Report Recommendations

- **Pillars**: GHG emissions information development and evaluation should strive to align with the pillars
- **Clearinghouse**: GHG information should be better coordinated globally
- **Transparency**: information providers should communicate data, methods, and uncertainties
- **Granularity**: information should be developed at more granular space and time scales
- **Accuracy**: accuracy and representativeness of underlying data should be improved
- **Operationalize**: research efforts should transition with urgency to operational capabilities
- **Hybrid**: data collection, modeling, and information development should enable fuller integration and “hybridization”
- **Iterate**: information generators, decision makers, and stakeholders should engage in an iterative process

Pillars — Recommendation

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

Communication

Guidance for Evaluating Greenhouse Gas Emissions Information

Key questions, guided by the pillars, that decision makers, communicators, and other users of GHG emissions information should pose as they consider the credibility and usefulness of new GHG information:

- Are underlying data, methods, and uncertainties clearly communication?
- Over what time period, spatial domain, and for which sources was the information collected?
- Have the approaches and data been appropriately evaluated and validated?
- Are multiple data sources or approaches used to support conclusions about greenhouse gas emissions?
- Have the approaches and resulting data involved locally-based researchers and benefited from stakeholder input and expert review?

Clearinghouse — Recommendation

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.

Critical characteristics and functions would include:

- Timely, transparent, and **traceable information**;
- **Standardized data** formats and metadata;
- **Documentation** in nontechnical and multiple languages;
- Qualitative and/or quantitative **evaluation metrics**;
- Updated and accessible databases of **key input data**;
- **Governance mechanisms** that are coordinated, trusted, and inclusive;
- Education modules and **capacity building**; and
- **Collaborations** with air quality and meteorological communities.

Transparency — Recommendation

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

https://blogs.microsoft.com/on-the-issues/2020/09/01/open-data-climate-finance-foundation/

Granularity and Accuracy — Recommendations

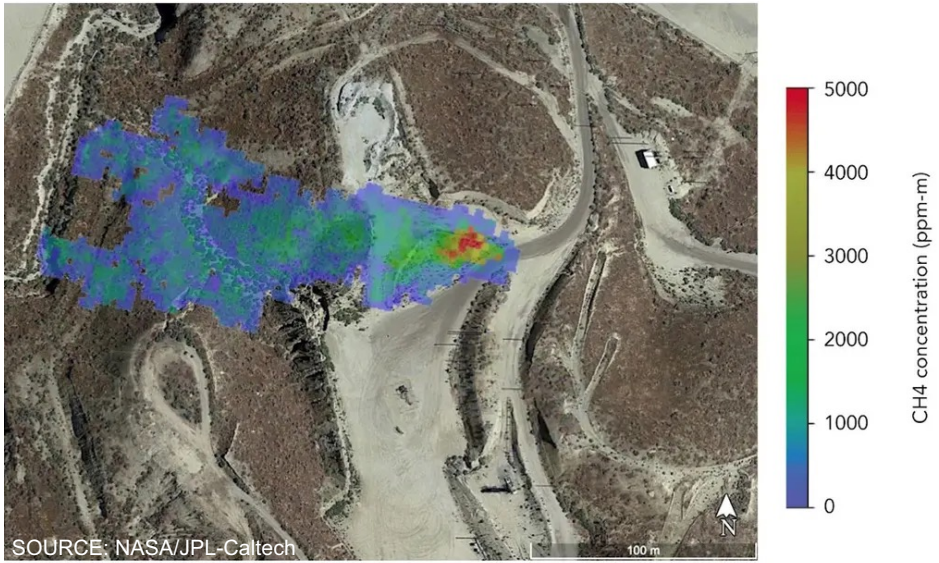
Greenhouse gas emissions information (e.g., observations, data analysis, activity data, emission factors) development at more **granular temporal and spatial scales** with **source-level detail** should be accelerated to meet the rapidly increasing **needs of cities, states, and provinces** for managing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


https://www.climate.gov/media/2838

Operationalize — Recommendation

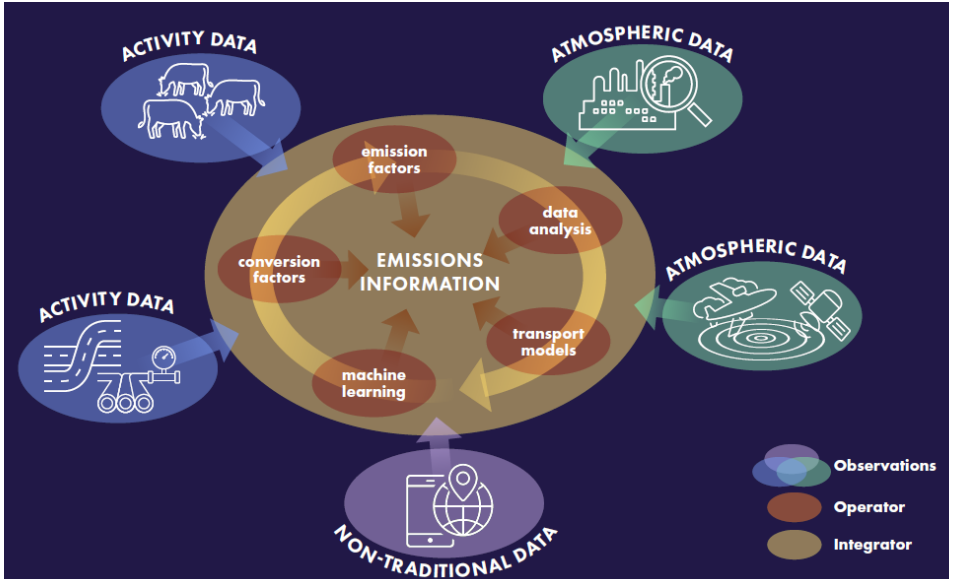
Greenhouse gas emissions estimation research efforts should **transition with urgency to operational capabilities** with institutions to maintain and ensure longevity.



Methane plume detected by NASA identified a leaking gas line in California that the operator was able to repair

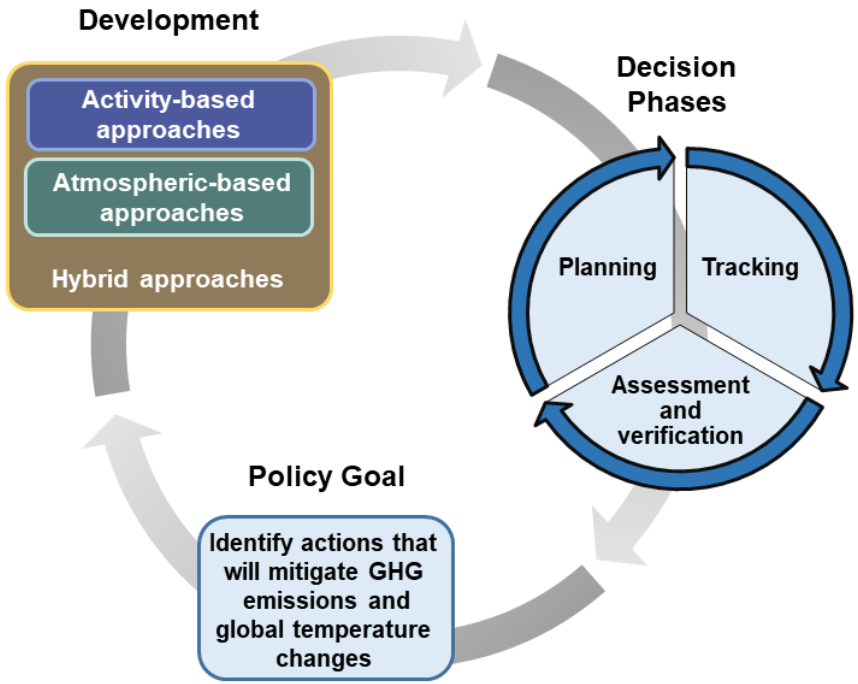
Hybrid — Recommendation

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



Iterate — Recommendation

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.



The Discussion Going Forward

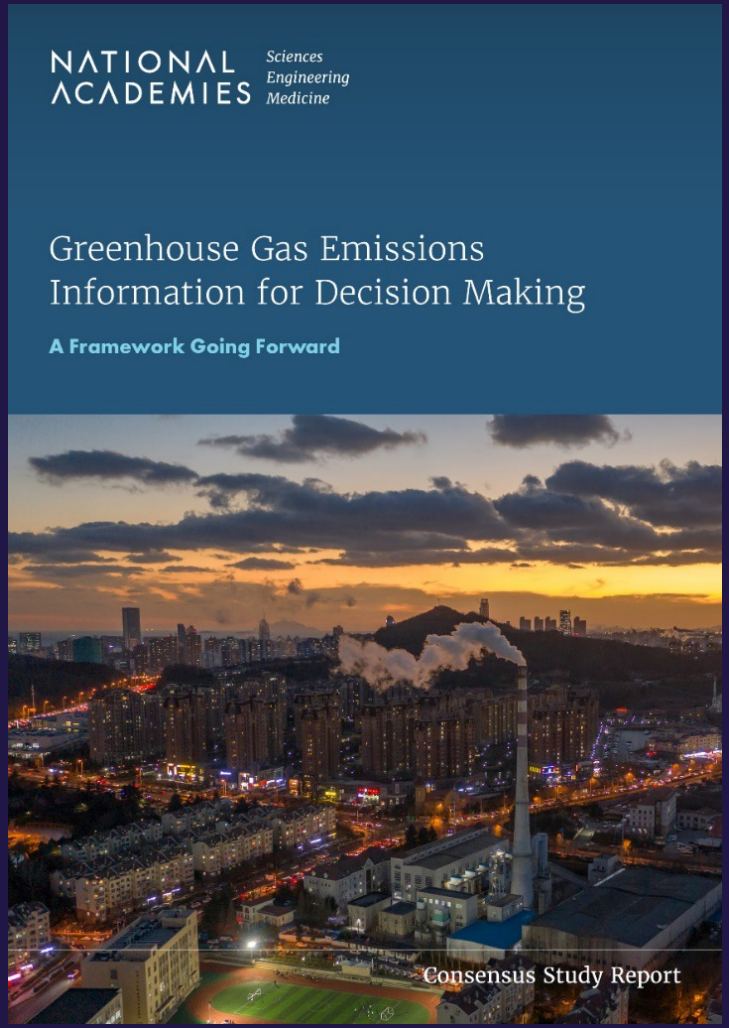
- By examining existing efforts and future needs, the hope is that this report will help push the global community forward in assisting the future decision-making process.

- There are ripe opportunities for innovation, including a role for new approaches and cutting edge techniques, emphasized in the report.

- The report intends to spark a discussion, with many potential future directions.

SOURCE: Marcin Jozwiak

Download the report now at nap.edu



Case Study: *Methane emissions estimates from the U.S. oil and gas supply chain – PermianMAP*

Strengths:

- Information reported shortly after collection, specific to individual facilities
- Methods and data freely available on project website
- Different measurements compared, independent evaluation and validation by researchers

Opportunities for improvement:

- Enhance temporal coverage to capture daily variability and stochastic super emitters
- Engage local communities in project design
- Provide better context and background information to the general public

	Pillars					
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