A Future in Counting Carbon

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With regulatory mandates on the horizon, understanding the steps outlined in the *Greenhouse Gas Protocol*, the de facto standard for emissions accountability, will help organizations stay within acceptable limits.

As climate change concerns expand to life-threatening scenarios, individuals and organizations have had to become considerably more interested in how to calculate their carbon footprint. Aside from environmental concerns and financial incentives, implementing corporate policies and strategies that account for greenhouse gas (GHG) emissions could soon become mandatory for certain organizations.

GHG accountability is penetrating all facets of society. Citizens are becoming more aware of their responsibility in deliberately or inadvertently contributing to GHGs. Legislators are developing more policies that will regulate emissions. Companies are considering how they measure up in light of these regulations and some are finding the potential liabilities sobering. Stakeholders are requesting reports containing information on GHG emissions to begin assessing any current or potential legal or financial risks.

The Environmental Protection Agency's (EPA's) finding that GHG emissions pose a risk to human health and the environment is the first official U.S. government action that acknowledges threats from climate change.[1] A 60-day comment period must take place before EPA issues the final ruling, but the draft rule issued March 10, 2009, would make it mandatory to report GHG emissions annually for suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions.[2] With such legislation imminent, obviously organizations must have some framework in place for accurately calculating and reporting GHG emissions.

Inside Track

- Until recently, no one has paid much attention to collecting meaningful information on greenhouse gas (GHG) emissions, but that is a critical first step in establishing a baseline for emission reduction.
- Calculating emissions need not be complex. A simple equation can often be better than more involved analysis that risks introducing error.
- Providing accurate reports to all stakeholders and regulatory bodies allows them to make informed and appropriate decisions.
- Certain states and other countries have already established registry programs, many of which support organizations that voluntarily report their emissions and set reduction targets.

Where to start?

Only since energy security and environmental sustainability have gained momentum has much attention been paid to collecting meaningful information on GHG emissions. Consequently, some organizations are naturally overwhelmed with the flood of information and "methods" and are searching for practical, immediate action. In other words, how *do* you calculate a carbon footprint? Seemingly hundreds of so-called carbon calculators are available on the Internet that collect information on everything from spending patterns to food preferences.

Many of these tools yield questionable results, however, and with an issue as serious as GHG emissions, an organization cannot afford to risk precious resources on methods that are not always accurate and might not meet regulatory demands.

The most reliable and widely accepted methods for calculating GHG emissions are outlined in the *GHG Protocol*,[3] a document published by the World Resources Institute and the World Business Council for Sustainable Development, both of which were pioneers in establishing GHG accounting and reporting standards. At present, nearly all programs for reporting GHGs have adopted the *GHG Protocol* standards for setting program requirements, so understanding its principles will equip any organization to participate in GHG programs. Even the International Organization for Standardization has acknowledged and adopted the *GHG Protocol* in defining its standards for quantifying and reporting GHG emissions. Knowledge of these standards is essential for adapting to future regulations and developing GHG management strategies.

Preparing an emissions inventory

A GHG inventory enables an organization to identify its GHG contribution, set reduction targets, and manage its actions to achieve those goals. Table 1 shows the four questions an organization should ask before developing such an inventory.

All these questions need to be answered to accurately determine which GHG emissions an organization can claim ownership of and how the results will be used. Following the quantification methodologies and reporting standards described in the *GHG Protocol* will ensure that the inventory is accurate, transparent, and acceptable.

Each GHG program has individual reporting requirements for accepted calculation methods, as well as lookup reference values for use in complying with requirements. Generally, these methods and values are similar, but it is important to know a specific program's requirements. Being a few decimal points off for a single value is not egregious but repeated to a very large number, error can be significant. Although most programs adopt the *GHG Protocol* standards, an organization should expect program-specific requirements, particularly when aggregating emissions into separate categories and reporting individual facilities.

Guiding principles

The *GHG Protocol* outlines five principles in developing inventories for reporting: relevance, completeness, consistency, transparency, and accuracy. By following these principles, organizations will be able to develop a GHG inventory that accurately depicts their activities and is suitable for all intended users and decision makers. More important, they will be able to accurately measure their reduction strategies and determine if those strategies meet reporting requirements.

Relevance. This principle ensures that the inventory appropriately reflects the organization's GHG emissions and meets the decision-making needs of its intended users, both within and outside the organization. Relevance enables decision makers to make informed choices about GHG management and mitigation strategies. It also enables third-party assessors and regulatory bodies to adequately determine an organization's GHG contribution relative to its allowances.

Completeness. This principle ensures that the inventory accounts for and reports all GHG emission sources and activities within the defined boundary ("defined boundary" is explained in the next section). Completeness means that the organization fully asserts its GHG contribution. It is also an essential principle in determining the organization's baseline GHG emissions and subsequently tracking the progress of various reduction strategies.

Consistency. This principle ensures that the organization uses consistent methodologies in developing an inventory so that it can make meaningful comparisons of emissions over time. Consistency means that the organization clearly documents any changes in emission data, inventory boundaries, methods, or any other relevant factors. Consistency also makes it easier to track reduction efforts from the baseline and identify what is not improving and might represent a future liability. Documenting changes in the inventory approach will help in later assessments of a particular change and will help explain differing results.

Transparency. This principle ensures that the organization addresses all relevant issues factually and coherently with a clear audit trail. Transparency means that the organization documents any relevant assumptions and appropriately references the methods and data sources used. Internal audits and clear documenting of key inventory activities guard against missing information and partially fulfilled procedures. Transparency means that the organization can be less concerned about the integrity of its GHG assertion.

Table 1. Four questions to ask before developing a greenhouse gas (GHG) inventory and first steps to take in response.

Question	Sample Response	First Steps
What is the inventory's objective?	The objective might be to report emissions under the EPA's mandatory GHG rule or to provide stakeholders and top management with reports regarding GHG activities.	Check if state, regional, or national GHG regulations apply to the organization's operations. Present GHG and energy management initiatives to top-level management.
What emissions should the inventory include?	Most GHG programs require reporting *direct* emissions from stationary and mobile combustion, processes and fugitive emissions and *indirect* emissions from purchased electricity, heating, and cooling.	Check the specific GHG program to determine what must be reported.
What internal sources are causing those emissions?	Sources might include diesel-fuel combustion from backup generators, natural gas combustion from cooking operations, and purchased electricity.	Work with facilities or plant managers to understand the sources and how to report them.
What data is needed to quantify emissions?	Typical measures are gallons of diesel fuel, therms of natural gas, and kilowatt-hours of electricity. Sources are generally utility bills, purchase records, and meters.	Check the GHG program for accepted quantifying practices and any allowable estimations.

Accuracy. This principle ensures that the organization quantifies GHG emissions properly, neither overstating nor understating its true emissions and thereby reducing uncertainties as much as possible. Accuracy must be high enough that those using the results of the inventory can make decisions with reasonable assurance of the reported information's integrity. The required accuracy level depends on the GHG program, but every program limits the number of assumptions or unapproved methods allowed. Accurate results are easiest to obtain if the organization has tools that can deliver accurate, relevant data and uses accepted values and methods that are consistent with the selected GHG program.[3]

What emissions to include?

Determining what to include in an organization's inventory requires establishing boundaries that define which facilities and emission sources the inventory should include. The *GHG Protocol* requires two boundary types. The *organizational* boundary defines the facilities that will be included; the *operational* boundary defines the emission sources of each facility within the defined organizational boundary. Clearly delineating both these boundaries is instrumental in developing the inventory's components.

Organizational boundaries. Defining organizational boundaries ultimately establishes responsibility for certain emissions. As Figure 1 shows, the *GHG Protocol* provides two ways to consolidate and report emissions. The first is to use the *equity-share approach*, which requires entities to report partially or fully owned emission sources on the basis of the percentage of equity share in each.

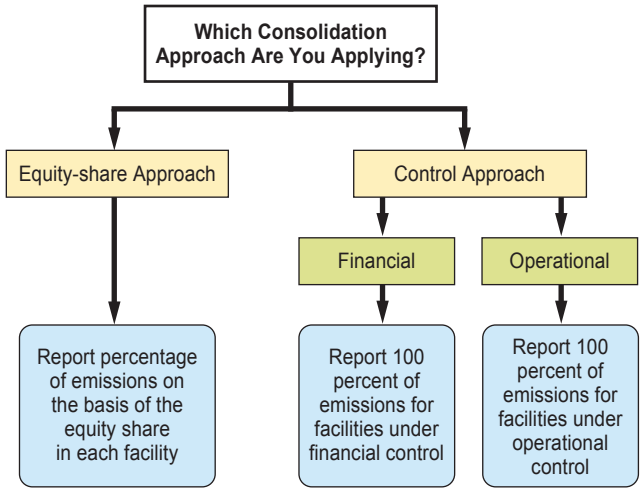

Figure 1. Decisions in choosing either the equity-share or control approach for reporting emissions. An entity with direct financial interest is likely to choose the equity-share reporting approach, but the control approach is useful in tracking the performance of new operating policies. Organizational boundary setting is an ongoing exercise, but once an entity chooses a path, it must continue to follow it each time to enforce consistency. (Source: *The Climate Registry: General Reporting Protocol*, May 2008.)

The second is to use the *control approach*, which requires entities to report 100 percent of both partially and fully owned emission sources that are under their control. Control can be either operational or financial, and the choice dictates which emissions entities must report:

Operational control. Entities report emissions from operations for which they have the full authority to introduce and implement operating policies.

Financial control. Entities report emissions from operations for which they have the ability to direct financial policies with an interest in gaining economic benefits.

Selecting boundaries and determining which emissions to report can be a complicated exercise, especially when dealing with joint-control (operational or financial) operations and subsidiaries. Figure 1 can serve as a basis for decision logic, but an organization must also consider the specific GHG program requirements. Neither the *GHG Protocol* nor its authoring organizations favor one approach over the other. Rather they encourage organizations to calculate their emissions separately using both approaches so as to address the variety of user needs. However, organizations must be consistent and clear in defining organizational boundaries so that the GHG program can detect any emissions that might inadvertently be omitted or double counted. The sidebar "Overlaps and Gaps in Organizational Boundaries" on p. 40 describes how this might happen.

As a rule, organizations with a direct financial interest in a specific activity are likely to choose the equity-share reporting approach because the information has a direct bearing on their financial risk. However, using the operational control approach can provide information for performance tracking as new operating policies are implemented. Also, with the equity-share approach, emissions are harder to consolidate because access to proper financial records may be difficult. Aggregation can be complicated when dealing with different entities and subsidiaries under a single reporting organization.

Defining the organizational boundary should be an ongoing activity, repeated when new facilities emerge and as new relevant emission sources become apparent. However, once an entity chooses an option for setting organizational boundaries, it must use that option consistently. GHG programs generally require this to enforce the consistency guiding principle.

Operational boundaries. Identifying all GHG emission sources within the organization is essential to any assessment of the organization's environmental impact. Because operational boundaries define which emission sources an inventory should include, any exclusion or addition of sources could drastically change emissions and performance-monitoring results. Consequently, establishing a complete, accurate baseline sets the groundwork

for both emission and consumption reduction. Without a baseline, the organization will find it impossible to determine the effectiveness of any sustainability adjustments.

Each GHG program recognizes certain categories for defining and aggregating emissions, but most adopt the categories set forth in the *GHG Protocol* because they are universally accepted and appropriate for a variety of organizations, climate policies, and business goals. The *GHG Protocol* characterizes two groups of emissions. *Direct* emissions are directly attributable to the operations and activities under the organization's ownership. *Indirect* emissions are from a downstream or upstream process that the organization's activities influence, such as purchased electricity, heating, and cooling. Some argue for excluding indirect emissions from an inventory, but most of the newer GHG programs include them because they can represent the largest percentage of emissions for many organizations.

GHG programs generally require organizations to aggregate and report according to certain categories. Table 2 shows the reporting categories that the *GHG Protocol* requires, classifying direct emissions as Scope 1 (first four rows) and indirect emissions as Scope 2 (last two rows). Scope 3 consists of indirect emissions from upstream and downstream emissions that the organization does not own or control, such as from employee commuting and business travel. It is mandatory to aggregate and report Scopes 1 and 2 separately, but it is optional to report Scope 3 emissions.

Figure 2 displays emission source categories and their associated scope.

Understanding the requirements of the specific GHG program selected ensures that the organization is capturing all the necessary emission sources and categorizing them appropriately.

Table 2. Categories in Scopes 1 and 2, which the *GHG Protocol* requires in reporting GHG emissions.

Category	Description
Stationary combustion	Combustion of fuels to produce electricity, heat, or motive power using equipment in a fixed location
Mobile combustion	Combustion from on-road and other mobile vehicles such as automobiles, buses, trains, airplanes, marine vessels, and construction equipment
Fugitive emissions	Unintentional releases from the production, processing, transmission, and storage of certain substances that do not pass through a stack, chimney, vent, or exhaust pipe
Process emissions	Emissions generated from specific physical and chemical processes other than fuel combustion (the manufacturing of cement, aluminum, adipic acid, and so on)
Purchased electricity	Indirect emissions associated with the purchase and use of electricity generated through the combustion of fossil fuels from an upstream utility company
Purchased steam, heating, cooling	Applies to organizations that purchase electricity, steam, or heat from a combined heat and power plant or import steam, heating, or cooling from a conventional boiler that they do not own or operate

Quantifying emissions

Once an organization has categorized its emission sources according to the requirements specified, it must quantify the emissions. The inventory must include the six GHGs regulated by the Kyoto Protocol: carbon dioxide (CO_2), sulfur hexafluoride (SF_6), methane (CH_4), nitrous oxide (N_2O), hydorfluorocarbons (HFCs), and perfluorocarbons (PFCs). CO_2 is the most prevalent GHG, but the other five gases have a greater potential to cause global warming.

Although many quantification approaches are available, this simple equation will suffice for most organizations:

activity data x emission factor = emissions

where *activity data* is data from a certain activity used to quantify an emission source, such as gallons of diesel fuel, and *emission factor* is a ratio that represents the general emissions released for consuming a specific unit of activity data, such as pounds of CO_2 emitted per gallon of diesel fuel combusted.

Activity data. Monitoring the proper activity data accurately within an operation is the key to generating suitable results. Most of this data should come from the facility or plant manager in the form of utility bills, purchase records, meter readings, and so on. Some organizations experience major setbacks in emissions quantification because they find that such data has not

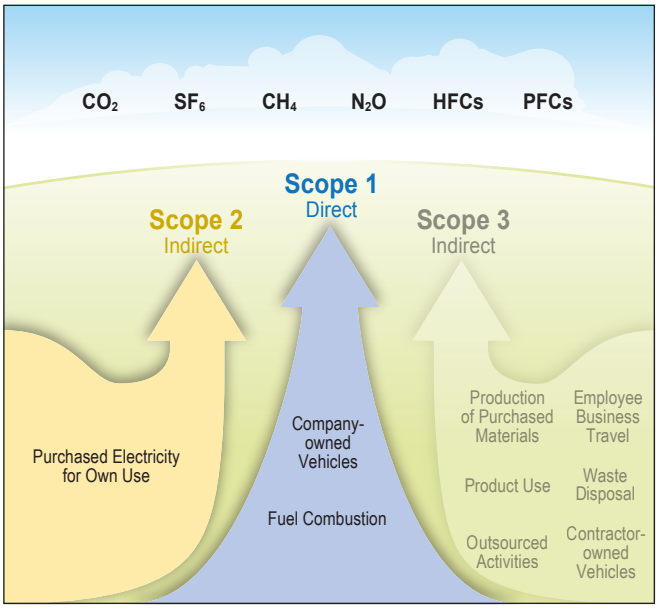

Figure 2. Emission source categories. The *GHG Protocol* mandates the reporting of emission sources in Scopes 1 and 2, but makes reporting emissions in Scope 3 optional. The emissions are the six GHGs regulated by the Kyoto Protocol. CO_2: carbon dioxide; SF_6: sulfur hexafluoride; CH_4: methane; N_2O: nitrous oxide; HFCs: hydrofluorocarbons; PFCs: perfluorocarbons. (Figure from *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, rev. ed.*, p. 26.)

been maintained efficiently, making it difficult for those developing the inventory to access what they need. An organization might first have to improve its data management practices so that accessing and using the data will be far less complicated.

Emission factor. An organization generalizes the emission factor by averaging various GHG emitting processes (combustion, electricity generation, transportation, and so on). Thus, it assumes that a gallon of diesel burned in a backup generator in one facility releases the same emissions as a generator operating in another facility. Although this averaging is not an entirely accurate quantification of emissions, it is still accepted because it is reasonable and uses easily attainable information.

Aggregating to a common unit. Because activity data and the emission factor are often in terms of the specific GHG emitted, the organization must first put all GHGs in a common unit to aggregate them. This unit is metric tons of CO_2 equivalents (CO_2e). The *global warming potential (GWP)* is the ratio comparing a GHG's potential to cause global warming to CO_2's potential, and it is used to calculate emissions from the specific GHG relative to CO_2. The sidebar "A Hypothetical Calculation" shows this additional quantification step.

Calculating emissions. The simple equation given earlier is suitable for any organization that is office-based and consequently has relatively simple emissions that are mostly from purchased electricity and fuel consumption. More complex emissions require more rigorous calculations and access to additional data. The more complex calculation methods account for the actual energy content of the specific fuel used and for operation efficiencies. Although these methods might give a more precise measurement of a specific emission activity, the risk of inaccuracies is higher because the calculations are more complex and more data is needed to perform them. Organizations can make it easy on themselves by using the simple equation to calculate their emissions and minimize the risk of error.

Verifying results

To ensure a report's accuracy, an inventory must undergo verification and validation before a GHG program will accept it. These activities certify that the reported results are reasonably accurate according to the program's requirements.

Verification either by a governing agency or a third party ensures that the reporting organization has followed the reporting protocol and has sufficient and accurate data management controls. Verification also ensures that the personnel who developed the inventory fully understand the calculation procedures and have accounted for all GHG emission activities. Each GHG program usually has its own requirements for achieving a certain accuracy threshold; the *GHG Protocol* requires accuracy within a 5 percent margin of error.

Providing accurate reports to all stakeholders and regulatory bodies allows them to make informed and appropriate decisions. For a market-based reporting program under a cap-and-trade system, a GHG inventory can be critically important in asserting

Overlaps and Gaps in Organizational Boundaries

Because entities have options for choosing their boundaries, two entities might report some part of the same facility's emissions, or not report them at all. Consider two entities, both of which have a mix of facilities that they partially or wholly own or operate. This mix—not a particular facility—guides each entity's decision for the most appropriate organizational boundary approach. Consequently, a single facility's emissions can be double-counted or omitted.

Figure A illustrates how this can happen. Organization 1 uses the control approach to set its organizational boundary and thus reports 100 percent of Facility A's emissions because Facility A is under its operational control. But Organization 2 has financial interest in Facility A, and it chooses the equity-share approach and reports a percentage of Facility A's emissions. Thus, some percentage of Facility A's emissions would be double-counted, as in Scenario 1.

In Scenario 2, Organization 1 uses the equity-share approach, so it would not report any of Facility A's emissions. And if Organization 2 decides to use the operational control approach, then it would also not report *any* of Facility A's emissions. Thus, Facility A's emissions would never get reported.

The GHG program must ultimately identify any overlaps or gaps, so it is essential that entities clearly identify their boundaries. Identifying possible overlaps and gaps is a prerequisite to determining if an entity has complied with specific allowances or other requirements.

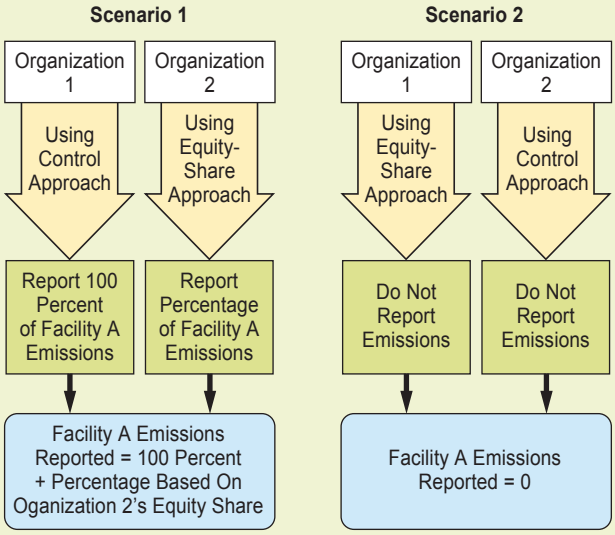

Figure A. How an overlap or a gap can occur in emissions reporting. In both scenarios, both organizations are reporting emissions from Facility A. Organization 1 has operational control over Facility A but no financial interest. Organization 2 has financial interest but no operational control. The choices of the two organizations result in an overlap in Scenario 1 and a gap in Scenario 2.

A Hypothetical Calculation

Suppose that a facility has a stationary combustion source that emits methane (CH_4) and nitrous oxide (N_2O), such as in a diesel fuel commercial boiler. Suppose also that activity data shows 5,000 gallons of diesel fuel.

1 The first step is to derive the emission factor of the specific greenhouse gas:

$$\frac{137{,}380\ \text{Btu}}{\text{gallon}} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} \times \frac{10\ g\ CH_4}{MMBtu} \times \frac{1\ metric\ ton}{1{,}000{,}000\ g} = 1.37\times10^{-6}\ \frac{metric\ tons\ CH_4}{gallon}$$

(a) (b) (c) (b)

$$\frac{137{,}380\ \text{Btu}}{\text{gallon}} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} \times \frac{0.6\ g\ N_2O}{MMBtu} \times \frac{1\ metric\ ton}{1{,}000{,}000\ g} = 8.24\times10^{-8}\ \frac{metric\ tons\ N_2O}{gallon}$$

(a) Value from properties lookup table: http://www.afdc.energy.gov/afdc/fuels/properties.html

(b) Standard unit conversion

(c) Emission factor given by EIA tables: http://www.eia.doe.gov/oiaf/1605/emission_factors.html (Table 3. Petroleum, Commercial)

2 The next step is to find the total emissions by multiplying activity data and emission factor:

$$5{,}000\ gallons\ of\ diesel\ fuel \times \frac{1.37\times10^{-6}\ metric\ tons\ CH_4}{gallon\ of\ fuel} = 0.0069\ metric\ tons\ CH_4$$

$$5{,}000\ gallons\ of\ diesel\ fuel \times \frac{8.24\times10^{-8}\ metric\ tons\ N_2O}{gallon\ of\ fuel} = 0.00041\ metric\ tons\ N_2O$$

3 The next step is to convert each emission value to the carbon dioxide equivalent (CO_2e). CH_4 has 21 times the potential to cause global warming than CO_2, so its global warming potential (GWP) is 21. N_2O has a much higher GWP of 310. The GWPs for the Kyoto Protocol greenhouse gases are listed in a table provided by Intergovernmental Panel on Climate Change (http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf; p. 212).

$$emissions \quad GWP = emissions\ in\ CO_2e$$
$$0.0069\ metric\ tons\ CH_4 \quad 21 = 0.14\ metric\ tons\ CO_2e$$
$$0.00041\ metric\ tons\ N_2O \quad 310 = 0.13\ metric\ tons\ CO_2e$$

Thus, arriving at the reportable CO_2e takes only three relatively simple calculations.

an entity's GHG contribution relative to its emission allowance. Allowances can be costly at times depending on how stringent the emissions cap is and the number of credits available from reduction projects. Credits possessing a monetary value need to be traded correctly and transparently so that the allocation of expenditures and dividends is accurate. Having a correct and fair program is possible only with verification.

Reporting results

After an agency or third party has verified the organization's GHG inventory, the organization reports it to a GHG registry and can make it publically available. Depending on the goals or requirements, participating in such reporting programs enables the organization to accurately set reduction targets and measure its progress. Certain states and other countries have already established voluntary and mandatory registry programs. Though some programs are a response to industry or government policy, many are established to support organizations who are volunteering to report their emissions and set reduction targets.

Some GHG registries use a market-based approach to reduce GHG emissions, in which they allow organizations to trade emission credits to meet compliance or reduction targets. In this case, managing GHG emissions and meeting program requirements could present financial risks or incentives. In mandatory cap-and-trade programs, reduction projects would be an incentive for selling CO_2e credits to agencies that have exceeded their emission allowances. Future climate policy may result in a large market for emission-reduction projects, and investors are likely to be interested in the gains associated with going green.

Whether it is to demonstrate environmental responsibility, fulfill a requirement, or grow a business, it pays to be knowledgeable about GHG accounting and reporting standards. Armed with this understanding, organizations will be prepared to adapt to new regulations and mitigate potential liabilities. Developing GHG inventories according to the standards in the *GHG Protocol* will empower an organization to accurately gauge the progress of emission-reduction efforts throughout the years. Reporting emissions appropriately and consistently to inform stakeholders and decision makers of specific activities is essential for developing GHG management strategies and for demonstrating the effectiveness of emission-reduction efforts. Following the methods and principles established by the *GHG Protocol* will allow an organization to count carbon with confidence. ■

References

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