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EXPLORING LINKAGES BETWEEN NATIONAL AND CORPORATE/FACILITY GREENHOUSE GAS INVENTORIES

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SUMMARY

Inventories of greenhouse gases prepared at the national level and at the corporate/facility level can complement each other and help decision-makers understand emission trends and inform mitigation activities, among other functions. Most countries already have at least some experience preparing national inventories and may have also developed a national inventory system. At the same time, corporate/facility reporting programs are becoming more prevalent. However, the two systems are often developed independently of each other, and as a result countries are unable to capitalize on potential linkages between them. Moreover, confusion often surrounds the purpose and need for corporate/facility inventory programs when data are already being collected and disclosed for national inventories.

This working paper describes national and corporate/facility inventories and outlines the various roles they can play related to emissions measurement, management, and policymaking. It also discusses corporate/facility reporting programs and compares national and corporate/facility inventory systems to highlight their differences. It then explores possible linkages between corporate/facility programs and national inventory systems. These linkages include the use of source-level data from facilities to improve accuracy and/or provide validation to national emissions estimates as well as the use of existing institutional and technical capacities, likely associated with developing a national inventory, to support a corporate/facility reporting program. Utilizing these linkages can enhance the quality of information provided in both national and corporate/facility inventories, thus strengthening the foundation for subsequent mitigation efforts. The linkages discussed could facilitate efforts to reduce emissions in countries with competing demands within a mitigation program and limited resources.

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INTRODUCTION

An inventory of greenhouse gas (GHG) emissions is a fundamental tool to address climate change. Ideally, inventories provide a comprehensive accounting of GHG emissions and removals within a specified geographic or operational scope. They can then be used to help identify mitigation opportunities and enable emissions tracking over time. GHG inventories are developed at various levels, such as at the national, subnational, corporate, and facility levels and for a product's life cycle (Box 1). For the purposes of discussion in this paper, two of these inventory types—corporate and facility inventories—are grouped together, as they involve similar data collection processes and emissions calculation methodologies.

Box 1 | **Types of GHG Inventories**

- **National inventories** include all human-caused emissions and removals within a country.
- The information in a **subnational inventory** is similar to that in a national inventory, but it is attributable to a subnational government or region (e.g., state, city).
- **Corporate inventories** provide a company's direct emissions (from sources owned and controlled by the company) as well as indirect emissions. Inventories can include both emissions and removals.
- **Facility inventories** include emissions from a specific industrial installation.
- A **product life cycle inventory** documents emissions associated with a specific good or service throughout its life cycle.

Source: Adapted from Fransen, 2011.

Most countries have produced at least one national inventory in the past two decades,[1] in response to international reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC). However, new UNFCCC reporting requirements taking effect in 2014 require most countries to report information on their national GHG inventory every two years (UNFCCC, 2011). While countries that have already produced several national inventories typically have established a comprehensive management system for regularly reporting their emissions, with these new requirements, more countries will likely pursue similar systems for national inventory development. At the same time, emissions reporting programs at the corporate or facility level have been set up in countries such as Australia, Brazil, Canada, France, India, Mexico, the United States, and the United Kingdom (ERM, 2010; Kauffmann, Tébar Less, and Teichmann, 2012). The systems to support both efforts—that is, the human, technical, institutional, and financial resources necessary to produce a national inventory report or operate a corporate/facility reporting program—can be complex. Consequently, stakeholders may not understand clearly the unique purpose and potential roles of each of these two inventory systems. There may even be doubt regarding the need for implementing both systems. Also, it is often unclear how national and corporate/facility inventory reporting systems can be integrated for improved accuracy and quality and for achieving the systems' objectives while efficiently using limited resources.

This working paper, therefore, seeks to describe national and corporate/facility inventories, highlighting major differences between these two common types of inventory systems. It also explores potential system linkages to support the efficient use of resources. The first section, "National Inventories," introduces national inventories and the potential roles they can play in emissions measurement, management, and policymaking. The second section, "Corporate/Facility Inventories and Reporting Programs," discusses GHG inventories for companies and individual facilities and their roles. This section also introduces corporate/facility programs that are designed to promote emissions reporting. The third section compares national inventories and the inventory data that can be aggregated from corporate/facility reporting programs. The fourth section explores possible linkages between reporting programs and national inventory systems.

NATIONAL GHG INVENTORIES

Overview

A national GHG inventory presents estimates of the total amount of annual GHG emissions and removals resulting from human activities[2] in the reporting country. The UNFCCC is the primary driver of national reporting of GHG emissions by countries.

Based on the convention's principle of "common but differentiated responsibilities," UNFCCC reporting and review requirements for national inventories differ for Annex I and non-Annex I Parties.[3] Annex I Parties are required to submit annual reports of calendar-year estimates of GHGs for all sources and sinks to the UNFCCC Secretariat. Reports provide source, sector, and aggregate totals from the base year (typically taken as 1990) to the most recent year (typically 2 years prior to the current calendar year). Annex I country national inventory reports also include detailed information regarding methods and uncertainties, and they undergo a multistage peer review process.[4]

Non-Annex I Parties do not have to adhere to this same timeline or rigor for reporting.[5] Currently, national GHG inventories of non-Annex I Parties are submitted as part of the National Communication report, which also includes information on relevant climate change programs and activities.[6] The national GHG inventory portions of these reports are not required to provide emissions trends over time; indeed, they may only cover a few years, as required by the UNFCCC reporting guidelines.[7] Non-Annex I Parties' national GHG inventories are also not required to document methods and data sources (though some do); nor have they been required to undergo a UNFCCC review process. To date, approximately 100 non-Annex I Parties have submitted at least two national GHG inventories as part of their National Communications.[8] However, starting in 2014, non-Annex I Parties (with the exception of least developed countries and small island states)[9] will be required to submit their National Communications every four years and biennial update reports—including information on their national inventories—every two years, as codified in Decision 2/CP.17 of the Durban Outcomes (UNFCCC, 2011).

To support countries in reporting national GHG inventories, the Intergovernmental Panel on Climate Change (IPCC) has developed extensive methodological guidance. Published reports include the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories,* the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000),* the *2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry*, and the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. The IPCC guidelines are designed to enable countries to estimate and report anthropogenic GHG emissions and removals in a transparent, consistent, comparable, complete, and accurate manner (IPCC, 2006). The *2006 IPCC Guidelines* (the latest published) include calculation methods for all major GHGs, including those required to be reported to the UNFCCC: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). According to the *2006 IPCC Guidelines*, these emissions are categorized and reported across four major economic sectors: energy; industrial processes and product use (IPPU); agriculture, forestry, and other land use (AFOLU); and waste.[10] Each of these sectors includes a number of emissions source and sink categories (e.g., transport) and subcategories (e.g., domestic aviation).[11]

Although the IPCC guidelines provide some standard conventions to ensure comparability, they also account for differences that exist among countries in terms of, for example, available data, by offering multiple (tiered) methods of varying complexity and rigor for most source and sink categories. Consequently, emissions calculations for national GHG inventory sources can be compiled using a combination of "top-down" and "bottom-up" approaches.[12] However, for most national inventories, the emphasis is on the former, as they rely heavily on national activity data and statistics.[13] The basic method for estimating emissions involves multiplying national data on an emissions-generating activity, such as metric tons of cement produced or coal consumed, by an emissions factor that specifies the amount of GHG emissions per unit of activity—for example, gigagrams of CH_4 per metric ton of coal mined. However, calculation methodologies for some emissions sources, particularly nonenergy sources (i.e., AFOLU), can be significantly more complicated. IPCC guidance is also provided on possible data sources, data collection methods, quantification of uncertainties, management of inventories, quality assurance and control, documentation, and data archiving. Although the ICC guidelines provide a flexible foundation to accommodate varying national circumstances, several key steps can be generally outlined for the national GHG inventory preparation process. Box 2 describes these steps.

Box 2 | Major Steps for Developing a National GHG Inventory

1. **Identify key categories.** A key category is "one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals" (IPCC, 2006). Analysis of key categories enables countries to estimate the sources that have the largest contribution to total net GHG emissions and therefore helps prioritize source categories for more detailed assessment. Where an inventory already exists, the key categories can be identified from previous estimates.

2. **Selection of emissions estimation methods.** For calculating emissions from each source category, the IPCC describes three options: Tier 1 is the most basic, requires the least disaggregated activity data, and employs international 'default' emissions factors. Tier 2 and Tier 3 utilize more country-specific data and are generally considered to be more accurate. Compilers choose an appropriate tier based on national circumstances, such as data availability, and the IPCC offers good practice guidance for choosing methodologies and focusing resources on the largest sources and sinks (i.e., key categories).

3. **Activity data and emissions factors collection.** Activity data quantify "the extent to which a human activity takes place" within a given time period, and emissions factors "quantify the emissions or removals [of emissions] per unit of activity" (IPCC, 2006). This step involves evaluating and collating existing sources of national or subnational data that can help quantify activities for a given source and planning new measurements and surveys where data are unavailable.

4. **Emissions estimations.** The selected calculation methods are used to generate emissions estimates. If time series data are available, calculations can be applied consistently for all available inventory (calendar) years.

5. **Uncertainty assessments.** These analyses may identify categories for which a higher-tier method should be used and additional data collected.

6. **Quality Assurance/Quality Control (QA/QC).** QA/QC procedures for data, methods, and compilation should be performed throughout the overall inventory preparation process to limit errors. Inventory compilers may also ask technical experts not involved in the preparation of the inventory to review the methodological choices, data sources, calculation estimates, and documentation prior to releasing the inventory publicly.

7. **Reporting and archiving.** Countries may report their national inventory as part of a submission to the UNFCCC Secretariat. They may also publish the national inventory as a domestic government report.[i] Underlying data, methodologies, and documentation, as well as the final version of the inventory, should be copied and archived for reference by future inventory teams.

[i] For example, the United States releases a domestic national inventory document and also submits its inventory annually to the UNFCCC. Similarly, Brazil and India have produced national inventory reports as domestic reports and also incorporated the data from these reports into their National Communications.

Source: Adapted from IPCC, 2006.

In addition to the data, methods, and review processes, other institutional, technical, and human resource capacities are necessary for producing a robust national GHG emissions inventory. These collectively may comprise a national inventory management system. This system can include a central coordination agency, such as the Ministry of Environment, as well as any number of institutions with inventory-relevant expertise, such as other federal agencies, research and nongovernmental organizations, universities, and subnational entities, among others. Other aspects of a national GHG inventory system may include agreements among inventory-relevant entities that ensure the provision of data, sector-specific coordinators, training programs, and software or databases for data management and storage. Certain practices, such as the establishment of clear institutional roles and responsibilities, may be particularly critical to maintaining a national inventory management system and ensuring successful completion of a national GHG inventory over time (Damassa and Elsayed, 2013).[14]

Roles in emissions measurement, management, and policymaking

National inventories help countries quantify, track, and communicate trends in GHG emissions that result from domestic activities. They are also critical components of reporting internationally (i.e., to the UNFCCC). The development of national GHG inventories and their associated systems can also support countries through activities such as the following:

- **Prioritization of mitigation strategies.** Complete and accurate national GHG inventories enable countries to identify major sources and sinks of GHGs and track trends in emissions with greater confidence. Governments can thus make more informed decisions with respect to appropriate response measures, including GHG reduction or low-emissions development policies and/or national goals. For example, Brazil adopted Decree 7.390,[15] which regulates the National Policy for Climate Change (PNMC) and states GHG projections and estimated GHG reductions from sectoral actions[16] based, in part, on Brazil's second (2010) National Communication and inventory report.

- **Building capacities and expertise.** Developing a national GHG inventory can help establish a system of measuring and reporting GHGs within the country, thus building a strong foundation to mainstream emissions reporting and spurring the development of a community of GHG inventory professionals and of related institutions.

- **Providing a basis for linking estimates of emissions and other environmental concerns.** Designing data management systems and processes that support the analysis of GHG data and other air, water, and/or waste pollution datasets can create resource and management efficiencies and provide a more comprehensive picture of national environmental trends. For example, South Africa is developing a National Atmospheric Emission Inventory System to aggregate, analyze, and archive energy- and industry-related data necessary for compiling its national GHG inventory in accordance with IPCC guidelines.[17] This system will be part of a larger system, also in development, for air quality management—the South African Air Quality Information System (SAAQIS). SAAQIS aims to track air quality trends on a local, regional, and national scale and provide near real-time air quality data to enable the government to identify "hot spots" and facilitate compliance with air quality standards (Wait, 2011). By using a single platform to store and track GHG emissions and air pollution data, South Africa has centralized and enabled deeper analysis of critical components of its environmental monitoring and evaluation strategy.

- **Improving national data quality.** Compiling a national inventory of GHG emissions may help countries identify activity data gaps and create plans to address them. These strategies may include establishing new data collection processes, targeting research initiatives, or improving data access. For example, the Department of Science and Technology in South Africa developed—after the second National Communication submission in 2011—a detailed plan to address gaps associated with the compilation of the national inventory that include supporting effective observation and monitoring and targeted research over the next 10 years (DEA, 2011). Improvements to activity data—for example, accounts of the consumption of natural resources and the production of industrial products—will help improve the national inventory over time. These data may also be helpful to a country's development planning and evaluation.

- **Objective and accurate accounting for carbon markets.** The estimates of a country's emissions and removals reported in a national inventory can, in certain instances, be used to support robust accounting in carbon markets. For example, Annex I countries, with commitments under the Kyoto Protocol, are allowed to buy and sell emissions reduction units[18] to supplement their domestic efforts to meet their reduction targets. These countries were required to provide the UNFCCC Secretariat with a national GHG inventory for use in establishing a baseline for carbon crediting and to maintain a national inventory reporting system.[19] National GHG inventories were also part of the reporting requirements under the Kyoto Protocol's first commitment period,[20] supplementing the tracking of transfers and acquisitions of these units through a national registry or a mandatory emissions trading scheme.[21] (Braatz and Doorn, 2005)

CORPORATE/FACILITY GHG INVENTORIES AND REPORTING PROGRAMS

Overview

A corporate inventory is a quantified list of the entire corporation's GHG emissions for all facilities and sources. A facility inventory, in contrast, represents emissions associated with a single facility (Box 3). Companies and facilities may voluntarily develop inventories to understand their emissions profile and climate risks and opportunities. They may also prepare their inventories as part of voluntary reporting programs in response to demands from stakeholders for information related to climate change. In addition, governments may develop mandatory GHG reporting programs that require certain facilities or companies to calculate and report their emissions. Corporate and facility inventories are compiled using a bottom-up approach. The most common approach is for organizations to gather site-specific activity data from individual sources, within a defined boundary, to calculate associated emissions (see Box 4). Examples of activity data include consumption of electricity (kilowatt hour [kWh]) and fuel combustion (e.g., metric tons of coal, liters of gasoline). For most emissions sources, multiplying activity data with emissions factors gives emissions from a particular activity. Emissions factors can be default factors or site- or company-specific factors and are expressed in units such as metric tons of CO_2 per kWh and grams of CH_4 per vehicle mile. The practical difficulties in compiling corporate/facility inventories lie in collecting activity data from sources and obtaining accurate emissions factors. Other methods to calculate emissions include using a mass balance approach or direct measurement of GHG emissions with continuous emissions monitoring systems (CEMS).

In corporate/facility inventories, emissions are categorized as direct or indirect emissions. Direct emissions (Scope 1 emissions as defined in the GHG Protocol Corporate Standard [WRI and WBCSD, 2004]) are emissions that occur from sources owned or controlled by the company or facility. For example, emissions from stationary fuel combustion, mobile fuel combustion in company-owned vehicles, and process-related emissions such as from calcination in the cement industry. Indirect emissions result from a reporting company or facility's activities, but they are from sources not owned or controlled by the reporting company or facility. These are further divided into Scope 2 emissions resulting from the use of purchased electricity, heat, or steam, and Scope 3 emissions, which include all other indirect emissions (e.g., employee commuting, outsourced production activities) (WRI and WBCSD, 2004).

Over the past two decades, GHG reporting programs have emerged to promote emissions reporting. These can be voluntary or mandatory depending on whether participation by companies or facilities in the program is voluntary or mandated by the government. Examples of voluntary programs include the Brazil GHG Protocol program, The Climate Registry, and CDP.[22] Voluntary sector-specific initiatives, such as the Cement Sustainability Initiative,[23] have also provided a platform for companies and facilities to report their emissions. Examples of mandatory programs at both the facility and corporate level include Australia's National Greenhouse and Energy Reporting Scheme and the U.S. GHG Reporting Program.[24]

Box 3 | Relationship between Facility and Corporate Inventories

Facility inventories reflect GHG emissions from sources within the boundary of a single facility. *Facility* refers to a physical installation with one or more emissions sources, for example, a power plant, a cement plant, or an oil well. The inventory typically includes emissions from stationary sources (e.g., from fossil fuel combustion), process emissions (e.g., from calcination in cement plants), and fugitive emissions (e.g., in natural gas facilities). Emissions associated with the use of purchased electricity, heat, and steam may also be included in facility inventories. Facility inventories can be considered a subset of a corporate inventory. Even where a company aggregates emissions from all facilities, it may not necessarily equal the emissions total in the corporate inventory. For instance, emissions from a jointly owned facility may or may not be included in the corporate inventory depending on the selected boundary approach.

Corporate inventories include emissions from all operations within the company's boundary, emissions associated with purchased electricity and steam as well as emissions from mobile sources such as transportation. Companies may also include in their corporate inventories emissions along their supply chain (e.g., those associated with the purchase of raw materials). How companies define their organizational boundaries determines which emissions sources are included in the corporate inventory.

Box 4 | Major Steps for Developing Corporate/Facility Inventories

1. **Organizational boundary.** Set an organizational boundary which sources to include in the corporate inventory. The GHG Protocol Corporate Standard defines two approaches to determine the organizational boundary. Which approach to use is guided by how a company intends to utilize the information in the inventory. This step is not applicable for a facility inventory.

2. **Operational boundary**. Set operational boundaries to identify emissions associated with each operation. Depending on who controls the source, emissions are categorized as

   - direct (Scope 1) emissions (e.g., emissions from combustion in company-owned boilers and furnaces, process emissions, etc.) and
   - indirect (Scope 2 and Scope 3) emissions (e.g., emissions from purchased electricity, the use of sold products, etc.).

   It is more common for a corporate inventory to include all three scopes. A facility inventory typically includes direct emissions and may include Scope 2 emissions. It is not customary to include Scope 3 emissions in facility inventories.

3. **Emissions calculation.** Calculate emissions using the appropriate methodology based on emissions source. Companies and facilities collect site-specific activity data to quantify emissions. Well-defined calculation methodologies exist for various sectors and emissions sources.

4. **Quality checks.** Conduct quality checks to spot errors in data, methodology, inventory processes, and documentation.

5. **Reporting.** Report the information on emissions by scopes and by GHGs.

Organizations developing GHG inventories follow established accounting and reporting standards such as the GHG Protocol Corporate Standard or sector-specific protocols such as the cement sector's CO_2 Quantification Protocol.[25] In cases where companies/facilities are part of a reporting program, they adhere to program requirements for calculating and reporting GHG emissions. In many cases, these requirements are based on the GHG Protocol Corporate Standard, but the programs may provide more specificity in areas that the Corporate Standard leaves flexible, such as using a particular approach to define boundaries for companies and prescribing specific calculation methodologies and information disclosure requirements (CDSB, 2012). Programs may also provide resources, such as high-quality default emissions factors, to help companies and facilities develop their inventories.

Roles in emissions measurement, management, and policymaking

Corporate/facility GHG inventories and reporting programs help corporations deal effectively with climate change by quantifying and tracking emissions. They support governments' efforts to formulate policies that deal with climate change. Inventories and reporting programs can facilitate GHG measurement and management through activities such as the following:

- **Informing mitigation efforts.** Companies/facilities can use inventories to understand their emissions profile and find cost-effective opportunities to reduce emissions. Measuring the GHG impact of energy use, transportation use, and other sources of GHGs informs how to manage those emissions—for example, by using alternative fuels, reducing waste, and using efficient transport and logistics. Organizations that better understand their emissions can set realistic reduction targets and use annual inventories to track their progress.

- **Managing risk.** Inventories can help identify potential GHG liabilities or climate risks throughout a company's supply chain. Emissions-intensive businesses face climate change-related risks such as the regulatory risk of a national or global cap on emissions, the risk that rising energy prices will change consumer demand, reputational risks, and the risk of losing competitive advantage in an increasingly environmentally conscious marketplace.

- **Supporting business development.** Climate change liabilities identified by measuring emissions can be transformed into new business opportunities, for example by developing new products with a smaller carbon footprint and differentiating the company in the marketplace as a "green" company.

- **Recognizing early voluntary action and increasing accountability.** Corporate- and facility-level reporters may have the opportunity to use their inventories as a means of demonstrating early voluntary action, so that their efforts to reduce emissions are

recognized in a future regulatory program. Public disclosure of emissions in GHG inventories promotes transparency and improves business accountability.

- **Building capacities and expertise.** Reporting programs establish a system of measuring and reporting GHGs within the country, thus building a strong foundation to mainstream emissions reporting and spurring the development of a community of GHG inventory professionals and of the institutions related to such a community.

- **Supporting government policy formulation and implementation.** Emissions data gathered through reporting programs can inform national, subnational, and sectoral policies to reduce emissions. For example, when facility inventories provide information about major sources of emissions and emission trends in a region, this can support the establishment of mitigation goals. Over time, the data help monitor compliance with the goals (Richardson, 2012). Reliable emissions data at the facility level form the backbone of a cap-and-trade program and determine emitter allowances. (WRI and WBCSD, 2004; Kauffmann, Tébar Less, and Teichmann, 2012)

COMPARISON: DATA IN NATIONAL AND CORPORATE/FACILITY INVENTORY SYSTEMS

National and corporate/facility inventories, like all GHG inventories, are estimates of GHG emissions, largely derived from multiplying activity data by an emissions factor. Although the overall process for using these data may be similar, the scope, methods, and categorization of calculated emissions associated with both national and corporate/facility inventories can differ. It is important to understand the data-related differences in order to best determine how each inventory type can support different objectives. Table 1 provides a comparative summary of important attributes related to inventory data.

Table 1 | **Comparing Facility, Corporate, and National Inventories**

	FACILITY INVENTORIES	CORPORATE INVENTORIES	NATIONAL INVENTORIES
Inventory Boundary	Single facility	Company, which will be defined based on the approach selected— operational control, financial control, or equity share	Country
Emissions Categories	Emissions categorized as direct (Scope 1) and indirect (Scopes 2 and 3)		Emissions categorized in terms of sectors, subsectors, and source categories defined by IPCC guidelines, e.g., energy, industrial processes
Reporting Period	Annual (calendar or fiscal year)		Annual (calendar year)
Approach	Bottom-up: Developed using activity data obtained at a corporate or facility or source level (e.g., utility bills from metered buildings, fuel consumption from individual company-owned vehicles) or direct measurement of emissions		Primarily top-down: Developed using aggregated national data (e.g., national fuel consumption data, national energy data); some sources may also rely on bottom-up approaches to calculating emissions
Standards and Calculation Methodologies	Source-specific calculation methodologies, which are often specified as part of facility reporting programs.	Standards such as the GHG Protocol Corporate Standard and source-specific calculation methodologies. Reporting programs may also specify standards and calculation methodologies for companies to adhere to.	Guidelines provided by the Intergovernmental Panel on Climate Change (IPCC)

There are also important overlaps between national and corporate/facility inventory data and data systems.[26] For example, high-quality activity data from facility/corporate reporting programs can be aggregated for meaningful comparisons with the data from national inventories in certain situations. Several important caveats apply, however, when comparing national and corporate/facility data (US EPA, 2012):

- **Emissions data definitions and coverage:** Aggregated emissions data from corporate/facility reporting programs will differ from the emissions totals reported in the national inventory if not all sectors and emitters are covered under the program. For example, reporting programs may have sector-specific or program-wide thresholds limiting the number of reporters. Further, not all sectors may be part of the program. In addition, the boundaries set by individual corporations/facilities for estimating GHGs may differ as a result of different inventory objectives, making data aggregation and comparisons to the relevant national sectoral emissions difficult. Valid comparisons may be made for sectors where direct emissions from all entities are included, for example, if all fossil-fuel based power plants participate in the program.[27]

- **Calculation methods and emissions factors:** Reported emissions totals depend on the method selected and the emissions factors used in the calculation. Both methods and emissions factors can differ, even for the same activity, between national and corporate/facility inventories. For example, a corporate/facility reporting program may require direct or continuous emissions monitoring for some sources—an approach rarely used in national inventories. Additionally, facilities may use facility-specific factors for fuels burned, while national inventories may use default emissions factors provided by the IPCC or a national average factor based on a representative sample of facilities in the country.

- **Reporting classification:** A facility or corporate inventory classifies emissions from multiple sources such as fossil fuel combustion and industrial processes under scopes (Scopes 1, 2, and 3). National inventories, in contrast, categorize emissions largely by emissions source; for example, emissions from fossil fuel combustion across sectors (e.g., the cement, iron and steel, and aluminum sectors) are listed under a single category. Similarly, industrial process emissions are aggregated and reported in a single category, though totals are often available for process emissions from major-emitting industries (e.g., iron and steel, cement). This distinction should be kept in mind when comparing aggregated corporate/facility emissions reported to a program with those under a national inventory. The iron and steel industry example in Table 2 illustrates how emissions from different sources are classified in a corporate/facility inventory and as part of a national inventory.

Table 2 | **Classifying Select Emissions Sources in an Iron and Steel Company in Accordance with the GHG Protocol Corporate Standard and IPCC Source Categories**

EMISSION ACTIVITY	CLASSIFICATION IN CORPORATE INVENTORY IN ACCORDANCE WITH THE GHG PROTOCOL CORPORATE STANDARD	IPCC SOURCE CATEGORIES FOR NATIONAL INVENTORY
Internal heat generation	Scope 1	1A2a Iron and steel
Sinter production	Scope 1	2C1 Iron and steel production
Hot rolled flat production	Scope 2 (use purchased electricity)	1A1 Part of emissions from energy industries
Transportation of material and product	Scope 1 or Scope 3	1A3 Transport
Waste handling	Scope 1 or Scope 3	4A Solid waste 4D Waste water
Business activities—administrative	Scope 2 (use purchased electricity)	1A1 Part of emissions from energy industries
Business activities—travel	Scope 1 or Scope 3	1A3 Transport
Use of product	Scope 3	Not included

Source: Adapted from Sakulku, 2012.

LINKAGES BETWEEN NATIONAL AND CORPORATE/FACILITY INVENTORY SYSTEMS

Often national and corporate/facility inventory systems exist independently of each other and involve separate data collection, management, and quality assurance procedures. Aspects of the two systems, however, can be linked in a manner that brings mutual benefits, even when these may have been operating independently. In countries where national inventory and corporate/facility reporting systems are being contemplated or are in the early stages of development, it may be useful to capitalize on the opportunities for integration from the start. Communication and linkages between national and corporate/facility inventory reporting systems, such as those discussed below, can help improve the quality and accuracy of both inventories, enhancing their value for decision makers.

Incorporating data from corporate/facility inventory systems in national inventories

Using source-level data (i.e., data related to emitting activity) from a corporate/facility program can improve the overall quality and accuracy of national inventories by providing validation for national inventory estimates and improved emissions factors. For example, the U.S. Environmental Protection Agency (US EPA) used source-level data collected through its mandatory Greenhouse Gas Reporting Program (GHGRP) to evaluate estimates for emissions from the natural gas sector for the 2013 national inventory report (US EPA, 2013). These included estimates for methane emissions from liquids unloading (the process of removing liquids in wet gas wells) and from hydraulically fractured well completions and workovers. The US EPA updated the estimates as the cross-check against GHGRP data supported the direction of the changes (US EPA, 2013). It continues to evaluate

GHGRP data for potential updates to the national inventory and has proposed using GHGRP data on well completions and workovers with hydraulic fracturing to develop emissions factors for the 2014 national inventory report.

Source-level data could include activity data, emissions factors, and/or reported emissions totals. These data could be accessed individually from facilities or through existing programs where they are collected. In some instances, the data may not have been intended for use in national inventories, as in the case of the European Union Emissions Trading Scheme (EU ETS). But they could still be utilized to improve national inventories; the UK inventory agency, for example, has used the EU ETS data to improve emissions factors (IPCC, 2010). Therefore, national inventory compilers will have to assess the quality of available corporate/facility data, as well as determine whether these data can be mapped to the national inventory categories and whether the available data from facilities completely cover a single category. In order to facilitate consistent use of facility-level data in national inventories, countries can set clear conditions that should be met before the facility data can be incorporated, including the following:

- **Consistent definitions of emissions source categories:** Source-level facility data can be used in support of national inventories if sectors and national inventory categories are defined in the same way under corporate/facility and national inventory systems, respectively, or where sufficiently disaggregated data are available to combine data in line with the national inventory category definitions. Australia has integrated data across systems by using the national inventory classification system under its National Greenhouse and Energy Reporting (NGER) scheme, which governs data collection from facilities and corporations. Companies must provide enough information to classify facility-level data by industrial process and by fossil fuel combustion (Sturgiss, 2012). This allows Australia to use facility-level data directly in the national inventory. Systems may be designed to achieve this kind of integration from the beginning. In countries where national inventory systems and corporate/facility reporting programs are already in place, integration can also be achieved at a later stage by ensuring that disaggregated data are gathered from companies and communication between the two systems enables them to share and utilize the gathered data.

- **Completeness of data within a reporting category:** Compilers of a national inventory will need to understand what portion of a reporting category/sector is covered by a corporate/facility inventory system before incorporating data from those systems in the national inventory. Even when the entire sector is not covered, the data can be used if a reliable estimate can be obtained for the missing facilities. For example, if the average emission rate is considered representative of the entire sector, it can be applied to the rest of the sector to obtain emissions. Source-specific emissions factors can also be compared with those used in the national inventory to assess the reasonableness of the country-specific factors and/or their representativeness. Source-level data can also be used for validation depending on what percentage of the sector's emissions it covers (IPCC, 2010). In Australia, 4 out of 40 underground coal mines do not report their emissions under the NGER. So the NGER data for emissions from underground coal mines are used in the national inventory with a knowledgeable estimate based on other data sources for the missing information.

In the case of mandatory reporting programs, early linkages can ensure that databases are designed to support data use in national inventories. For example, the Australian reporting program database has been designed to collect data in a form readily useful for the national inventory. Companies must provide enough information to classify it into categories relevant for national inventories such as industrial process emissions and fossil fuel combustion (Sturgiss, 2012).

Sharing institutional capacity

National inventory systems are typically in place before corporate/facility reporting programs are established. Countries seeking to create reporting programs may find it more efficient to build on the existing institutional systems and technical methodologies developed by national inventories to make the best use of limited resources. This has several benefits, including:

- **Building on existing institutional resources:** Preparing national inventories requires strong institutional capacity[28] to regularly compile the inventory and technical capacity on methods, data collection, and documentation. As corporate/facility GHG programs are established, these can capitalize on existing capacities and be developed in a manner that enables communication and integration with national inventories. Agencies managing the national inventory development process often have the most emissions reporting-related experience in the country (covering knowledge of existing data sources, key stakeholders such as trade associations, among others). These are likely to be environment or climate change-related agencies and are often also tasked with leading a corporate/facility inventory program, thus building on the existing accounting capacity. For example, in the United States, the US EPA's Office of Air and Radiation, which leads the development of the national inventory, also led the development of the national mandatory reporting program. In Australia, the National Greenhouse and Energy Reporting system was developed under the Department of Climate Change and Energy Efficiency (DCCEE), which also prepares the national inventory. Similarly, in South Africa, the Department of Environmental Affairs is leading the development of its mandatory GHG reporting program and it also prepares the country's inventory. Sharing of institutional knowledge and resources can continue beyond the initial development phase even as the corporate/facility program begins to take shape and grow. Institutional linkages can also facilitate data sharing and coordination across the two systems as appropriate.

- **Sharing technical capacities and expertise:** With institutional integration comes sharing of technical expertise and enhanced communication on aspects such as linking databases, using appropriate emissions factors and methodologies. The process of developing national inventories brings together a wide range of research institutions and technical experts. GHG programs promoting corporate/facility inventories also require similar capacities and resources to design specifications and develop methodologies. For example, the technical staff working on the U.S. national inventory was involved in developing source category rules under the US EPA reporting program. The reporting program also used existing national inventory methodologies to inform emissions calculation approaches for most sources (IPCC, 2010). National inventory estimates can also help identify emissions-intensive sectors to focus on if the country is considering initiating a corporate/facility program at a smaller scale. Additionally, new reporting programs can adopt country-specific emissions factors used in the national inventories instead of international default factors.

CONCLUSION

An effective climate change strategy for a country, corporation, or facility requires a detailed understanding of GHG emissions sources, quantities, and trends over time. An inventory is the tool to provide such information. It allows both governments and companies to take into account their emissions-related risks and opportunities and focus efforts on mitigation activities that can produce the greatest GHG reductions.

National inventories and corporate/facility inventories each fulfill unique roles: for example, while the former track a country's total emissions, the latter allow individual companies or facilities to assess their emissions performance. Further, corporate/facility reporting programs can provide localized information on the most significant emissions sources and emissions trends. Despite important differences in category definitions, methodology, and other elements, governments interested in developing (or enhancing) a national inventory system and corporate/facility reporting program should seek to capitalize on possible linkages between the two systems. In this paper, we have identified two potential areas for linkages: (1) integrating source data into the national system to improve completeness and accuracy; and (2) sharing institutional resources, technical expertise, and data systems to build on existing capacities and get the most from limited resources.

Proactively identifying and exploiting these and potential other linkages between national inventory and corporate/facility reporting systems can bring enhanced benefits, such as greater consistency across national datasets, formalizing the role of data from corporate/facility inventory systems in the national inventory system, and maximizing data collected and analyzed. Establishing such linkages will continue to be critical in improving the quality of inventories, increasing their utility for mitigation strategies, and reducing emissions at both the national and corporate/facility level.

ACRONYMS AND ABBREVIATIONS

AFOLU	Agriculture, forestry, and other land use
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety)
CDSB	Climate Disclosure Standards Board
CEMS	Continuous emissions monitoring systems
DCCEE	Department of Climate Change and Energy Efficiency
DEA	Department of Environmental Affairs
ERM	Environmental Resources Management
EU ETS	European Union Emissions Trading Scheme
GHG	Greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
NGER	National Greenhouse and Energy Reporting
PFC	Perfluorocarbon
PNMC	Política Nacional sobre Mudança do Clima (National Policy for Climate Change)
QA/QC	Quality Assurance/Quality Control
SAAQIS	South African Air Quality Information System
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

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ENDNOTES

1. See unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php and unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php.
2. "In the Agriculture, Forestry and Other Land Use (AFOLU) Sector, emissions and removals on managed land are taken as a proxy for anthropogenic emissions and removals, and interannual variations in natural background emissions and removals, though these can be significant, are assumed to average out over time" (IPCC, 2006).
3. For a list of Annex I Parties to the UNFCCC, see unfccc.int/parties_and_observers/parties/annex_i/items/2774.php. Non-Annex I Parties are those countries that have ratified or acceded to the UNFCCC but are not listed under Annex I and are therefore not under any emission reduction obligation. For a list of non-Annex I Parties, see unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php.
4. For more information on Annex I reporting requirements for national GHG inventories, see unfccc.int/national_reports/annex_i_ghg_inventories/reporting_requirements/items/2759.php. For more information on the review process of Annex I national GHG inventories, see unfccc.int/national_reports/annex_i_ghg_inventories/review_process/items/2762.php.
5. For more discussion, see Breidenich, 2011. www.nrdc.org/globalwarming/files/trackingcarbon-wp.pdf. See also unfccc.int/national_reports/non-annex_i_natcom/items/2716.php.
6. A National Communication is a government document submitted periodically by a country to inform other Parties of the Convention of their national activities to address climate change. Guidelines for non-Annex I National Communications state that the report should include a summary of the national GHG inventory. See unfccc.int/resource/docs/cop8/07a02.pdf#page=2.
7. "The inventory for the first national communications was to cover the year 1994 or 1990; the second the year 2000" (www.nrdc.org/globalwarming/files/trackingcarbon-wp.pdf).
8. See unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php.
9. Adopted guidelines state that least developed countries and small island states may report biennial update reports at their discretion. See unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf#page=10 or unfccc.int/national_reports/non-annex_i_natcom/guidelines_and_user_manual/items/2607.php.
10. Additionally, the "Other" category accounts for miscellaneous sources (e.g., indirect emissions from nitrogen deposition from nonagricultural sources).
11. For more information, see www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf.
12. A top-down approach is the method in which generalized factors such as total fuel use, total volume of waste, total industrial production, or annual carbon stock changes for a land-use category are used as indicators of emissions. A bottom-up approach may include gathering data from individual facilities for a particular industry and aggregating it to produce GHG estimates for a particular source category.
13. National magnitude of an activity resulting in emissions or removals in a given period of time. Examples include data on energy use, metal production, forest clearing, and fertilizer use.
14. For further discussion of emerging good practices for improving countries' national GHG inventory systems, see Damassa and Elsayed, 2013.
15. See www.planalto.gov.br/ccivil_03/_Ato2007-2010/2010/Decreto/D7390.htm for full text of Decree 7.390.
16. Reduction of projected emissions by 36.1–38.9 percent by 2020.
17. For more information on South Africa's national atmospheric emission inventory system, see https://sites.google.com/site/maptpartnerresearch/national-ghg-inventory-case-study-series/national-ghg-inventory-data-management-systems.
18. The Kyoto mechanisms are emissions trading, the Clean Development Mechanism, and Joint Implementation.
19. See unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php.
20. For more information, see unfccc.int/resource/docs/publications/08_unfccc_kp_ref_manual.pdf.
21. Note, however, that emission reductions from projects that generate emission reduction units are unlikely to be directly assessed using a national GHG inventory, as emission reduction units are quantified against a hypothetical project baseline and total emission reductions from a project are relatively small compared with total national, sectoral, or source category emissions.
22. More information on these programs can be found on their respective websites: The Brazil GHG Protocol program at www.ghgprotocolbrasil.com.br/; The Climate Registry at www.theclimateregistry.org/; and CDP at www.cdp.net/.
23. More information about the Cement Sustainability Initiative can be found at www.cement-co2-protocol.org/en/ and www.wbcsdcement.org/.
24. More information about these programs can be found on their respective websites: Australia's National Greenhouse and Energy Reporting Scheme at www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/Pages/default.aspx and the US Greenhouse Gas Reporting Program at www.epa.gov/ghgreporting/.
25. More information about the CO_2 Quantification Protocol can be found at www.cement-co2-protocol.org/en/.
26. Comparison is made between national inventories and aggregated activity data from corporate/facility programs. Activity data allow aggregating emissions by distinct emissions sources (e.g., fossil fuel combustion and industrial processes) either from a facility or corporate for comparison with national inventories data. Further, only direct emissions or Scope 1 emissions are considered for comparison with emissions totals in national inventories.
27. Indirect emissions related to transport and purchased electricity, which are covered in Scope 2 and 3 in corporate/facility inventories, are reflected under transport and energy categories of national inventories. Scope 2 and 3 emissions data are not compared with national inventory data.
28. Institutional capacity refers to the presence of effective institutions and agencies with a mandate to take the lead on, provide, and support services.

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