An Overview of **greenhouse gas emissions inventory** Issues

Prepared for the Pew Center on Global Climate Change

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Foreword *Eileen Claussen, President, Pew Center on Global Climate Change*

At a Pew Center conference on Early Action held in September 1999, DuPont announced plans to reduce its greenhouse gas emissions 65 percent from 1990 levels by 2010. BP Amoco intends to reduce greenhouse gas emissions by 10 percent of 1990 levels by 2010 and has implemented an emissions trading system across all of its businesses. United Technologies Corporation has announced targets to reduce energy and water usage by 25 percent per dollar of sales by 2007.

Motivated by factors ranging from a desire to monitor and reduce energy consumption to concern for the environment to anticipation of future requirements to cut emissions that contribute to climate change, a growing number of companies are voluntarily undertaking action to reduce their greenhouse gas emissions. This report provides an overview of how greenhouse gas emissions are estimated and reported in emissions inventories. It highlights a variety of approaches taken by companies to identify, track, and curb their emissions, and provides insights from their experiences.

This Pew Center report is the first in a new series aimed at identifying practical solutions to address climate change. The Solutions series is aimed at providing individuals and organizations with tools to evaluate and reduce their contributions to climate change. This first report, prepared by Christopher Loreti, William Wescott, and Michael Isenberg of Arthur D. Little, Inc., identifies credible approaches and offers a set of principles for conducting emissions inventories. The authors identify key decision points in efforts to conduct an emissions inventory. They note that the purpose of an inventory should influence the approach, pointing out, for example, the tension that exists between encouraging consistency in reporting practices and providing flexibility to reflect a specific company's unique circumstances.

In the absence of a comprehensive climate policy regime, voluntary efforts to identify and reduce greenhouse gases at the source are critical. Ensuring that such efforts are ultimately recognized under future policy regimes is equally important and only likely to be possible if greenhouse gas emissions reductions are found to be real, quantifiable, and verifiable. A subsequent Pew Center report will address key issues in the verification of emissions inventories and emissions reductions.

The authors and the Pew Center would like to thank the companies featured in this report for sharing their stories and insights, and acknowledge the members of the Center's Business Environmental Leadership Council, as well as Janet Raganathan and others involved in the Greenhouse Gas Measurement & Reporting Protocol Collaboration, for their review and advice on a previous draft of this report.

Executive Summary

There is great interest today in the inventorying of greenhouse gas (GHG) emissions by corporations — perhaps more than there has ever been for a voluntary environmental initiative. This interest is part of the general trend among corporations towards increased reporting of environmental performance. In addition, many organizations have concluded that enough is known to begin taking action now to understand, to manage, and to reduce their GHG emissions. The possibility of earning credit for taking voluntary actions to reduce emissions is also a motivating factor for many companies to conduct inventories. Conducting an inventory is a necessary first step in managing GHG emissions.

This paper provides an overview of key issues in developing greenhouse gas emissions inventories, with particular emphasis on corporate-level inventories. It illustrates the range of current activities in the field and the experience of major corporations that conduct GHG emissions inventories. Areas of general agreement, as well as unresolved issues in emissions inventorying, are described. More specifically, the paper discusses:

- How national level emissions inventories relate to corporate and facility inventories,
- How companies conduct their inventories,
- Inventory accuracy,
- How companies decide which emissions to include (drawing boundaries),
- Baselines and metrics,
- Challenges for corporations in conducting global inventories, and
- Learning from similar measurement approaches.

One important issue this paper does not address is the verification of emissions inventories and emissions reductions. Verification is the subject of another paper being prepared by Arthur D. Little, Inc. for the Pew Center on Global Climate Change.

This review of GHG emissions inventory issues is based on meetings and discussions with the Pew Center's Business Environmental Leadership Council, a survey of selected major corporations on their GHG inventory practices, and a review of pertinent literature. It is also informed by the participation of the Pew Center and Arthur D. Little, Inc. in a collaborative effort led by the World Resources Institute and the World Business Council for Sustainable Development to develop an internationally accepted protocol for conducting GHG emissions inventories.

The intent of this paper is not to advocate any specific methodology or approach for conducting GHG emissions inventories, nor to promote any particular policy positions. The review of the experience to date and issues surrounding GHG emissions inventories, however, suggests several general principles for developing effective GHG emissions inventory programs:

1. Start by understanding your emissions. Knowing the relative magnitude of emissions coming from various sources is necessary to understand whether or not they are material contributors to a firm's total emissions. Understanding the nature and the number of the emissions sources will facilitate the use of the inventory development guidance that is becoming available.

2. Understand the likely uses of the emissions inventory. Companies conduct GHG emissions inventories for purposes that range from internal goal-setting to external reporting to obtaining financial benefits. These different uses of the inventory information imply different levels of completeness, accuracy, and documentation in the inventory. Each organization will need to reach its own conclusion as to the cost/benefit balance of developing its inventory, depending upon its set of likely uses.

3. Decide carefully which emissions to include by establishing meaningful boundaries. Questions of which emissions to include in a firm's inventory and which are best accounted for elsewhere are among the most difficult aspects of establishing GHG emissions inventories. Since the purpose of conducting an inventory is to track emissions and emissions reductions, companies are encouraged to include emissions they are in a position to significantly control and to clearly communicate how they have drawn their boundaries.

4. Maximize flexibility. Since requirements to report or reduce GHG emissions under a future climate policy regime are uncertain, companies should prepare for a range of possibilities. By maximizing the flexibility in their emissions inventories — for example, by being able to track emissions by organizational unit, location, and type of emission or by expressing emissions in absolute terms or normalized for production — organizations will be prepared for a wide range of possible future scenarios.

5. Ensure transparency. Transparency in reporting how emissions and emissions reductions are arrived at is critical to achieving credibility with stakeholders. Unless the emissions baseline, estimation methods, emissions boundaries, and means of reducing emissions are adequately documented and explained in the inventory, stakeholders will not know how to interpret the results.

6. Encourage innovation. Now is the time to try innovative inventory approaches tailored to a company's particular circumstances. The range of experience and lessons learned will be invaluable as voluntary reporting protocols are developed or as possible regulatory requirements are established. Learning what works best — and doing it before any requirements for reporting are in place — will be as important as learning what does not work.

I. Introduction

There is currently much interest among corporations in undertaking greenhouse gas (GHG) emissions inventories. This interest has been accelerated by the trend toward increasing voluntary reporting of corporate environmental performance, including the emissions of greenhouse gases. Increasingly, companies are concluding that enough is known to begin taking action now to understand, to manage, and to reduce their GHG emissions. Conducting an emissions inventory is a necessary first step in this process. By properly accounting for their GHG emissions and removals (sinks), corporations have an opportunity to establish a foundation for setting goals and targets; provide a baseline to measure progress; evaluate cost-effective greenhouse gas reduction opportunities; clearly communicate with their stakeholders; contribute to the development of accurate national inventories; and provide data that supports flexible, market-oriented policies.

The 1997 Kyoto Protocol, under which industrialized countries pledged to collectively reduce their greenhouse gas emissions to roughly 5 percent below 1990 levels during the period 2008-2012, is one impetus for conducting emissions inventories. Although the Protocol has not been ratified by any major industrialized nation, and it is unclear how corporations would be affected by any such plan to reduce emissions, knowledge of their current emissions (and means for their reductions) is essential for companies to understand how the policy options currently being debated might affect them and how they should participate in the debate.

Other reasons cited by companies for conducting GHG emissions inventories are primarily financial. Conducting inventories in conjunction with energy measurement and conservation programs enables companies to identify opportunities to reduce their energy usage, greenhouse gas emissions associated with this energy usage, and energy costs. Reducing emissions of the greenhouse gas methane by, for example, reducing losses during oil and gas production and transport or capturing landfill gases, saves a valuable commodity.

Inventorying GHG emissions and emissions reductions is necessary to document the effects of voluntary actions taken to reduce emissions and to enable companies to claim credit for these reductions. Even if marketable credits are not a primary reason for conducting an inventory, the historical documentation of inventories may be useful in ensuring that companies are not penalized in the future for any voluntary emissions reductions they make today. By accurately inventorying emissions, companies will be in a better position to count emissions reductions they voluntarily undertake today towards reductions they may be required to make under a future regulatory regime.

The particular purpose of conducting an inventory differs from company to company. To meet these different needs, companies may inventory greenhouse gas emissions on several levels: across the company, by facility, for a specific emissions reduction project, or over the entirety or part of their products' life cycles. Though there are many different inventory types, they are generally complementary. To a large extent, the differences in inventory types have more to do with the way inventory results are reported than the way the data are collected. The importance placed on flexibility throughout this paper reflects the need to be able to produce more than one type of inventory from the same basic set of inventory activities, because the purpose of conducting the inventory may evolve over time.

This report provides an overview of key issues in developing greenhouse gas emissions inventories, with particular emphasis on corporate-level inventories. The purpose is not to develop or propose a protocol for use in conducting inventories, but rather to illustrate the range of approaches being taken by different organizations and corporations in inventorying and reporting their emissions. No particular approach or methodology for conducting inventories is advocated, nor are any particular policy positions taken. Instead, because potential future requirements for reporting emissions are uncertain, and at present reporting is a voluntary activity, pragmatic considerations for dealing with different possible future scenarios are emphasized.

This paper is intended to give guidance to interested non-experts and insights to experienced professionals on those emissions inventory issues that have largely been agreed upon, as well as on issues that remain to be resolved. Emissions inventories conducted by corporations and other organizations are the focus of this paper because decisions regarding the implementation of GHG management measures will be undertaken at this level, particularly under a voluntary system. Therefore, this paper should be of greatest interest to those responsible for establishing or conducting corporate, or organization-wide, inventories. The points explored here are intended to inform both large and small businesses and those that operate both nationally and internationally.

Specifically, the paper addresses seven major areas:

- How national level emissions inventories relate to corporate and facility inventories,
- How companies conduct their inventories,
- Inventory accuracy,
- How companies decide which emissions to include (drawing boundaries),
- Baselines and metrics,
- Challenges for corporations in conducting global inventories, and
- Learning from similar measurement approaches.

The focus of this paper is primarily on domestic issues faced by corporations in conducting GHG inventories. Many of these issues are not uniquely domestic, however, and the approaches discussed here can be — and indeed are being — applied by multinational corporations, as shown by the examples presented.

One important topic this paper does not address is the verification of emissions inventories and emissions reductions. Issues associated with verification will be the subject of another paper being prepared by Arthur D. Little, Inc. for the Pew Center.

The discussion of greenhouse gas emissions inventory issues contained in this report is based on:

1. Discussions with the Pew Center on Global Climate Change's Business Environmental Leadership Council (BELC)[1] on the major questions and considerations the council members face in undertaking greenhouse gas inventories.
2. A brief survey on GHG emissions inventory issues conducted among BELC members and several other companies for this paper.
3. Review of the literature related directly to GHG inventory management and materials on related subjects, such as GHG emissions trading, early action proposals and programs, and emissions inventories for other gases.

4. Participation of the Pew Center on Global Climate Change and Arthur D. Little in the Greenhouse Gas Measurement & Reporting Protocol Collaboration convened by the World Resources Institute and the World Business Council for Sustainable Development, a multi-stakeholder group established to develop an internationally accepted protocol for measuring and reporting business GHG emissions.

5. Presentations and insights provided at a Practitioner's Forum of the Pew Center on GHG emissions inventory and verification issues.

6. The prior experience of Arthur D. Little, Inc. in the field.

II. National Greenhouse Gas Emissions Inventories

Countries conduct national-level GHG emissions inventories both as part of their domestic policies and to comply with international agreements, namely the United Nations Framework Convention on Climate Change. These inventories are typically conducted independently of corporate or facility level inventories (except for some of the less significant GHGs). They are conducted on a top-down basis using national activity data rather than data from specific facilities. Corporate inventories, in contrast, are typically conducted on a bottom-up basis by summing emissions from individual facilities.

The Intergovernmental Panel on Climate Change (IPCC) is the primary developer of guidelines for conducting national inventories. The IPCC guidelines are designed to estimate and report on national inventories of both anthropogenic greenhouse gas emissions and removals. The core of the system is the establishment and use of a standard tabular reporting format using common source and sink categories and common fuel categories in six major sectors:

- Energy,
- Industrial Processes,
- Solvents and Other Product Use,
- Agriculture,
- Land Use Change and Forestry, and
- Waste.

Countries complete a table of GHG emissions for each of these sectors, with each table listing data on subsectors. For example, carbon dioxide (CO_2) emissions from the manufacture of cement and nitrous oxide emissions from the production of adipic acid would be listed as part of the industrial processes. In addition to a sector-by-sector approach of summing carbon dioxide emissions from fossil fuel combustion by each sector, the IPCC requires that as a check on selected figures, a top-down approach be used to calculate emissions based on national fuel consumption data.

The IPCC guidelines follow an approach that is commonly used throughout the world for estimating emissions: multiplication of emissions factors, which relate the quantity of GHG emitted per unit of activity, by the activity level for each source or sink category. Countries may develop more sophisticated measures to minimize uncertainties associated with the default emissions factors provided in the IPCC guidance, and are encouraged to do so. The default method was developed to help countries easily compile a greenhouse gas emissions inventory and to provide a common starting point for countries to develop their own national assumptions and data.[2]

The IPCC guidelines provide a basis for expressing the emissions of different greenhouse gases on a common basis (IPCC, 1996a). Because greenhouse gases vary in their relative radiative effects — their potency as greenhouse gases — the IPCC has developed a Global Warming Potential (GWP) for each gas.[3] The GWP is an expression of the warming effectiveness of the gas over a given period — most commonly 100 years — compared to carbon dioxide. Methane, for example, has a GWP of 21, meaning the emission of one kilogram of methane is equivalent to the emission of 21 kilograms of CO_2. GWPs are multiplied by the mass emissions rate of the respective gas to arrive at the emissions rate in CO_2 equivalents for each gas. Unlike mass emissions rates, the GHG emissions of different gases expressed in CO_2 equivalents can be meaningfully compared or summed.

National governments have also been active in developing and publishing methods for conducting GHG emissions inventories. The U.S. EPA publishes its Inventory of U.S. Greenhouse Gas Emissions and Sinks (e.g., EPA, 1999) annually, which in addition to providing the results of the latest national emissions inventory describes the methodology for estimating the emissions. Australia's Greenhouse Office has prepared a series of workbooks on the methodologies for conducting its national inventory (e.g., AGO, 1998). Many other countries have published similar guidance.

For developing countries, less inventory guidance is available, and following and customizing existing guidance is more difficult. Much of their emissions are related to economic activities that are not reliably tracked. This creates particular inventorying problems in assessing emissions from land use changes, for example, where there is no clear method to track forest burning and land clearing (Brown et al., 1998). In addition, the technology transfer rates are lower and equipment is often older in these countries, increasing the probability that the default IPCC emissions factors are not appropriate, particularly for non-combustion emissions sources.

In some countries, sub-national governments conduct GHG emissions inventories. Many U.S. states have performed statewide GHG emissions inventories with the support of the U.S. EPA. As part of its Emissions Inventory Improvement Program, the EPA has recently published a volume on Estimating Greenhouse Gas Emissions (EPA, 1999a). This volume consists of fourteen chapters that describe how GHG emissions can be inventoried at the state level for a wide range of emissions sources. Australia's Greenhouse Office has prepared supplemental methodologies for conducting state and territory inventories to accompany its national inventory workbooks (AGO, undated).

A. Implications at the Corporate and Facility Levels

There are important links between national inventories and corporate inventories. The greenhouse gases included in corporate inventories are typically those included in national inventories. Methodologies for estimating emissions at the corporate level are often derived from the methods used for conducting national inventories, particularly emissions of carbon dioxide from fuel use. The baseline used for establishing emissions trends at the national level influences those used at the corporate level. These linkages also affect the way facility inventories are conducted.

One of the more significant ways in which national level inventories and commitments affect the conduct of emissions inventories at the facility level is in defining the scope of the activity. The Kyoto Protocol covers six greenhouse gases or categories of gases, as shown in Table 1, and these are the gases typically included in facility level emissions inventories. The Kyoto list of greenhouse gases is not exhaustive, however, and some reporting schemes include other gases. For example, the U.S. Department of Energy's voluntary reporting program developed under Section 1605b of the Energy Policy Act (DOE, 1994) includes reporting of emissions and emissions reductions for chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), Halons[4], carbon tetrachloride (CCl_4), and 1,1,1-trichloroethane (1,1,1-TCA), but none of these categories of compounds is included in either the Kyoto Protocol or the IPCC reporting framework. They were intentionally left out of both because reporting commitments and schedules for ending their use are part of the Montreal Protocol.

In the aggregate, the CFCs, HCFCs, and the other compounds covered by the Montreal Protocol phase-out are relatively small contributors to greenhouse gas emissions and whether or not they are included in emissions inventories has little effect at the national level. At the facility level, however, they may account for the majority of GHG emissions, depending on the nature of the operation and the other types of sources present.[6]

Table 1

Greenhouse Gases Included in Various Reporting Schemes

Greenhouse Gas		Reporting Scheme		
Name	**Abbrev.**	**Kyoto**	**IPCC**	**DOE1605b**
Direct GHGs				
Carbon Dioxide	CO_2	√	√	√
Methane	CH_4	√	√	√
Nitrous Oxide	N_2O	√	√	√
Hydrofluorocarbons	HFCs	√	√	√
Perfluorocarbons	PFCs	√	√	√
Sulfur Hexafluoride	SF_6	√	√	√
Indirect GHGs				
Nitrogen Oxides	NO_x		√	√
Carbon Monoxide	CO		√	√
Non-Methane VOCs[5]	NMVOCs		√	√
Montreal Protocol Compounds				
Chlorofluorocarbons	CFCs			√
Hydrochlorofluorocarbons	HCFCs			√
Halons				√
Carbon Tetrachloride	CCl_4			√
1,1,1-Trichloroethane	1,1,1-TCA			√

The IPCC reporting guidelines and the U.S. DOE voluntary reporting guidelines include several conventional air pollutants due to their indirect effects as greenhouse gases. These compounds are included because of their role in the formation of tropospheric ozone, another greenhouse gas. These pollutants,[7] which are not included in the Kyoto Protocol, are:

- Oxides of nitrogen (NO_x),
- Carbon Monoxide (CO), and
- Non-methane Volatile Organic Compounds (NMVOCs).

These compounds are typically not included in corporate greenhouse gas emissions inventories because their global warming potentials are highly uncertain (IPCC, 1996a). Companies that report emissions of conventional air pollutant emissions as part of their broader environmental reporting would account for them on a mass basis. Until the global warming effects of these compounds are known with more certainty, it is unlikely that their inclusion in corporate emissions inventories will become widespread. The reporting of emissions of these gases (on a mass basis) at the national level is expected to continue, however, as their emissions rates over larger areas are of interest to climate researchers.

Few companies actually report on exactly those compounds covered by the Kyoto Protocol or the IPCC. Table 2 illustrates the wide range of GHGs that are included in the emissions inventories of selected companies. While some firms limit their reporting to CO_2 emissions (and may have no other significant emissions), others, such as ICI and Shell International, report on the whole suite of GHGs.

Table 2

Greenhouse Gases Included in the Inventories of Selected Companies

	Greenhouse Gases Included in Inventory								
Company	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**CFCs**	**HCFCs**	**Others**
AEP	√					*	√**		
Air Products	√	√	√	√	√	√			
Baxter	√						√	*	CO, NO_x, under consideration
BP Amoco	√	√							
DuPont	√	√	√	√	√				
ICI	√	√	√	√	√		√	√	CH_2Cl_2, CH_3Cl, CCl_4, 1,1,1-TCA, CO, NO_x, VOCs
Niagara Mohawk	√	√							
Shell International	√	√	√	√	√	√	√	√	Halons, TCE, VOCs, NO_x
Suncor	√	√	√						
Sunoco	√	√	√				√		NO_x
UTC	√								

Note: CH_2Cl_2 = methylene chloride, CH_3Cl = chloroform, CCl_4 = carbon tetrachloride, TCA = trichloroethane, CO = carbon monoxide, NO_x = nitrogen oxides, VOCs = volatile organic compounds, TCE = trichloroethylene

AEP = American Electric Power, UTC = United Technologies Corporation; The ICI Group is one of the world's largest coatings, specialty chemicals, and materials companies.

*to be tracked in future

**inventoried but not counted toward reduction targets

Another way in which national level inventories affect facility level accounting is in the methodology used for estimating emissions. For emissions of many greenhouse gases, the procedure for estimating emissions is not fundamentally different at the enterprise level compared to the national level. This is especially true for carbon dioxide because emissions are estimated by multiplying the rate of fuel consumption by the carbon content of the fuel, adjusting for the percentage (typically 98-99.5%) that is oxidized to carbon dioxide. Instead of using national figures for annual fuel consumption and the carbon content of that fuel, facility-specific figures are used. Default fuel emission factors are included in the IPCC methods and in guidance provided by the U.S. DOE in its voluntary reporting program. For developed countries with properly maintained combustion equipment, these factors are considered to be quite accurate (EPA, 1999).

National and international programs also influence the selection of the baseline companies use to measure their progress in voluntarily reducing emissions. The United Nations Framework Convention on Climate Change (UNFCCC), opened for signature at the 1992 Rio de Janeiro Conference on Environment and Development, uses 1990 as the target year for stabilizing GHG emissions. Based on the Framework Convention, the 1993 U.S. Climate Change Action Plan adopted 1990 GHG emissions as the goal to which net U.S. emissions would return by the year 2000. Similarly, the U.S. DOE's 1605b voluntary GHG reporting program suggests 1990 as a base year for companies reporting emissions reductions. The Kyoto Protocol, the text of which was drafted in 1997, also uses 1990 as a base year, with emissions reductions to be met during the period 2008-2012.

Though nothing requires the use of 1990 as a base year, it is often used by corporations. Of the 11 corporations listed Table 2, six have set explicit targets for controlling GHG emissions. Five of these — American Electric Power, BP Amoco, Niagara Mohawk, Shell International, and Suncor — have selected 1990 as their base year. One — ICI — has selected 1995.

It might be thought that since GHG emissions reporting by corporations is voluntary, activities at the national or international level do not affect them. While technically this may be true, companies deviating from the approach of the national conventions may raise questions among various stakeholder groups. Reporting on less than the suite of Kyoto gases could lead to questions about why some gases have been left out. Conversely, including compounds covered by the Montreal Protocol could lead to criticism that companies are trying to take credit for emissions reductions they would legally be required to make anyway, even though the reductions represent a real decrease in GHG emissions. Similarly, large deviations from accepted estimation procedures used at the national level could lead to questions about the accuracy of corporate emissions estimates, unless it can be demonstrated that the approach used by the company is more appropriate.

III. Approaches to Estimating Emissions at the Company Level

The purpose of a firm's inventory determines how it approaches its inventory. While the purposes and thus the inventory approaches vary, successful corporate inventories share a variety of attributes including: simplicity, credibility, transparency, comparability, consistency, materiality, flexibility, and the ability to be verified (e.g., WRI/WBCSD, 1999).

Simplicity (and cost-effectiveness) is particularly important at a time when GHG reporting is voluntary, because the success of corporate-wide reporting is dependent upon obtaining broad acceptance and support within the organization. Credibility is important for satisfying both external and internal stakeholders. One way to promote credibility is to ensure that the inventory methods and assumptions are transparent. Comparability — the potential for the results of a company inventory to be compared with those of other companies within an industry or for a given facility inventory to be compared to that for past or future years — is also important in establishing credibility. Consistency in emissions estimation and reporting throughout an organization is closely related to comparability and is also important. Materiality — properly determining which emissions are material and which are negligible — serves both the goals of simplicity and credibility. Flexibility — the ability to estimate and report emissions in a variety of ways and to draw boundaries around GHG emissions to maximize the incentives to reduce them — is also essential at a time when inventory methods are still being developed and the future of any possible GHG emissions reduction program is uncertain. The ability of an independent party to verify that the emissions reductions achieved by a company are real is a particularly important attribute for companies that wish to obtain credit for the emissions reductions or participate in trading programs.

Clearly, tensions among these attributes exist. Having flexible boundaries, for example, means that a facility or firm has the flexibility to decide what to include or not include in its inventory. If all firms within an industry decide boundary questions the same way, then broad comparability will exist between one firm's emissions estimates and those of other firms within the same industry. If different firms decide the boundary questions differently, however, comparisons among firms will not be as meaningful.

This is not to suggest that comparisons among firms are or should be a primary goal of emissions reporting. Experience with other reporting schemes has shown, however, that once information on emissions is made public, comparisons will be made whether they are valid or not. To address potential inconsistencies in reporting and assure comparability among reports, initiatives like the Greenhouse Gas Measurement and Reporting Protocol collaboration[8] and certain trade groups are encouraging the widespread use of "best practices."

A. Types of Inventories

GHG emissions inventories may be conducted to report on emissions on a facility, entity-wide (corporate), or project-specific basis – or to report on the emissions of a product over its entire life cycle or part of its life cycle. These types of inventories are not mutually exclusive, and many companies conduct more than one type. Company-wide emissions inventories are usually derived from facility inventories. Emissions over the life cycle of a product require that inventories be conducted for specific parts of its life, such as its use and its manufacture, the latter of which would also require that a facility-level inventory be conducted.

Project-specific inventories are used by organizations to track and report specific emissions reduction projects, and firms may report on emissions reduction projects without conducting inventories of their entire operations. Indeed, the vast majority of the reports that are submitted to the U.S. DOE's 1605b reporting system, which allows for both project-specific and corporate-wide reporting, are for specific emissions reduction projects.

Emissions may also be inventoried and reported on a product life-cycle basis, which means the total emissions for a product from its design phase, through its manufacture, use, and disposal (or recycling) are quantified. While particularly important for products that have large GHG releases over their working lives, the estimation of life-cycle emissions can be quite complicated and life-cycle emissions inventories are much less common than the other types.

In most cases, inventories are conducted on an annual basis soon after the end of the reporting year. In some cases, however, it is necessary to estimate emissions retrospectively. Retrospective emissions inventories are conducted when a company wishes to establish emissions levels in the past as the baseline against which to evaluate future emissions changes.

A key question in conducting company-wide inventories for past periods is that of data availability. In order to construct an inventory of past emissions, data on the quantities and types of fuel combusted are needed.[9] If the inventory is to include emissions from purchased electricity, information on electricity consumption and the source of that electricity (how much CO_2 and other GHGs are emitted per kilowatt-hour produced) is required. Information is also needed on process-related emissions, such as the level of activities and the emissions factors for these activities during the base year. Since GHG emissions were not typically accounted for during the past, the accuracy of the retrospective inventory will depend on how complete a company's records are and how far back they go.

The inventorying of emissions related to the implementation of a specific emissions reduction project is performed somewhat differently from company-wide inventorying. Typically, the emissions reduction is counted as the difference in emissions with and without the project, with the baseline emissions being what the actual emissions were immediately prior to the project's implementation. Emissions from a new project would be inventoried after the project is completed and compared to the emissions just prior to its implementation to enable the emissions reduction to be quantified. In this case, it is assumed that the baseline is fixed. In some cases, it may be more appropriate to use a dynamic baseline (e.g., one that changes annually) to represent what emissions would have been in the absence of the project.

The inventorying of emissions sinks provides special challenges since the methodologies for estimating the amount of carbon sequestered are generally less well-developed than for the major greenhouse gas emission sources. Quantification of carbon sequestration is often left to experts in the field. (See Box 1).

Box 1

Entergy's Approach to Carbon Sequestration

Entergy is a major global energy company in the field of electric power production, distribution operations, and related services. Entergy's approach to reducing the GHG impacts of its operations includes forests and wetlands projects to offset its emissions. The projects are managed by forest management consultants and include analyses of the net amount of CO_2 removed from the atmosphere and stored as carbon in the forests and wetlands. Entergy believes the analyses will help it understand, and possibly improve, removal rates and methods for estimating carbon stored. The analyses also enable the company to track projects and report results under the Department of Energy's 1605b program. Finally, the analyses help address stakeholder concerns regarding the validity of the environmental benefits of the projects.

Entergy's analyses follow the Department of Energy's "Guidelines for Voluntary Reporting of Greenhouse Gas Emissions, Reductions, and Carbon Sequestration." It is important to note that each project is different and requires project-specific estimates for growth rates, conversion factors and baselines. Neither Entergy nor DOE supply detailed rules for determining inputs for the reports. Entergy looks for clear, simple, logical analyses and relies on the best professional judgment of its consultants for specific factors.

Each analysis estimates the net amount of carbon removed from the atmosphere (stored in the forest or wetland) by the project. Estimates of net carbon removal can be made using tables of factors provided by the DOE, factors from other credible sources, or the consultant can develop its own. Field studies may be conducted, but this is not required.

For one set of projects, Entergy planted pine and hardwood forests on 24 different sites, for a total of 4,096 acres. Each site had different characteristics. On one of the sites, a forest had been clear-cut, while the other sites had been farmlands and pastures. The amount of carbon stored was estimated following DOE guidelines specific for site characteristics and species planted. These guidelines provide moderate accuracy, but assume, for example, ideal planting conditions. While field studies would be more accurate, the guidelines provide a quick, economical means to estimate carbon stored. Entergy's forest projects are estimated to remove 7,500 tons of CO_2 from the atmosphere per year. The wetlands projects are estimated to remove 60,500 tons of CO_2 per year.

B. Tools for Conducting the Inventory

Companies approach the actual conduct of their GHG emissions inventories in a variety of ways, with no two doing it exactly alike. Most firms have developed their own protocols for collecting data and reporting emissions. The calculation of emissions is typically based on emissions factors that have either been developed for company-specific operations, or more likely, are available as published guidance. Some firms have used computerized accounting and reporting tools, such as the U.S. EPA's Climate Wise software for tracking their emissions. (See Box 2).

Table 3 lists a sample of the tools available to companies conducting GHG emissions inventories. These tools range from guidance manuals to computer programs, many of which have been developed for specific industries or for specific kinds of emissions sources.

Most of the guidance listed in this table has been developed over the past few years, and some of it is still a work in progress. As interest in reporting emissions has increased, so has the amount of guidance on emissions reporting. In addition, as more countries and companies gain experience in conducting emissions inventories, this experience is being codified in publications and computer software. Therefore, the material listed here should be considered a snapshot of some of the initiatives that are continually being revised and expanded.

Box 2

Greenhouse Gas Inventorying and Reporting at Sunoco, Inc.

In 1998, Sunoco, Inc. joined the EPA's Climate Wise program, committing to the voluntary submission of greenhouse gas emissions data and an action plan for future reductions. A first pass at assembling a greenhouse gas inventory had previously identified several problems, making the collection and verification of the required data somewhat complex and time-consuming:

- There was no systematic process for collecting and summing corporate energy consumption or greenhouse gas production data,
- The conversion of energy consumption data to greenhouse gas emissions was being done by the production facilities, and
- Energy action planning was primarily a facility activity.

Climate Wise personnel had seen most of these problems before, and were already at work on a solution based on earlier work at Lucent Technologies and Johnson & Johnson. Their recommendation — an Energy Reporting and Tracking software package — appeared to have potential. Sunoco decided to assist in its development, and ultimately to use it to organize its reporting systems.

The software is designed to model organizational structure, accepting input and providing output reports that match the configuration of the user company. It is capable of accepting raw energy consumption data, and making the conversions to greenhouse gas automatically, using industry standard (AP-42) factors. (See Table 3). It summarizes the data, and produces reports at any level of the organization, from facility to parent company. It also has the ability to accept and track progress on specific energy reduction projects, and present the projects as one component of an Energy Action Plan. Equally important, the software comes with a database of case studies and generalized checklists to assist those working on energy management with examples of what others have already done. This database is expandable, and Climate Wise intends to solicit additional case studies from its partners to make it more useful over time.

Sunoco worked with the EPA through the development stage, and is now entering its data into the system. It has decided to roll out the system initially at five refineries and one chemical facility, by setting up a common network drive to share data among the six operations. Sunoco believes that the system will help it meet its original expectations, and a few unanticipated ones:

- Energy consumption and greenhouse gas generation data will now be managed using a single system, simplifying internal and external reporting processes.
- Auditing energy consumption and greenhouse gas generation data will be easier, as each business unit will be using the same reporting system and conversion factors.
- Corporate energy goal setting and evaluation will become more effective with data more easily available.
- A firmly documented basis for the company's greenhouse gas emissions from the base year to the present will be in place, and should documentation become necessary for emissions trading or early reduction credit, the system will serve as a credible record of the company's performance.
- Each energy consuming facility will have access to the data and proposed conservation projects of all the other facilities. Communication and idea sharing among the facilities should be improved.
- The case study database and conservation checklists should help generate more good ideas for conservation.

Table 3

Resources for Estimating Greenhouse Gas Emissions

Resource	Scope	Comments
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories	Estimation methods for the major sources of gases listed in Table 1.	Developed for national level inventories, but may be useful for company-level estimates in the absence of other data. Available at: www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm
U.S. DOE, Lawrence Berkeley National Laboratory	Guidelines for Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation, Monitoring, Evaluation; Reporting, Verification, and Certification of Climate Change Mitigation Projects: Discussion of Issues and Methodologies and Review of Existing Protocols and Guidelines.	Successors to International Performance Monitoring and Verification for energy efficiency projects. Other related reports also available. Focus is on energy-related emissions and reductions, rather than industrial emissions of GHGs. Available at: http://eetd.lbl.gov/ea/ccm/ccpubs.html
Australian Greenhouse Office: • National Greenhouse Gas Inventory Committee Workbooks; and • Greenhouse Challenge Vegetation Sinks Workbook	Workbooks on national emissions inventory with supplements for state and territory governments. Step-by-step procedures for estimating carbon sequestration. Focuses on forest-based sinks.	National workbooks available at: www.greenhouse.gov.au/inventory/methodology/method_content.html State and territory supplements available at: www.greenhouse.gov.au/inventory/inventory/stateinv/statemethod.html Summary of vegetation sinks workbook available at: http://www.greenhouse.gov.au/pubs/sinks.html
U.S. EPA Emissions Inventory Improvement Program, Volume 8, Greenhouse Gases	Fourteen chapter volume designed to provide guidance to states on estimating emissions of each of the Kyoto GHGs.	Available at: www.epa.gov/ttn/chief/eiip/techrep.htm#green
Global Environmental Management Initiative (GEMI)[10]	Overview of the corporate GHG emissions inventory process; contains links to other resources.	See "Measurement and Metrics" section of: www.businessandclimate.org
U.K. Department of Environment, Transport, and Regions Guidelines for Company Reporting on GHG Emissions	Manual on GHG emissions reporting for voluntary reporting by companies. Covers Kyoto gases.	Provides guidance on boundary questions as well as emissions estimation for fossil fuel combustion. Includes lists of guides for sector-specific emissions. Available at: www.environment.detr.gov.uk/envrp/gas
U.S. DOE 1605b	Guidance for participants in the DOE's 1605b program on the estimation and reporting of GHGs emissions and emissions reduction projects.	Estimation methods focus on emissions from fossil fuel combustion (including transportation), forestry, and agricultural sectors. Available at: www.eia.doe.gov/oiaf/1605/guidelns.html
U.S. EPA AP-42	Compilation of conventional and GHG air pollutant emissions factors for stationary sources.	Available at: www.epa.gov/ttn/chief/ap42.html#chapter
U.S. EPA Climate Wise	Software for tracking GHG and conventional pollutant emissions, energy use, and costs at the process unit, facility, and company level.	Distribution of software is currently limited to participants in the Climate Wise Program.
World Business Council for Sustainable Development/World Resource Institute Collaboration	Standardized, international, GHG emissions reporting protocol under development. Web site contains a wide range inventory resources and related materials.	See "Resources" section of: www.ghgprotocol.org
Winrock International Institute for Agricultural Development	Methods for inventorying and monitoring carbon in forestry and agroforestry projects.	Publications, bibliography, and case studies available at: www.winrock.org/REEP/forest_carbon_monitoring_program.htm
World Bank Greenhouse Gas Assessment Handbook	GHG emissions assessment methodologies for energy, industrial, and land use projects.	Designed for evaluation of World Bank-sponsored projects. Available under "Tool Kit for Task Managers" at: http://www-esd.worldbank.org/cc/
American Petroleum Institute Petroleum Industry GHG Emissions Estimation Protocol	Methods to estimate emissions of carbon dioxide and methane from petroleum industry sources.	Under development; expected to be completed in 2001.
Gas Research Institute GRI-GHGCalc™	Personal computer program to calculate methane, carbon dioxide, and nitrous oxide emissions from natural gas operations.	Software description and ordering information available at: www.gri.org/pub/content/jan/20000117/115155/ghgcalc.html

IV. Inventory Accuracy

The accuracy of emissions inventories is an important issue even though reporting by corporations is at present a voluntary activity. This is true because reported emissions may serve as a baseline against which future compliance may be measured. In addition, credit for emissions reductions made voluntarily now may be granted in the future. Whether a firm receives credit for early reduction actions and the value of the emissions reduction credits it generates will depend on the accuracy of its emissions inventories.

A. Estimates vs. Measurements

Emissions of greenhouse gases may be measured or estimated. Which approach is taken depends on the availability of emissions-related data, the cost of developing it, and the accuracy needed for the inventory. In practice, most organizations use a combination of measured and estimated parameters to calculate their emissions. Except for carbon dioxide emissions measured by the electric utility industry, the direct measurement of GHG gas emissions is relatively uncommon.

The reason greenhouse gases are not typically measured is that current air pollution regulations generally do not require them to be, and doing so is expensive. If the emissions are from a distinct point, such as CO_2 emissions from a smokestack, the same measurement methods as used for conventional air pollutants may be applied — the concentration of the pollutant in the flue gas is measured, and this concentration is multiplied by the measured flow rate of the flue gas to arrive at a mass emissions rate. The mass emissions rate is then annualized to give the emissions for an entire year. The main shortcoming of this approach is its cost, particularly if the sampling is done frequently or continuously. In the case of CO_2 emissions from combustion sources, direct measurement of emissions may be no more accurate than emissions estimates based on fuel use. (See Box 3).

For GHG emissions that do not emanate from a single point, such as fugitive emissions of methane from pipeline systems or nitrous oxide emissions from agriculture, taking direct measurements is more difficult. For these types of emissions, estimates are typically made based on extrapolations from studies of similar operations.

Fortunately, for emissions of most greenhouse gases — and in particular for CO_2 from combustion, the largest source of emissions in industrialized countries — emissions can be estimated indirectly. This is so because when fossil fuels are combusted, the amount of CO_2 released is directly proportional to the amount of carbon in the fuel. Combustion systems are optimized to maximize the conversion of carbon to carbon dioxide without forming excessive amounts of other pollutants (nitrogen oxides) or compromising the thermal efficiency of the process.[11] Nearly all of the carbon is converted to carbon dioxide, depending on the type of fuel being burned and the type of equipment burning it.

Three pieces of information are needed to estimate CO_2 emissions from fuel combustion: the amount of fuel burned, the carbon content of the fuel, and the fraction of the carbon in the fuel that is converted to CO_2. Because fossil fuels are valuable commodities, systems are typically already in place to accurately monitor the amount of fuel being burned. The carbon content of the fuel — either as a function of the mass or volume of the fuel, or as a function of its heat content — is less commonly measured, though data have been widely published for the various fuel types (e.g., IPCC 1996). In addition, for coal, the fossil fuel with the greatest variability of carbon content (on a mass basis), electric utilities regularly analyze the coal, and thus know how much carbon is being combusted. Similarly, larger combustion sources like utilities will measure the conversion efficiency of their operations, and published data are available for other sources.

The possible need to use two estimated parameters to calculate combustion emissions of CO_2 might suggest that direct measurement would be more accurate. However, direct measurements, particularly of the stack flow, also are subject to error. As discussed in Box 3, it cannot be assumed that calculated CO_2 emissions based on fuel consumption are necessarily less accurate than direct measurements. For both this reason and the added cost associated with direct measurement, at both the national and corporate levels, calculation of emissions based on fuel composition and consumption can be expected to remain the primary means used for inventorying CO_2 emissions from fossil fuel use (UNCTD, 1999).

In general, the degree of uncertainty in GHG emissions estimates is greatest for the smaller sources of emissions and least for the largest source of emissions — fossil fuel combustion. Figure 1, which shows the relationship between the degree of uncertainty and the magnitude of the emissions for the five largest U.S. source categories illustrates this point. The key observation is that the largest source of greenhouse gas emissions — CO_2 from fossil fuel combustion — is also the source that is known with the most accuracy, while the sources with greater uncertainty are relatively small, none accounting for more than 4 percent of the total emissions. This generalization applies to total U.S. emissions, and for individual companies or industries, the largest source of emissions may not be CO_2 from fuel combustion. The level of uncertainty for their principal sources of emissions could be much greater.

For smaller sources, or ones where the costs of inventorying may be excessive, highly accurate emissions estimates may be difficult to achieve. For such sources, flexibility in the measurement or estimation of emissions is needed. The U.S. Acid Rain Program provides an example of how this could work for greenhouse gases. To provide flexibility and ease the burden of conducting a thorough inventory for sulfur dioxide

Box 3

American Electric Power's Experience Measuring Emissions

American Electric Power (AEP) is a leading supplier of electricity and energy-related services throughout the world. AEP operates a diverse fleet of coal-fired generating units representing approximately 21,500 megawatts of total rated capacity. The emissions from these units, as at virtually all fossil fuel electric utility power plants in the United States are required by the 1990 Clean Air Act Amendments to be monitored with Continuous Emissions Monitoring Systems (CEMS).

After the monitoring program began in 1993, a discrepancy was noted between the CEMS values and emissions calculated by the traditional mass balance method of calculating emissions based on fuel consumption. For the AEP system, it was estimated that the CEMS values were approximately 6 percent high on average, and as much as 30 percent high for individual stacks. At current market prices, the high emissions readings could cost AEP around $6 million annually in over-consumption of sulfur dioxide (SO_2) emissions allowances. The CEMS-derived values were immediately suspect, as the fuel-based information has had an extensive history.

The traditional, fuel-based method for calculating heat input analyzes daily fuel samples to determine the heating value of the fuel (Btu/lb coal). Fuel flow meters, which weigh the coal as it is fed to the boilers, measure the number of tons of coal burned each day. Multiplying the heat value (expressed in Btu/lb) by the amount of coal burned (lbs) provides the heat input to the power plant boiler. SO_2 emissions are calculated by multiplying the heat input rate by the amount of sulfur in the coal (lbs/Btu), which is also measured daily. CO_2 emissions are calculated similarly, though the carbon content of the coal is analyzed less frequently. Since coal carbon analyses are highly accurate, and little variability has been observed in the carbon content of the coal (lbs/Btu), emissions calculated in this way are considered accurate.

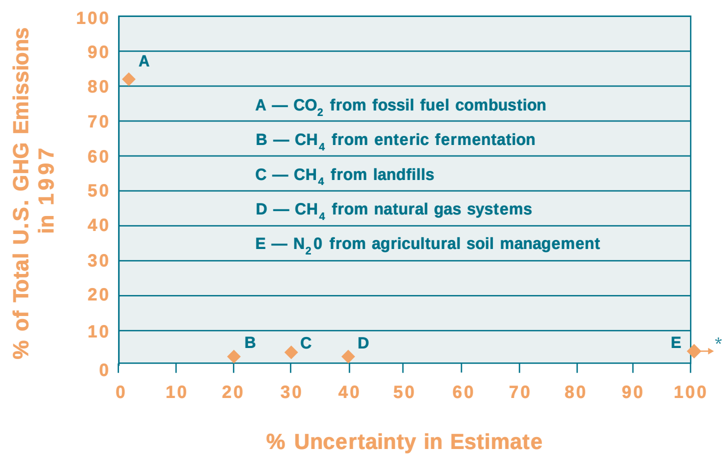
Emissions derived from CEMS are calculated by multiplying the concentration of the pollutant in the stack gas by the volumetric flow rate of the stack gas. Problems with the volumetric flow rates used to calculate the emissions with the CEMS were found to be the cause of the overestimate of the SO_2 emissions. AEP has worked with the vendor that installed its flow monitors to improve the calibration of its flow meters. The result has been the development of an automated method for performing required test audits, which AEP believes has improved the accuracy of the flow measurements.

The current method of calculating volumetric flow does not properly account for non-axial flow within the stack (swirl) and wall effects, contributing to the inaccuracies. In May of 1999, after extended field studies, EPA promulgated optional flow measurement techniques to account for these flow effects. AEP will be implementing these techniques in 2000. With the combination of the automated auditing system and the correction to the methodology used to calculate volumetric flow, AEP believes that the CEMS-measured emissions should more closely match the fuel-derived measurements. Nevertheless, AEP would choose the fuel method over the CEMS for CO_2 emissions measurements because AEP believes it to be more reliable.

emissions reductions made as a result of implementing energy conservation programs, the Acid Rain Program uses an approach to calculate savings that gives credit based on the level of detail of the estimation or monitoring approach. This approach is illustrated in Figure 2. For sources that are continuously monitored, 100 percent credit is given each year, based on the results of the monitoring. For emissions reduction sources that are inspected, credit for 90 or 75 percent of the first year savings is applied in subsequent years, based on whether the equipment requires active attention or maintenance. Finally, if no monitoring is performed, a 50 percent default factor is applied to the first year savings for determining subsequent year reductions.

Figure 1

Uncertainty in the Estimates of U.S. GHG Emissions



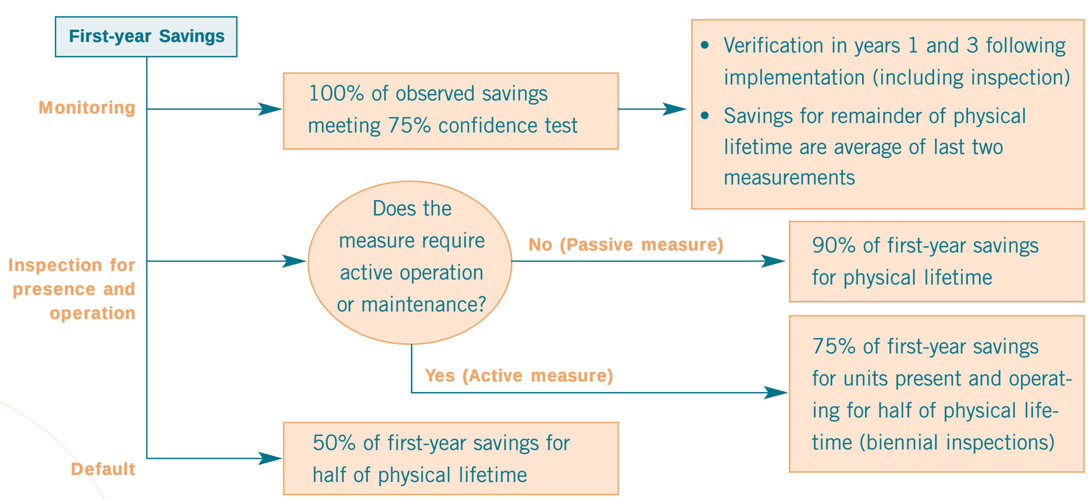
Note: Data from EPA (1999).

*Estimated emissions vary by more than a factor of ten.

Though these specific percentages may not be applicable to GHG emissions, the concept of providing flexibility in estimating emissions is clear. Such an approach might be applied in the case of reducing

Figure 2

General Approach Used in the Acid Rain Conservation Verification Program to Calculate Savings after the First Year



Source: Adapted from Meier and Solomon (1995).

methane losses from gas pipeline systems through improved maintenance. Since measuring such emissions is difficult, and regular maintenance is necessary to maintain the emissions reductions, partial credit for reductions could be granted. Variables that could be important in allocating percentage weights include size, complexity of operation, fluctuation of production or operation, and growth or decline in production or operation.

B. Inventory Frequency

The frequency of air pollutant source monitoring varies considerably depending on the significance of the source. For major sources, continuous monitoring may be used. Indeed, for virtually all of the sources participating in the U.S. EPA's Acid Rain Program, continuous monitoring is required. For large sources in certain industries, such as oil and chemicals, continuous monitoring may also be used. For smaller sources, monitoring is much less frequent — quarterly, annually, or even less than annually. Due to the uncertainties inherent in such infrequent monitoring, the use of these data would not be acceptable for quantifying major greenhouse gas emissions.

Greenhouse gas emissions inventories, like those of other air pollutants, are generally reported on an annual basis. This frequency has been adopted by convention rather than for any particular reason. The actual frequency of inventorying should be based on the reason for conducting the inventory. If the inventory is being conducted to calculate emissions reductions that are involved in an emissions trading program, then the frequency of inventory should, at a minimum, correspond with the frequency with which the organization wishes to accumulate tradable credits. For example, if a party wishes to accumulate credits (and if necessary have them certified) on a quarterly basis, then the inventory would have to be conducted at least quarterly to establish the number of available credits.

For many industrial emissions of GHGs, other than those resulting from the combustion of fossil fuels (e.g., emissions of nitrous oxide and hydrofluorocarbons), national inventories may be conducted in a bottom-up manner, based on the emissions of each facility. As a source of information or a check on the national figures, companies would want to schedule their inventories to coincide with the annual, national inventory process.

Where companies have targeted particular parts of their operations for emissions reductions, or merely want to track certain emissions more closely, they may wish to inventory these operations more frequently than others. BP Amoco, for example, which has set aggressive targets for greenhouse gas emissions reductions, requires quarterly reporting frequency for its exploration and production operations, the primary area that it has targeted for reductions, while its refining, chemical, and other divisions are required to report annually.

V. Drawing the Boundaries

Deciding how to clearly, consistently, cost effectively, and equitably draw the boundaries around emissions sources (i.e., determining which sources to include and how to include them) is one of the most difficult aspects of developing and maintaining a GHG emissions inventory.

Important questions relevant to the issue of setting the boundary for a corporate emissions inventory are:

- Ownership — who "owns" or is responsible for the emissions?
- Acquisitions and divestitures — how can corporate emissions be tracked in a changing corporation?
- Direct and indirect emissions — which upstream and downstream emissions should be included in an inventory?
- Materiality — which emissions are significant enough that they must be included in the inventory and which are so insignificant that they can be ignored?

At present, there is no clear consensus on these questions. To guide decisions about boundary issues before a consensus develops, there are two basic principles a company should consider:

1. Drawing boundaries to make a difference, meaning companies should be encouraged to include emissions that they are in a position to significantly control; and
2. Transparency, meaning that it should be easy for third parties to understand the boundary assumptions used in developing the inventory and to aggregate or disaggregate data in various ways to allow, for example, meaningful comparisons with other organizations or with different performance measures.

A. Ownership and Control of Emissions

The determination of who "owns" GHG emissions is complicated by the range of ownership options for corporations and other organizations. Corporate ownership can have a wide variety of structures from wholly owned operations to joint ventures incorporated by other companies to non-incorporated joint ventures. Further complicating the issue of ownership of emissions are situations in which:

- Contractors (third-party operators) produce emissions from assets owned by another company,
- There are multiple and varying levels of ownership in a production chain (for example, a partially-owned subsidiary produces a part that is transferred to the parent company, which in turn produces a final product),
- A joint venture, of which a company may own a very small amount, has greater emissions than the company's wholly-owned facilities,
- Emissions result from a franchised operation, and
- One party subsidizes another for reducing their emissions — in the case of utility demand-side management (DSM) programs through the reduction in electricity consumption.

To resolve the dilemma of accounting for ownership of emissions, various approaches have been taken, including ones based on majority ownership of the source, equity share, managerial control, and share of output. Majority ownership refers to the firm owning most of the operation or source taking responsibility for all of its emissions. Equity share, as the name implies, is the accounting of emissions based on the fraction of the emitting source each party owns. For example, if one firm owns 60 percent of an enterprise and another owns the remaining 40 percent, the firm owning 60 percent would account for 60 percent of the emissions from the enterprise and the firm owning 40 percent would account for 40 percent of the emissions. A combination of the latter two approaches based on Financial Accounting Standards Board (FASB) rules for managerial control has also been suggested (PWC, 1999). The share of output taken by the owner has been used to scale emissions from jointly owned power plants.

Most companies account for and report emissions from operations they partly own by scaling the operation's emissions by their equity share or by accounting for all of the operation's emissions if they own half or more of the operation or if they are the operator, as shown in Table 4. (The distinction between majority ownership and operational control is important, because in some industries, such as the oil industry, operators without majority ownership are common.) The other methods listed do not appear to be in widespread use.

Table 4

Inclusion of Greenhouse Gas Emissions from Partially Owned Operations in the Inventories of Selected Companies

Company	Means of Accounting for Emissions from Partially Owned Operations
AEP	Scale by amount of energy taken from jointly owned assets
Air Products	Scale by equity share
Baxter	Include 100% of emissions if ≥ 50% ownership, otherwise none
BP Amoco	Scale by equity share
DuPont	Include 100% of emissions if ≥ 50% ownership, otherwise none
ICI	Include 100% of emissions if ≥ 50% ownership, otherwise none
Niagara Mohawk	Scale by equity share
Shell International	Include 100% of emissions if under operational control, others may be included if Shell HS&E policy has been implemented and external verification of data is permitted
Suncor	Include 100% of emissions if under operational control, otherwise none
Sunoco	Under investigation
UTC	Include 100% of emissions if ≥ 50% ownership, otherwise none

Each of the methods listed above has advantages and disadvantages, as shown in Table 5. While equity share might seem to be the appropriate way of sharing the emissions, it raises several practical problems. A minority owner wishing to include its share of the operation's emissions may not be able to obtain the necessary data from the majority owner, or may not be able to verify the accuracy of the data it receives. If reporting is left to only a majority owner, the emissions from facilities with no single majority owner may not be counted at all.

Table 5

Approaches to Addressing Emissions from Partially Owned Operations

Approach	Advantages	Disadvantages
Majority Ownership Report 100% of owned (≥50% equity) joint ventures	• Simple • Clearly defined	• May overstate (if minority owners also report) or understate emissions (if there is no majority owner)
Equity Share Sharing according to the share of equity	• More fully represent GHG emissions • Control might not be clearly defined	• More complex and detailed • Information may not be readily available
FASB Managerial Control Accounting Approach 100% of emissions for ≥ 50% ownership Scale by equity share for 20-50% ownership 0% of emissions for <20% ownership	• Follows established accounting procedures	• Emissions not accounted for at all if more than 5 equal owners • Emissions may be double-counted (e.g., 2 owners, one with 60%, the other 40%) • A consensus on what constitutes a *de minimis* level has not been defined

Companies that support the reporting of emissions on the basis of equity share do so in order that the reported emissions are more closely related to the activity of the company (WRI/WBCSD, 1999). One company taking this approach is BP Amoco, which accounts for, and publicly reports, its equity share of total carbon dioxide emissions "from *all* BP Amoco operations or activities where the Group has a financial (or equity) share" (Dutton and McMahon, 1999). Because the convention in the oil industry, however, is to report 100 percent of the conventional air pollutant emissions from a facility that a company operates, even if it is a minority shareholder, BP Amoco also tracks the total GHG emissions from all facilities it operates (McMahon, 1999).

In the United Kingdom (UK), voluntary reporting guidelines published by the Department of Environment, Transport and Regions (DETR) recommend that companies report the activities they would include in their financial reporting that are within their control, including the activities of satellite companies (DETR, 1999). This approach would thus include situations where third parties are operating an asset owned by a company.

Using financial accounting standards, control is defined as "the ability of an entity to direct the policies and management that guide the ongoing activities of another entity so as to increase its benefits and limit its losses from that other entity's activities" (PWC, 1999). This leads to a hybrid approach to accounting for emissions as shown in Table 5. Where one firm has clear majority control, it accounts for all emissions; where it has a clear minority interest (less than 20 percent) it accounts for none, and in between it accounts for emissions by equity share. The benefits of using this approach are that a company can integrate GHG tracking into existing financial reporting and tracking systems, have the ability to use similar software packages, and utilize internationally recognized standards (e.g., FASB, 1999).

The limitation of applying this approach is that unlike in financial accounting where revenues and costs are well documented, there may be many joint ventures or contracted activities in which a company has a very small ownership stake and where it does not have control over, or the ability to obtain information on, emissions. The UK reporting guidelines judge this situation to reasonably fall outside the scope of the company's reporting. Therefore, if all of the companies are deemed to lack control (e.g., all own less than 20 percent), then emissions from the facility are not counted.

Changing business operations can complicate the issue of emissions ownership even when there are no questions about the ownership or control of the facility. If a manufacturing plant begins to manufacture a part that it formerly purchased, it would then own the associated emissions. All other things being equal, the facility's emissions would rise, even though the total emissions might be unchanged — they would merely be moved from one company to another. Conversely, if the facility outsourced a part by purchasing it from outside vendors rather than producing it itself, emissions from the facility would be reduced. This raises a question of how to evaluate trends in emissions, for, at present, there are no agreed-upon approaches to GHG emissions inventories that account for these situations. It is generally agreed, however, that emissions reductions that occur merely as a result of outsourcing would not be given credit for early emissions reductions actions. The question of how the opposite activity — "insourcing" — might be handled is usually not considered.

One proposal on early action crediting, put forth by the Coalition to Advance Sustainable Technology (CAST),[12] treats outsourcing explicitly by imposing a special reporting requirement that emissions associated with outsourced activity be removed from the base-year inventory. In this way, meaningful comparisons can be made with the baseline. This approach requires additional reporting requirements for outsourcing, however, and also requires that a company determine whether its emissions are solely for the outsourced activity or product. CAST has suggested that a threshold be applied for this reporting requirement so that outsourcing of activities such as janitorial services, which have little effect on GHG emissions, would not require adjustments to the baseline (CAST, 1998). CAST has not suggested what the threshold should be.

B. Acquisitions and Divestitures

In an acquisition or divestiture, a company is either purchasing or selling an ownership stake in another entity. Just as acquired or divested entities are added to or removed from financial statements, GHG emissions need to be added or removed from inventories for the emissions and emissions reductions to be properly accounted for.

The CAST proposal treats mergers by summing the base year emissions and treating them as if they came from one company from the beginning. Alternatively, a company may maintain separate reporting for the two original firms, as if the merger had not occurred, if practical. The CAST proposal treats divestitures by splitting the base years and treating the entities as two different companies from the beginning.

In practice, most companies adjust their baselines to remove those emissions that have been divested and to add those assets that have been acquired, just as the CAST proposal suggests. (See Table 6). Since the divestiture of assets usually involves complete facilities, the adjustment to the baseline may not be as difficult as it may seem. The same is also true for assets that are acquired, if the acquired entity conducted its own emissions inventory over the same period as the parent company. If it did not, then the parent company would be in the position of conducting a retrospective inventory of emissions. How easily this may be done depends on the availability and accuracy of the records maintained by the acquired asset on activities resulting in GHG emissions (such as historical fuel consumption figures).

For large corporations, dozens — or even hundreds — of acquisitions and divestitures may occur each year, making the adjustment of the baseline a daunting task. For this reason, BP Amoco has taken a modified approach to that suggested by CAST. Unless the acquired or divested asset amounts to more than 10 percent of the total baseline emissions, the 1990 baseline is not adjusted. For large companies that are often acquiring and divesting relatively small assets, this approach avoids the need to be continually adjusting the baseline. Its effect on the ability of the company to meet its announced emissions reduction goals depends on the net effect of the changing emissions from the divested and acquired assets.

Table 6

GHG Emissions Inventory Baseline Adjustments for Acquisitions and Divestitures by Selected Companies

	Adjustments made to Emissions Baseline for:	
Company	**Acquisitions**	**Divestitures**
AEP	have not had to address	have not had to address
Air Products	add to baseline when possible	have not had to address, but would likely subtract from baseline
Baxter	add to baseline	subtract from baseline
BP Amoco	add to baseline if > 10% of baseline	subtract from baseline if < 10% of baseline
DuPont	add to baseline	subtract from baseline
ICI	add to baseline	subtract from baseline
Niagara Mohawk	accounted for by annually adjusting the baseline to account for the change in Niagara Mohawk annual kWh vs. the national total output (i.e., Niagara Mohawk's share of the total national market)	
Shell International	add to baseline	subtract from baseline
Suncor	add to baseline	subtract from baseline
Sunoco	add to baseline	subtract from baseline
UTC	not adjusted	not adjusted

C. Direct vs. Indirect Emissions

Indirect emissions are emissions from sources not owned or leased by a company but which occur wholly or in part as a result of the company's activities (Hakes, 1999). Emissions resulting from purchased electricity are one example. Including such emissions in GHG inventories — a subject of widespread interest and concern — has advantages and disadvantages that companies should consider in drawing meaningful boundaries.

Purchased electricity and steam are often included in emissions inventories because firms have a large degree of control over the consumption of these energy sources. This is especially true in countries like the United States, where due to deregulation of the electric power industry, firms have increasingly greater choice about their electricity supplier, and thus may select generators with more or less carbon intensive power (CO_2-equivalent emissions per kilowatt-hour). Firms also have control over the energy efficiency of their processes, which affects the amount of electricity they consume.

Corporations typically do include indirect emissions from electricity consumption in their inventories, just as electricity is counted in energy audits. (See Table 7). The U.S. DOE's 1605b reporting system has provisions for reporting indirect as well as direct emissions, including those from electricity, and the UK's DETR guidelines include emissions from purchased power.

Table 7

Indirect Greenhouse Gas Emissions Included in the Inventories of Selected Companies

	Include GHG Emissions Associated with:			
Company	**Purchased Energy?**	**Energy Sold to Others?**	**Business Travel?**	**Employee Commuting?**
AEP	no	yes	no	no
Air Products	yes	yes	no	no
Baxter	yes	na	no	no*
BP Amoco	yes	no	no	no
DuPont	yes	no	no	no
ICI	yes	yes	no	no
Niagara Mohawk	yes	yes	no	no
Shell International	no	no	no	no
Suncor	yes	yes[13]	no	no
Sunoco	yes	no	no	no
UTC	yes	no	yes	no

Note: na=not applicable

*While Baxter does not include emissions associated with commuting in its GHG inventory total, it does estimate and report them separately.

Including indirect emissions in an inventory has one principal disadvantage — the potential for double counting the emissions. This would occur if both the electricity producer and an electricity consumer reported the emissions as their own. The DETR guidelines acknowledge this, but note that since the purpose of conducting inventories is not to create a national level inventory by summing individual reports, double counting does not matter. Also, for firms that are voluntarily tracking the emissions resulting from their operations, and not responding to any government incentive or regulation, it is unimportant whether emissions may be double counted.

BP Amoco's protocol for accounting for emissions avoids the problem of double counting of steam or electricity it produces at its facilities by counting emissions from *net* energy consumption (energy imported into a BP Amoco facility minus energy exported). The company does not count as its own emissions from steam or electricity that it produces for outside sales. It does include emissions resulting from steam or electricity it produces for its own use, as well as emissions from the energy that it purchases.

The subtraction of emissions from exported energy is handled inconsistently among corporations. All of the oil companies listed in Table 7 (except Suncor) exclude emissions from exported power, while most of the chemical companies include these emissions. The rationale for excluding the emissions for exported power is that the power is being used by someone else, not by the company in its own operations, and thus should be accounted for by the purchaser, in the same way that the company accounts for emissions resulting from the electricity it purchases. Though internally consistent, if this form of accounting were applied to electric power companies, they would report only on emissions from electricity they consume (such as for pulverizing coal and operating electrostatic precipitators) but not from electricity they produce for sale to others. In actuality, power companies report all of their emissions regardless of where the power is sold, and many other business that sell power do as well.

The accounting of indirect emissions becomes more contentious when credit for emissions reductions is being considered. While a firm may wish to receive credit for emissions reductions resulting from the improved efficiency of one of its operations, a utility may also have played a role in these reductions through demand side management programs. The complexities that can arise can be seen in the following example (EIA, 1997). Suppose that in response to a voluntary government initiative, a refrigerator manufacturer designs and builds a refrigerator that far exceeds the energy efficiency of other refrigerators on the market. An electric utility then offers rebates to customers if they purchase this energy efficient refrigerator. Customers purchase less electricity and the electric utility generates less electricity from burning fossil fuels, thus reducing emissions. Who is “responsible” for this reduction and on what grounds?

- The government (for sponsoring the initiative),
- The refrigerator manufacturer (for building the refrigerator),
- The refrigerator dealer (for choosing to sell the more energy efficient model),
- The electric utility (for offering the rebate), or
- The customer (for choosing to buy the refrigerator)?

There is no clear answer to this question as all of the participants have some basis to claim credit for the outcome. Credit for the reductions might be allocated by agreement between a utility and the manufacturer. Alternatively, manufacturers could serve as the default party to receive credits for the emissions reductions, unless they relinquished the credit to another party. A more complicated — but perhaps more equitable — approach would attempt to give the credits to whoever funds the improvement (Nordhaus and Fotis, 1998).

Voluntary reporting programs like the U.S. DOE’s 1605b program do not provide guidance on who gets credit for indirect emissions reductions. The DOE considers the use of the program to give credit for early emissions reductions to be inappropriate because the program “is not intended to create a set of comparable, auditable emissions and reduction reports that represent ‘actual reductions’ and are not ‘double counted’” (Hakes, 1999). One legislative proposal, Senate Bill 547, the Credit for Voluntary Early Reductions Act introduced in 1999 in the U.S. Senate, defines ownership of emissions based on ownership of the source, suggesting that utilities would account for their own emissions and take credit for reductions.

The inclusion of GHG emissions from purchased electricity raises several practical questions related to the availability of information needed to estimate emissions. The amount of emissions per unit of electricity consumption (mass of CO_2-equivalents per kilowatt-hour) may be unclear, and obtaining this information may require cooperation of the electric utility. This information may be more readily available in some areas than in others. In the state of Massachusetts, for example, utilities are required to publish their estimated GHG emissions per kilowatt-hour. As a default, the instructions for the U.S. DOE's 1605b reporting program list state-averaged GHG emissions factors for electricity consumption. Also, large corporations that purchase their electricity directly from a wholesaler may be able to obtain emissions data from the generator.

Further complicating the accounting for electricity emissions are line losses. Line losses occur when the power that is generated is greater than what is actually delivered to the customer because of transmission and distribution losses. While companies meter their use of electricity, they are typically not aware of the losses that occur before the electricity reaches their meters. Utilities do have information about line losses, and should be able to supply this information. Otherwise, default values suggested in GHG emissions inventory guidance, such as that listed in Table 3, may be employed.

The concept of "causing emissions" is inherently more ambiguous than "owning a stack," and extends beyond the consumption of secondary energy sources. Other examples include emissions from employee business travel (or emissions from employees commuting to and from work), emissions from shipments of raw materials and finished goods, and emissions from waste disposal. Relatively little guidance on inclusion of these indirect sources exists. The UK's DETR guidelines recommend including long-distance business travel, but not commuting or short-distance business travel. In contrast, the U.S. DOE reporting guidelines for the 1605b program include measures for reducing employee commuting as examples of legitimate emissions reduction projects.

D. Life-Cycle Assessment

Companies that report their GHG emissions typically account for emissions from their own operations. Yet in some industries, the principal emissions and opportunities to reduce emissions come not from the direct or indirect emissions associated with manufacturing but rather from the use of the manufactured products. For example, appliances such as washing machines and refrigerators produce most of their GHG emissions through their use rather than through their manufacture. The same is true for motor vehicles. The GHG emissions reported by General Motors for all GM vehicles in operation in the United States accounts for 23 percent of transportation-related emissions (EIA, 1997), an amount far greater than the emissions from GM's factories.

The evaluation of greenhouse gas emissions throughout the full product or service system life cycle (see Figure 3), a process known as life-cycle assessment (LCA),[14] is an evolving area. The greater emissions from the use of products compared to their manufacture suggests that greater benefits could be achieved through improving the energy efficiency of the products than through reducing emissions during manufacture, although presumably such features could support a premium price or expanded market share. If, under some future greenhouse gas emissions reduction scheme, a company is required to reduce only its own emissions, then it would have little incentive to produce lower emitting products. For this reason, manufacturers have suggested that they be allowed to take credit for the emissions reductions that result from the improved efficiency of their products. (See Box 4).

Figure 3

Product/Service **Life Cycle**

For companies that desire to undertake a greenhouse gas life-cycle inventory, the activity needs to make business sense. Potential benefits of accounting for life-cycle emissions include the ability to implement product and process improvements, realize cost savings, take advantage of the emergence of eco-labels and product take-back regulations,[15] and gain insight into product improvements. The International Standards Organization (ISO) has developed standards for conducting life-cycle assessments (ISO 14040) which may be applied to GHGs. Efforts are underway by the Climate Neutral Network[16] to streamline life-cycle assessments by, for example, limiting the scope of life-cycle studies based on data availability, focusing on a limited number of priority stages, and concentrating on the needs of the intended audience (CNN, 1999).

Most companies though, especially small and medium-size companies, will not be able to justify the costs of conducting life-cycle assessments. This is due to the fact that life-cycle analysis itself is still not a standardized discipline with an information infrastructure in place. LCA data are expensive to develop and common databases and resources are of limited use because they are in aggregate form. The EPA and DOE are undertaking several projects to produce usable data, and resource industries such

Box 4

Whirlpool Corporation and Life-Cycle Emissions

Certain industrial sectors can make more of a contribution to reducing greenhouse gases by modifying the products they produce than by reducing the energy they consume in producing those products. This is because the products themselves are responsible for GHG emissions, particularly those that consume energy. The home appliance industry is an example of one such sector.

In the appliances industry, the greenhouse gas emissions at manufacturing sites are small when compared to the emissions associated with the power generated to run those appliances over their long useful lives. Whirlpool has estimated that its clothes dryers use 20 times more energy over their working lives than the energy used to produce them, and its washing machines 50 times more. Thus, limiting a GHG inventory to on-site emissions might misdirect the efforts of some industries, including appliance manufacturers, away from the areas where they can do the most to reduce greenhouse gas emissions.

By taking a life-cycle perspective, Whirlpool has identified an opportunity to retire inefficient appliances in Brazil and replace them with more efficient models. Refrigerators in Brazil account for 27 percent of residential energy consumption. Current models are 30 percent more efficient than products made four years ago, and an additional 20 percent efficiency improvement will occur by 2002 as a result of a voluntary industry agreement. Through financing of an incentive program in which utilities legally must direct 1 percent of revenues toward energy efficiency, up to 28.7 million refrigerators could be retired over a 10-year period. Whirlpool has calculated that this could reduce CO_2 emissions by more than 3 million tons annually, even accounting for the fact that most of Brazil's electricity comes from hydropower.

This project is only one example of applying a life-cycle assessment to address reducing greenhouse gas emissions related to the use of appliances. Other approaches Whirlpool might take to addressing greenhouse gas emissions resulting from the use of its products include designing consumer incentives to stimulate demand for energy efficient products, working with government and industry to showcase new energy efficient technologies, and minimizing emissions resulting from the disposal of its products.

as steel, aluminum, plastics, and glass are compiling data for public use (Env. Mgr., 1998). Many companies, though, are reluctant to release LCA data because it may invite regulation and provide competitors with too much information about a company's products (Arthur D. Little, 1999). For these and other practical reasons, the UK voluntary reporting guidelines have excluded life-cycle impacts, but intend to provide further guidance on the reporting of emissions from wastes.

Even if full life-cycle emissions are determined to be in excess of a company's boundaries, the company may still have opportunities to help customers reduce their own emissions, either through improving product quality or providing guidance on effective use to minimize emissions (WRI/WBCSD, 1999). The voluntary adoption of quality standards (e.g., for energy efficiency) may be a more effective strategy to achieve reductions across industries that produce energy-consuming products than imposing standards or limits on emissions from the manufacture of these products.

At present, it appears more likely that manufacturers may receive credit for reducing emissions associated with specific parts of the product life cycle — such as the use of the product or its manufacture — rather than for reducing emissions over its entire life cycle. This is due to the uncertainties in the LCA and the lack of its widespread application. Nevertheless, information on life-cycle emissions will be useful to consumers in making their buying decisions, just as energy-efficiency standards for appliances, and fuel efficiency standards on automobiles are used as guidance. For this reason, the information may be more valuable as a means of gaining competitive advantage than as a means of gaining GHG emissions reduction credits.

E. Materiality

An important aspect of drawing the boundaries around a firm's emissions is deciding which emissions are large enough to be included in the inventory and which are small enough that they can be ignored without any significant effect on the overall results. The answer to these questions varies with the industry, and even the particular firm that is conducting the inventory. For a service company, for example, emissions resulting from employee business travel may be significant, while for an electric utility they are unlikely to be. These emissions may also be material for firms that are primarily manufacturers. For example, United Technologies Corporation[17] (UTC), a major provider of high-technology products and services to the aerospace and building systems industries, has found emissions associated with business travel (as well as emissions from the testing of its jet engines) to be material.

Most firms conducting inventories today do not have strict rules on what qualifies as material. Only two of those participating in the survey conducted for this paper, UTC and ICI, had any rules at all. Rather, materiality has been treated as a matter of professional judgement for those performing the inventory. Where firms have set materiality thresholds, they have typically done so on the basis of a minimum size of emissions (e.g., X metric tons of CO_2 equivalents/year)[18] or a minimum percentage completeness for the inventory (e.g., at least 99 percent of corporate emissions will be accounted for). ICI is an example of one firm taking the latter approach. UTC, whose GHG emissions accounting is an outgrowth of its energy and water tracking and conservation program employs a variation of the former approach. Water and energy consumption (and thus GHG emissions) from non-manufacturing facilities are ignored if their combined cost is less than $100,000 per year. Even drawing the line at this amount, UTC inventories 229 facilities worldwide, including its corporate headquarters.

The issue of materiality is further complicated by the difficulty of estimating certain types of emissions. Emissions associated with employee commuting generally fall into this category, and typically are not included in corporate GHG emissions inventory.

Emissions due to product transportation can also be difficult to assess, and thus are not always included in inventories. BP Amoco, for example, includes emissions from commercial shipping in its inventory if it owns the vessels or has a charter for more than a year. If the transporter is also shipping the products of other companies, however, the activity is judged as too difficult to reasonably assess the fraction of the emissions attributable to BP Amoco. Thus, the inclusion of these emissions sources is based as much on the ability to estimate them as it is on their materiality to the total corporate emissions.

Emissions sinks — activities or operations that remove GHGs from the atmosphere — are another example of an item that may or may not be material to an inventory. Sinks can range from the absorbance of carbon dioxide by grass and trees around an office building, to absorbance by forest areas set aside for conservation, to sequestration through reforestation, to reinjection of CO_2 into depleted oil wells or other geological formations. In addition to the complexities of accounting for these sinks, their significance to a company's greenhouse gas inventory needs to be assessed. Typically major sinks such as reforestation programs or CO_2 reinjection into oil reservoirs for enhanced oil recovery are included in emissions inventories, while minor sinks such as growing trees around office buildings are not. One proposal that addresses the question of materiality directly, at least for domestic sinks, is that of CAST, which gives firms the option of including domestic sinks within their corporate inventories. However, firms must include all of their sinks if they choose this option (CAST, 1998).

In short, boundary issues present a multitude of options for the way firms may report their GHG emissions inventories, and a multitude of questions they must answer in conducting their inventories. On some of these questions there is general agreement. There is widespread consensus that an organization should include within the boundary of its inventory all material sources owned and operated by the organization, which typically corresponds to sources located within its facilities' fence lines and mobile sources that it owns. A consensus is also growing to account for electricity usage because of its ubiquity and the degree of control possessed by organizations to modify their electricity consumption. Further expanding the accounting boundaries, emissions resulting from employee business travel, product and raw material shipments by third parties, and employee commuting could be included. An additional widening of the accounting boundaries would be an assessment of the complete life-cycle emissions of a product. The extent to which sources beyond the fence line are included in the inventory depends on the degree of control the company has over these sources, its stakeholder expectations, and its ability to implement emissions reduction programs and initiatives. Box 5 describes how one firm, United Technologies Corporation, has addressed these questions.

The Greenhouse Gas Measurement and Reporting Protocol Collaboration (WRI/WBCSD, 1999) is discussing a tiered approach to inventory boundaries. In this approach, there are three levels, or "scopes," as shown in Table 8. The most basic approach, Scope I, focuses on direct GHG emissions. This approach could be used when double counting may be an issue (such as for emissions trading or credit for early actions to reduce emissions), and could serve as the base for the official inventory. Scopes II and III might be more appropriate choices for environmental reporting, or for entities whose emissions inventories include a significant amount of indirect emissions.

Table 8

Boundary Scopes Under Discussion by the GHG Measurement and Reporting Collaboration

	Emissions from Core Operations		
What is Included?	**Scope I**	**Scope II**	**Scope III**
Direct emissions of CO_2	√	√	√
Direct emissions of other GHGs, if any	√	√	√
Net emissions from energy import and export (e.g., purchased electricity)		√	√
Emissions from business travel, product transport, and waste disposal			√

Voluntary associations and industry groups could develop (and in many cases are developing) guides to ensure that companies with similar operations and products are drawing boundaries in a

Box 5

United Technologies' Approach to Boundary Issues

United Technologies Corporation (UTC), provides a broad range of high-technology products and services for the aerospace and building systems industries. UTC has developed a worldwide inventory of its energy use and the associated greenhouse gas emissions as part of its commitment to reduce energy consumption. The primary focus is energy use that UTC has direct control over and is material to the company. The UTC program is a dynamic, evolving effort. It is expected that as the program matures, additional refinements and enhancements will be made to improve the program based on changing circumstances and experience gained through implementation.

In designing the initiative, a number of boundary decisions were made that have defined the scope of information collected, analyzed, and reported. In general, decisions on what to include or exclude were driven by the desire to:

- Focus attention on major opportunities for improving energy efficiency;
- Recognize the diversity, complexity, and magnitude of the organization's operations;
- Ensure that the program parameters were understandable;
- Avoid duplication of other ongoing efforts; and
- Prevent overly burdensome reporting or management procedures.

The application of these principles can be illustrated by examining four boundary issues: ownership, direct/indirect emissions, materiality, and life-cycle emissions.

- *Ownership.* UTC requires facilities that manufacture products to report energy and water consumption data, and requires nonmanufacturing sites that have a combined annual energy and water cost of more than $100,000 (US) to report. An exemption is provided for manufacturing sites that have less than $500,000 (US) in annual sales. The reporting requirement applies to all joint ventures where the UTC ownership is 50 percent or higher.
- *Direct/Indirect Energy Emissions.* UTC indirectly causes the generation and release of carbon dioxide through its use of purchased electric power. UTC measures a facility's direct electrical energy consumption and, using this figure, calculates the energy required and carbon dioxide emissions produced by the utility to deliver such electrical power to the facility. The facility is therefore responsible for inefficiencies in the utility's generation and transmission of electric power.
- *Materiality — Energy Sources.* UTC identified the need to collect data on its usage of electricity, propane, natural gas, butane, oil, gasoline, diesel, and coal. In addition, the company included jet fuel as a key energy source since it is used in significant amounts in various UTC activities including corporate aircraft operated by the company, jet engine and helicopter testing, and employee travel on commercial airlines. UTC decided not to track certain fuels, such as kerosene, since initial measurements proved that not enough was consumed to warrant the tracking.
- *Materiality — Travel/Transportation.* UTC products consume energy as they are shipped around the world, and UTC employees consume energy as they travel on business. As a global corporation with significant travel and transportation activities directly under its control, the corporation decided to include employee travel on company business and transportation of its products by company vehicles in its inventory. On the other hand, a decision was made to specifically exclude employee commuting from the program since commuting is not controllable by UTC, and the collection of this type of information raised invasion of privacy issues. Similarly, non-UTC commercial trucking is excluded since there were questions regarding who "owns" any energy reduction associated with this activity.
- *Life-cycle Emissions.* UTC decided not to account for the life-cycle emissions of greenhouse gases associated with its products. Even though these emissions are orders of magnitude greater than the CO_2 emissions from all of its facility operations combined, efforts to reduce these emissions are managed as part of UTC's Design for Environment, Health and Safety program. Therefore it was decided not to duplicate these efforts and to focus exclusively on operations and travel related activities.

standard manner. In the GHG Measurement & Reporting Protocol Collaboration, key stakeholders are working on a standardized measurement and reporting protocol. This guidance will help avoid the double counting of emissions, or at least identify where double counting might be occurring.

Until a uniform GHG reporting protocol receives widespread adoption, transparency will be the key to meaningful reporting. In order to make meaningful comparisons from firm to firm or from year to year, should the boundaries change, firms will have to carefully document all of the assumptions they make in choosing the boundaries of their inventories, just as they document the methods they employ to calculate their emissions.

VI. Baselines and Metrics

In addition to determining what will be included in their inventory, companies also need to decide how they will track trends in emissions and progress toward any emissions reduction goals they may have established. In making this decision, they are setting the baseline against which future emissions and their voluntary emissions reductions will be evaluated. (See Box 6).

There are two important aspects to setting a baseline: timing and the way emissions are represented. Timing refers to the year in which a company begins to track its emissions and the year against which future progress is measured. In many cases these are the same. The year 1990 is often, but not always, set as the base year by companies that plan to reduce emissions. The CAST proposal, for example, uses 1995 as the base year, suggesting that using this year as the base will protect firms that have recently made emissions reductions. Target years for achieving announced emissions reductions vary considerably from firm to firm, though generally they are not later than the 2008-2012 target period used in the Kyoto Protocol.

In addition to selecting a base year, companies must choose the metric they will use to track and communicate their emissions and emissions reduction goals. These methods can be divided into absolute and normalized measures (also referred to as rate-based measures). Absolute reductions refer to specific mass or percentage reductions in emissions, or to specific caps on emissions, most commonly expressed in terms of metric tons per year of carbon dioxide equivalents.

Companies that normalize emissions do so in one of two ways: (1) emissions per dollar of revenues or expenditures, and (2) emissions per unit of product, potentially ranging from kilowatt-hours to stereo components to whatever else the company produces (CAST, 1998). The CAST proposal promotes a rate per dollar of sales approach, while one bill introduced in the U.S. Congress for providing credit for early emissions reductions (H.R. 2520) takes an emissions per unit of product approach. Each approach has advantages and disadvantages to understanding trends in reducing greenhouse gas emissions, and neither approach is applicable across all industries. (See Table 9).

Box 6

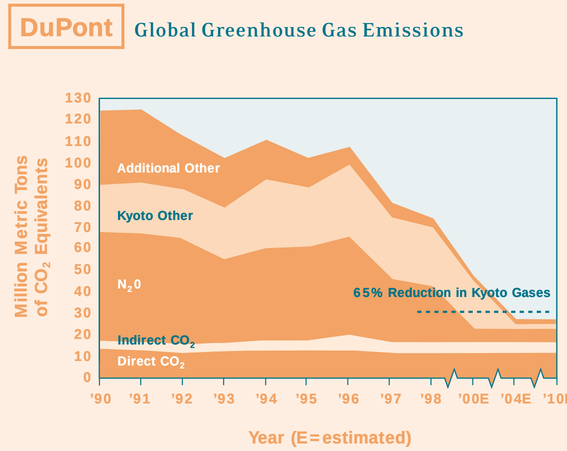
DuPont's GHG Emissions Reduction Goals

DuPont's recently announced plans to reduce its GHG emissions 65 percent from 1990 levels by 2010 illustrates two important points about tracking emissions and achieving reductions:

- The selection of the baseline, both in terms of the gases it includes and its timing, affects the magnitude of reductions that can be achieved.
- The path chosen to reduce emissions can greatly affect the potential for further reductions in the future.

For most companies, nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) account for negligible fractions of their greenhouse gas emissions. Often, these compounds are left out of corporate emissions baselines. For DuPont, however, these compounds are critical components of its GHG emissions inventory, accounting in 1997 for approximately 75 percent of total corporate emissions of gases covered by the Kyoto Protocol on a carbon dioxide equivalent basis. (See Figure 4).

Figure 4



DuPont intentionally based its GHG emissions reduction goal on the set of gases described in the Kyoto Protocol. Had it chosen to include other greenhouse gases or to use another date for its baseline based on the UNFCCC and the Climate Wise partnership program, it could have claimed even larger emissions reductions for the same endpoint. If chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) emissions (the "additional other" shown in the figure) were included in the baseline, DuPont could have stated its GHG emissions reduction goal as roughly 73 percent from 1990 levels. CFCs and HCFCs were specifically excluded from the Kyoto Protocol, however, because they are already scheduled to be phased out under the Montreal Protocol.

DuPont could also have announced a somewhat larger emissions reduction goal, 68 percent, had it selected its peak year as its baseline for emissions of the Kyoto gases (1996) rather than 1990, even with the final target in 2004 being the same. Doing so, however, would have meant that its base year would have been inconsistent with the Kyoto Protocol, and possibly raised questions about what its reductions were versus the more common base year of 1990.

The risk that DuPont faces is that having made a substantial investment to voluntarily reduce its emissions, further reductions may be required under some future regulatory scheme that do not account for its voluntary efforts. If 1990 is selected as the base year for the future regulatory program,[19] then through its voluntary reductions DuPont may have already met those requirements. If, however, a later base year — such as 2000 or later — is selected, then the company will be faced with making additional, and likely more expensive reductions from a baseline that has been substantially reduced. Financially, the company would have been better off not to have voluntarily reduced emissions, but instead to have waited for the reductions to be required. Had DuPont delayed action, however, the environmental benefits of the early reductions would be lost.

To date, use of rate-based metrics is still in an experimentation phase, and most companies report on an absolute basis. For example, Shell International has announced an absolute goal of reducing its 1990 GHG emissions by 10 percent by 2002. In contrast, Interface, Inc. has chosen an emissions rate based on annual sales figures. Another exception is UTC, which has announced targets to reduce energy and water usage by 25 percent per dollar of sales. Baxter International has based its goals for reducing energy consumption on physical units of output, rather than on the value of those outputs.

Though a total tonnage approach is clear, simple, and directly applicable to the goals agreed by national governments in the UNFCCC and the Kyoto Protocol, a normalized approach allows companies that are growing rapidly to participate in emissions reduction efforts without being penalized for their success and avoids the issue of granting companies credit for reduced output. On a national level, normalizing emissions (e.g., on a per capita or per GDP basis) also helps to understand greenhouse gas emissions absent population trends. The CAST proposal on emissions crediting advocates normalized factors because "only a rate based measurement will allow for large and small, service and manufacturing, utility and yogurt maker, and growing and nongrowing companies to make aggressive reduction commitments with the knowledge that they will be able to meet those commitments" (CAST, 1998).

Table 9

Comparison of Normalized Emissions Factors

Approach	Advantage	Disadvantage	Applicable Industries
Emissions rate per revenue or expenditures	• Can adjust the rate by allowing for real price* adjustments • Provides a benchmark to compare GHG intensity of different industries with different products • Eliminates the need to adjust the baseline as the business changes	• Creates difficulties for companies in sectors with real product price* declines over time (e.g., electronics, renewables) • Requires price adjustments across industries • Prices may be not be uniform across regions • Requires high quality public information about pricing trends	• Industries with products with well established price levels • Commodity industries with high levels of public pricing information
Emissions rate per unit of output	• Provides flexibility in changes to market share • Focuses on the efficiency of the sources	• Many companies have a wide variety of products • It is difficult to account for product enhancements	• Mature industries with lower rates of new product introductions • Companies with uniform product offerings

*Real prices are adjusted for inflation.

With the concrete examples still limited and discussions of the advantages and disadvantages of using different rate-based approaches still in embryonic stages, companies may wish to follow the guidance of the Global Reporting Initiative (GRI), an international effort to harmonize environmental reporting being led by the Coalition for Environmentally Responsible Economies (CERES).[20] In the pilot phase of the GRI, users are encouraged to report both total figures (total CO_2-equivalents) and to employ the normalization approach that works best for their company and/or industry. To convert between absolute and normalized figures is a relatively simple calculation for a company tracking its greenhouse gas emissions, since firms routinely track their outputs in physical and monetary units.

In addition to selecting a base year for measuring progress and choosing whether to express their emissions on an absolute or normalized basis, companies must also decide whether and how they will adjust their baseline over time. As discussed above, when significant divestiture or outsourcing of production occur, most companies reduce their baselines to avoid indicating emissions reductions when the emissions are merely transferred to another entity and not necessarily reduced on net. A similar situation would exist if a company loses market share to a competitor having comparable emissions. If the company reports its emissions on an absolute basis, its inventory might be misinterpreted to indicate a reduction in total GHG emissions when no net reduction actually occurred, unless it adjusted its baseline.

The setting of baselines to measure "real" GHG emissions reductions becomes particularly important when firms wish to receive financial benefit for their voluntary emission reductions.[21] Some people believe, a reduction is "real" only if it would not have otherwise occurred except for the voluntary reduction effort; others believe it is real if the actual emissions decreased, regardless of the reason. Determining what emissions levels would be in the absence of an emissions reduction project is a difficult and inherently subjective exercise, and guidance in this area continues to be developed. Given these current uncertainties, firms should be clear about how they define and report their reductions. By adequately documenting how they achieve emissions reductions, they will have a basis to claim any emissions reduction credits for which they may be eligible under either current voluntary or future regulatory programs.

Those companies involved in emissions reduction projects under the UNFCCC and the Kyoto Protocol will have to consider the concept of "additionality" in setting their baselines. Such projects include the Joint Implementation program in which an entity in one developed (Annex I) country acquires emissions reduction credits from projects in another developed country, and the Clean Development Mechanism in which emissions reduction projects are established in developing countries. Both of these programs require that the emissions reductions be additional to those that would otherwise occur. Determining what emissions would otherwise occur in these programs presents the same types of problems as applying the concept of additionality to domestic emissions reduction projects. To avoid these problems, simplified means of establishing baselines to evaluate additionality have been proposed. Some of the primary methods being discussed include:

- *Benchmarking,* under which host countries would establish default emissions rates for the different sectors, subsectors, or regions;
- *Technology matrix,* under which a number of pre-defined default technologies would be used as the baseline technologies for a defined region and for a specified time; and
- *Top-down baseline,* under which project baselines would be derived by the host government from a more aggregate baseline (e.g., a country might allocate project baselines from its national baseline, with reductions below the baseline being considered to be additional) (Center for Clean Air Policy, 1999).

Since it is not known how the setting and adjustment of baselines will be treated in whatever future domestic programs may be created to reduce GHG emissions, firms will need to maximize the flexibility in their inventorying and reporting.

VII. Challenges for Corporations in Conducting Global Inventories

The procedures set forth by the IPCC provide for a common basis for the reporting of national level GHG emissions inventories. For companies that operate internationally, conducting an inventory of worldwide operations can be more complicated. These complications result from different systems of measurement and the availability of data with which to make emissions estimates.

The most basic level of reporting is the measurement unit itself: tons (short tons — 2000 pounds), metric tons (tonnes — 1000 kilograms), or kilograms. In the UK voluntary reporting guidelines, kilograms — the most popular unit for the UK — are used. In the U.S. DOE's 1605b voluntary reporting guidelines, companies may use a variety of units including pounds, kilograms, tons or metric tons, indicating which they have selected on the reporting forms. In the Global Reporting Initiative, all emissions are required to be reported in metric tons, and this is how most international companies report their emissions. Metric tons are also the most common unit used throughout the world for the measurement of GHGs (White, 1999). In addition to the units to be used for reporting, the way in which emissions are represented must also be handled consistently. GHG emissions are most commonly reported either in terms of the mass emissions rate of the GHG itself, such as metric tons of carbon dioxide or methane per year, or in terms of CO_2 equivalents.

A third, though less common, means for expressing GHG emissions is in terms of carbon equivalents. Rather than reporting the amount of CO_2 emitted during fossil fuel combustion, the amount of carbon in the CO_2 is reported. Since the mass of carbon in carbon dioxide is $12/44^{\text{ths}}$ of the total, emissions of CO_2 can be converted to emissions of carbon by multiplying by this fraction.

Data availability and quality are other key issues for companies operating internationally. The formality of accounting systems varies across organizations and regions, which may make it difficult to track parameters such as energy usage. Depending on the types and quality of fuel being burned, and the efficiency of the equipment burning it, the reliability of standard emissions factors will vary. Emissions attributable to the consumption of purchased electricity may be very difficult to assess in some areas, though average national-level emissions factors may be available. Finally, there is not a uniform awareness or common vocabulary regarding greenhouse gas emissions, creating the potential for misunderstandings when information requests are made. These challenges point to the potential need for the training of staff in overseas operations in conducting the inventory, including obtaining the basic data on which reliable emissions estimates may be based.

VIII. Learning from Similar Measurement Approaches

Two programs that provide some lessons for conducting and reporting GHG emissions are the U.S. EPA's Toxic Release Inventory (TRI) program and the Acid Rain Program in the United States. While both of these programs are mandated by law, the experiences of companies participating in them is relevant to the voluntary reporting of GHGs.

A. The Toxic Release Inventory

The Toxic Release Inventory (TRI) serves as an annual profile of pollution produced by industrial facilities just as a greenhouse gas emissions inventory can become a profile of facilities' greenhouse gas emissions. TRI is an example of how companies have developed methods to estimate and measure releases (emissions) from a wide array of sources.

Although the TRI program operates at the facility level, not the company level, it provides some basic lessons:

- *Be prepared.* At the time the TRI regulations came into effect, many companies lacked experience in estimating emissions for many of the affected chemicals and processes. For this reason, the reliability of data from the early years of the program is often questioned. In the same way, estimation of GHG emissions, particularly those other than CO_2 from combustion, is a new activity for most companies. By voluntarily inventorying their emissions, firms learn how to estimate their emissions and can refine these estimates before reporting becomes required.

- *Provide context when communicating the results of the inventory.* Reported reductions in TRI releases have been criticized for not describing the reductions in the proper context. While the TRI program itself does not require emissions reductions, it is used to track year-to-year changes in releases of chemicals to the environment. Problems have occurred when these changes have not been put in the proper context. For example, the EPA reported a 7 percent increase in waste generation between 1991 and 1994 but neglected to note that chemical production was up 24 percent over the same period (Hess, 1997). While the total amount of waste had increased, emissions per unit of output had actually decreased. In other cases, reported emissions reductions have occurred due to reduced production, rather than through voluntary reduction activities. By placing their reported GHG emissions and reductions in the proper context, firms will be able to avoid misinterpretation of the results. Those firms that include CFCs in their inventory, for example, would be wise to note that the reduction in their emissions results from requirements under the Montreal Protocol, in contrast to their voluntary reduction efforts.

- *Clearly explain the measurement or estimation approach and the means for achieving reductions.* TRI emissions reductions have also been criticized for not adequately describing how the reductions were achieved (McCarthy, 1995). By providing complete transparency on how their emissions and emissions reductions are calculated, firms reporting on GHG emissions may avoid this criticism.

B. The Acid Rain Program

The Acid Rain Program also provides lessons on inventorying emissions, particularly in the context of a market-based system of tradable permits. Three of the key components of the program are:

- An allowance trading system which provides low-cost rules of exchange that minimize government intrusion and make allowance trading a viable compliance strategy for reducing sulfur dioxide (SO_2);
- An opt-in program to allow additional industrial and small utility units to voluntarily participate in allowance trading; and
- A continuous emissions monitoring systems (CEMS) requirement to provide credible accounting of emissions to ensure the integrity of the market-based allowance system and to verify the achievement of the reduction goals (EPA, 1997).

The Acid Rain Program offers a couple of lessons for the development of a greenhouse gas inventory:

- *Emissions inventorying works.* Current procedures to inventory SO_2 emissions are of sufficient accuracy to support verifiable emissions reductions and an active trading system in emissions reduction credits. Inventorying of the same accuracy will support GHG emissions reduction programs, though this is not to say that the same methods (CEMS) are needed or would be desirable for most GHG emissions.

- *Build on your current data systems.* At the time the CEMs were installed, the technology was well demonstrated and reliable. Many utilities already had CEMS in place, and built on their existing technology by establishing more detailed quality assurance and control systems. Organizations implementing GHG inventories should understand how their existing systems can be improved upon to provide reliable emissions data.

IX. Conclusions

A standardized protocol for conducting GHG emissions inventories has yet to be developed. Nevertheless, many corporations are already conducting inventories and reporting their results. The current, dynamic state of affairs in inventorying emissions, and the experimentation and range of approaches that companies are taking will ultimately lead to more uniform and recognized procedures that will have already been tested in the field. Indeed, there has been sufficient experience with GHG emissions inventories to allow several general principles to be stated for developing effective GHG emissions inventory programs:

1. *Start by understanding your emissions.* Knowing the relative magnitudes of emissions sources is necessary to understand whether or not they are material contributors to a firm's total emissions. The degree of complexity of the inventory and how much effort will be required to develop it depend directly on the number and nature of the sources.

   An understanding of emissions requires an understanding of how they can be measured or estimated. A considerable amount of guidance has been and is being prepared on this subject: guidance that firms can use for conducting their inventories or for checking their methodologies.

2. *Consider the likely uses of the emissions inventory.* Companies conduct GHG emissions inventories for a range of purposes. Understanding how the inventory will or may be used will influence how it is conducted. If it is to be used for internal goal setting, its coverage, accuracy, and ability to be verified may be modest. If it is to be used for external reporting, these attributes will become more important. If the inventory may be used for quantifying emissions reductions with the hope of receiving some kind of financial benefit, these attributes become essential.

3. *Decide carefully which emissions to include by establishing meaningful boundaries.* Questions of which emissions to include in a firm's inventory and which are best accounted for elsewhere are among the most difficult aspects of establishing GHG emissions inventories. Since the purpose of conducting an emissions inventory is to track emissions and

emissions reductions, companies are encouraged to include emissions they are in a position to significantly control. In addition to their own production, this would include emissions from purchased energy and possibly increased emissions from acquisitions of new companies. Where the boundaries are drawn will vary from firm to firm; how they are drawn should always be carefully documented and communicated.

4. *Maximize flexibility.* Since requirements to report or reduce GHG emissions under a future climate policy regime are uncertain, companies should prepare for a range of possibilities by maximizing the flexibility of their emissions inventories. Examples of this flexibility include being able to express emissions by facility, business unit, state or country, type of gas, and source type. It also includes the ability to express emissions in absolute or normalized terms (by amount or monetary value of production), to adjust emissions boundaries, and to adjust the emissions baseline.

5. *Ensure transparency.* Transparency in how reported emissions are arrived at is critical to achieving credibility with stakeholders. Unless the emissions baseline, estimation methods, emissions boundaries, and means of reducing emissions are adequately documented and explained in the inventory, stakeholders will not know how to interpret the results. This is true even if the inventory is conducted only for internal reporting. For companies that intend to have their inventories externally verified, transparency is a necessity.

6. *Encourage innovation.* Now is the time to try innovative inventory approaches tailored to a company's particular circumstances. In many cases, the best inventory approaches for specific types of sources and companies are still being determined. The range of experience and lessons learned will be invaluable as voluntary reporting protocols are developed or as possible regulatory requirements are established. Now is the optimal time to experiment and learn what works best.

Endnotes

1. The Business Environmental Leadership Council (BELC) of the Pew Center is a group of leading companies worldwide that are responding to the challenges posed by global climate change. This council explores how companies can contribute to solutions at home and abroad through their own products, practices, and technologies. The BELC includes: ABB, Air Products and Chemicals, Inc., American Electric Power, Baxter International, Boeing, BP Amoco, CH2M HILL, DuPont, Enron International Corporation, Entergy, Holnam, Inc., Intercontinental Energy, Lockheed Martin, Maytag Corporation, PG&E Corporation, Shell International, Sunoco, Inc., Toyota, United Technologies Corporation, Weyerhaeuser, and Whirpool.

2. The IPCC recommends that countries submit a description of the method used as well as other relevant assumptions, check their inventory for completeness and accuracy, and conduct an uncertainty analyses by, for instance, stating confidence levels. A complete description of the IPCC procedures can be found in the three-volume Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1996).

3. The GWP concept is currently inapplicable to gases and aerosols that are very unevenly distributed in the earth's troposophere, namely tropospheric ozone, aerosols, and their precursors, though the IPCC has published GWPs for these compounds in the past. The typical uncertainty in GWPs is +/-35 percent on global average basis (IPCC, 1996a).

4. Halon is a DuPont trade name for a group of bromofluorocarbons, which are used almost exclusively in fire protection systems.

5. VOCs are volatile organic compounds.

6. Manufacturers of HCFCs and their substitutes, and firms that have used CFCs as blowing agents in the manufacture of foam are examples of the types of companies where questions of whether to count CFC and HCFC emissions are key to accounting for GHG emissions and emissions reductions.

7. The IPCC reporting guidelines also include sulfur dioxide (SO_2) as a precursor to sulfate aerosol, which is believed to have a cooling effect.

8. In May 1999, WRI and WBCSD convened an open, international, multi-stakeholder collaboration to design, disseminate, and promote the use of an international corporate protocol for reporting business greenhouse gas emissions. The core operations module of the protocol is scheduled for public release in November 2000.

9. Information on the efficiency of the combustion process in converting carbon to carbon dioxide is also needed; default values from the literature are available if equipment-specific values have not been determined.

10. The Global Environmental Management Initiative (GEMI) is a non-profit organization of leading companies dedicated to fostering environmental, health, and safety excellence worldwide through the sharing of tools and information in order for business to help business achieve environmental excellence.

11. Incomplete combustion results in the formation of the pollutants carbon monoxide and soot.

12. The Coalition to Advance Sustainable Technology (CAST) is a public policy organization of CEOs who share the view that environmental stewardship is compatible with sound and competitive business practices.

13. If the energy generated and exported by Suncor is of a lower emissions intensity than the electricity being displaced and that would otherwise have been consumed by the same users, then Suncor would also credit to its account the associated emissions reductions.

14. Life-cycle environmental accounting or analysis, also abbreviated LCA, are other terms for life-cycle assessment.

15. Take-back regulations require a firm selling or producing a product to take it back after its useful life has ended; motor oil and nickel-cadmium batteries are examples of products to which take-back regulations have been applied.

16. The Climate Neutral Network is an alliance of companies and other organizations committed to defining and promoting climate-neutral products, activities, and enterprises — those determined to have little or no effect on the earth's climate because they result in little or no net emissions of greenhouse gases.

17. UTC's best known products include Pratt & Whitney aircraft engines, Carrier heating and air conditioning systems, Otis elevators and escalators, Sikorsky helicopters, and Hamilton Sundstrand aerospace systems.

18. The metric ton (or "tonne") — 1000 kilograms — is used in this report because it is the most common unit for reporting GHG emissions.

19. Because CFCs are not typically included in emissions baselines and their replacements — HFCs and CFCs — were not produced in significant quantities until the mid-1990s, 1995 could be chosen as the base year for HFC and PFC emissions. If 1990 were chosen as the base year, firms that emit the CFC replacements would have an unfairly strict baseline for these compounds. Neither the CFCs, which were emitted in 1990, nor the replacements, which were emitted later, would be included in the baseline.

20. The Coalition for Environmentally Responsible Economies (CERES) is a nonprofit coalition of investors, public pension funds, labor unions, and environmental, religious and public interest groups working in partnership with companies toward the common goal of corporate environmental responsibility worldwide.

21. The issue of what constitutes a creditable reduction has been a subject of discussion related to proposed legislation to give credit for early reductions of GHG emissions, as well as in discussions of programs for the trading of emissions reduction credits (for example, see Rolfe [1998]).

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