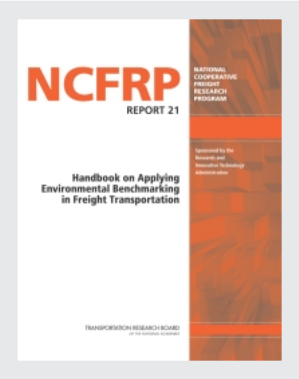


# Handbook on Applying Environmental Benchmarking in Freight Transportation

**DETAILS**

63 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-25875-3 | DOI 10.17226/22668



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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 21

# Handbook on Applying Environmental Benchmarking in Freight Transportation

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*Subscriber Categories*
Environment • Freight Transportation

Research sponsored by the Research and Innovative Technology Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2012
www.TRB.org

## NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Research and Innovative Technology Administration (RITA) under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between RITA and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

Program guidance is provided by an Oversight Committee comprised of a representative cross section of freight stakeholders appointed by the National Research Council of The National Academies. The NCFRP Oversight Committee meets annually to formulate the research program by identifying the highest priority projects and defining funding levels and expected products. Research problem statements recommending research needs for consideration by the Oversight Committee are solicited annually, but may be submitted to TRB at any time. Each selected project is assigned to a panel, appointed by TRB, which provides technical guidance and counsel throughout the life of the project. Heavy emphasis is placed on including members representing the intended users of the research products.

The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.

## NCFRP REPORT 21

Project NCFRP 27
ISSN 1947-5659
ISBN 978-0-309-25875-3
Library of Congress Control Number 2012953-767



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# FOREWORD

By William C. Rogers
Staff Officer
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*NCFRP Report 21: Handbook on Applying Environmental Benchmarking in Freight Transportation* identifies and evaluates approaches that can be used by public and private entities to estimate, monitor, and reduce freight emissions and impacts across the supply chain by examining how benchmarking can be used as a management tool in the freight and logistics industry to promote environmental performance. The handbook provides a step-by-step overview of the benchmarking process and describes a framework for applying this process to freight carriers, shippers, and freight hubs.

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The freight sector is increasingly recognized as a major source of air pollution. As such, public agencies are rapidly developing policies and programs to reduce related emissions and are challenged to maximize the environmental benefits of public investments. The private sector, including shippers and carriers, is also working to decrease emissions and meet expectations. In addition to complex, resource-intensive freight emissions models and studies currently undertaken by public agencies, many think that other tools are needed. Benchmarking presents an efficient approach to reducing freight emissions and impacts because it can accelerate improvements by eliminating the trial and error process.

Under NCFRP Project 27, ICF International was asked to (1) review existing environmental benchmarking practices and standards as well as best practices in freight, logistics, and other industries that are relevant to environmental benchmarking; (2) develop a glossary of key environmental benchmarking terms, including such properties as geographical coverage, freight mode, overall supply chain, public and private environmental goals, and metrics; (3) develop a general framework for environmental benchmarking and describe how it can be applied to freight systems within specific geographical scales and how it can be applied for supply chains, freight modes, and facilities; (4) describe how industry benchmarking has been an economically efficient and practical tool for improving industry in areas such as safety and quality; (5) conduct case studies, verified through industry interviews, that discuss the applicability, outcomes, benefits, challenges and implications of applying the benchmarking framework; and (6) develop a handbook that identifies and evaluates approaches that can be used by public and private entities to estimate, monitor, and reduce freight emissions and impacts across the supply chain and creates a framework to apply environmental benchmarking to addressing air quality impacts of freight transportation.

# CONTENTS



Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

CHAPTER 1

# Introduction

This handbook is intended to be used by freight transportation professionals and other stakeholders who are interested in reducing the air quality impacts of freight transportation. The handbook is applicable to freight carriers (truck, rail, air, marine), shippers, logistics providers, and intermodal freight transfer facilities (marine ports, airports). It describes how benchmarking can be used as a management tool to improve environmental performance in freight transportation. Organizations that systematically measure their performance, compare themselves to industry leaders, and develop strategies to improve operations can gain substantial benefits from improving their environmental performance. This resource provides a step-by-step overview of the benchmarking process and describes a framework for applying this process to freight carriers, shippers, and freight hubs. This handbook addresses air emissions at several different levels, including vehicle fleets, facilities, organizations, and transportation corridors.

This document is organized into seven chapters. Chapter 1 provides this introduction. Chapter 2 discusses the air quality impacts of freight transport. Chapter 3 provides an overview of the benchmarking process and the benefits of benchmarking. Chapter 4 reviews each step in the benchmarking process. Chapter 5 provides an overview of the benchmarking framework used to analyze freight transportation. Chapter 6 discusses benchmarking approaches and metrics for each sector. Chapter 7 addresses general implementation issues that are applicable across all sectors. There are three appendices. Appendix A is a glossary of terms. Appendix B provides a list of existing benchmarking programs relevant to the freight industry. Appendix C is a list of resources for those looking for more information on environmental benchmarking for freight transportation.

CHAPTER 2

# Air Quality and Climate Change Impacts of Freight Transportation

Air pollution from freight transportation is a public health issue of concern in communities and regions in the United States and around the world. Diesel-powered equipment is the most important source of air emissions associated with freight transport. Air emissions from freight facilities and equipment powered by other fuels are also discussed in the handbook. Air emissions can be separated into three primary pollutant categories: criteria pollutants, greenhouse gases, and air toxics. Each of these is described in detail below.

## 2.1 Criteria Air Pollutants

Criteria air pollutants (CAPs) are those for which either the federal government and/or the California State government have established ambient air quality standards based on short- and/or long-term human health effects. The federal government, via the U.S. Environmental Protection Agency (EPA) has established national ambient air quality standards (NAAQS) for the following six pollutants: ground-level ozone ($O_3$), carbon monoxide (CO), particulate matter (PM) less than 10 ($PM_{10}$) and 2.5 microns ($PM_{2.5}$), nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), and lead (Pb).

Although they are not a criteria pollutant, volatile organic compounds (VOCs) are often considered along with criteria pollutants because they are chemical precursors for ground-level ozone. Depending on the report or methodology, these gases are referred to in the following various forms:

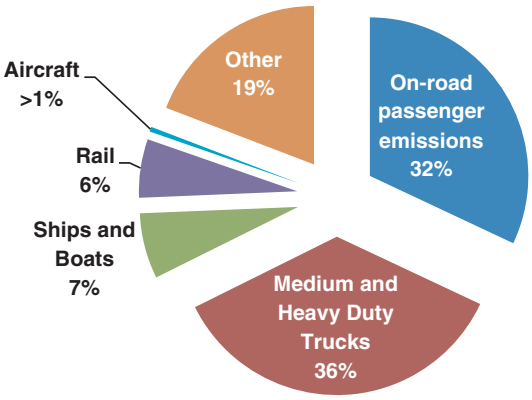
- Reactive organic gases (ROG),
- Total organic gases (TOG),
- Hydrocarbons (HC),
- Total hydrocarbons (THC),
- Non-methane hydrocarbons (NMHC), and
- Diesel exhaust organic gases (DEOG).

Although each term defines specific subsets of VOCs, references to these terms in various methodologies all refer to the same class of VOC pollutants.

The major criteria pollutants and freight transportation's contribution to emissions are discussed below.

- **Ozone,** which is a product of reactions involving NOx and VOCs, can aggravate asthma and other respiratory diseases, leading to more asthma attacks, visits to the emergency room, and increased hospitalizations. Sunlight breaks down the precursor pollutants NOx and VOCs. The oxygen atoms then recombine to form ozone. Ozone formation is thus greatest during the

**Exhibit 1. Mobile source NOx emissions.**




Source: 2009 National Emissions Inventory

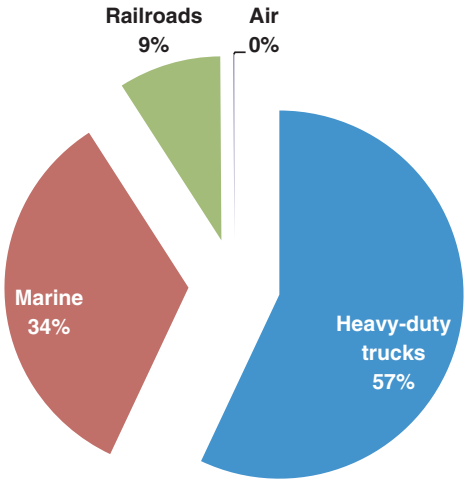
summer months when there is more and stronger sunlight. Ozone can inflame and damage the lining of the lungs. This may lead to permanent changes in lung tissue and to irreversible reductions in lung function if the inflammation occurs repeatedly over a long time period. Children, the elderly, and people with heart and lung disease are most at risk. Wind currents can transport ozone and ozone precursors for many miles. Major freight facilities that have congested operations during the day can be significant contributors to ozone formation. There are no reliable estimates for determining the proportion of ozone attributable to freight transportation, but diesel engines are a significant source of NOx, which is an ozone precursor.

- **Oxides of Nitrogen (NOx)** form a group of highly reactive gasses that are also called "nitrogen oxides" (NOx) and include nitrogen dioxide ($NO_2$). $NO_2$ is the component of greatest interest, and it serves as an indicator for the larger group of nitrogen oxides. In addition to contributing to the formation of ground-level ozone and fine particle pollution, $NO_2$ is linked to a number of adverse effects on the respiratory system. Current scientific evidence links short-term $NO_2$ exposures, ranging from 30 minutes to 24 hours, with adverse respiratory effects, including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Freight transportation accounts for approximately half of mobile source NOx emissions and 27 percent of NOx emissions from all sources.[1] Exhibit 1 shows the breakdown of NOx emissions for all mobile sources.
- **Particulate matter (PM)** is a complex mixture of extremely small particles and liquid droplets. PM is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. EPA is concerned about particles that are 10 micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

EPA groups particle pollution into two categories: inhalable course particles and fine particles. Inhalable coarse particles, such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter, and referred to as $PM_{10}$. The transportation sector, which includes road dust, is responsible for approximately 54 percent of

[1]U.S. Department of Transportation, Federal Highway Administration. "Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level." (Washington, D.C.: 2005), http://www.fhwa.dot.gov/environment/air_quality/publications/effects_of_freight_movement/, downloaded September 12, 2011.

**Exhibit 2. $PM_{10}$ emissions from freight sources.**




Source: 2005 National Emissions Inventory

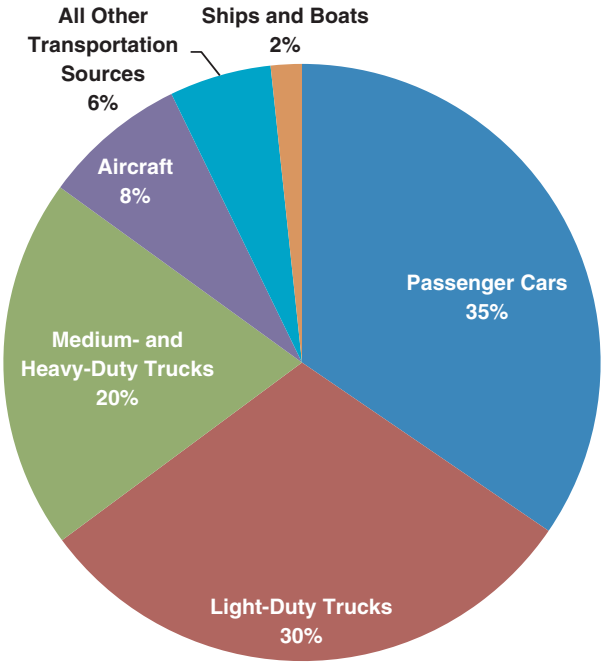
$PM_{10}$ emissions. Freight movement produces approximately half of these emissions, with marine vessels accounting for 29 percent of transportation emissions, heavy-duty trucks creating 17 percent, and locomotive emissions creating 5 percent. See Exhibit 2.

Fine particles, such as those found in smoke and haze, are up to 2.5 micrometers in diameter and are referred to as $PM_{2.5}$. These particles can form when gases emitted from power plants, industry, and automobiles react in the air. $PM_{2.5}$ has been associated with an increased risk of premature mortality, hospital admissions for heart and lung disease, and increased respiratory symptoms. There is significant evidence that $PM_{2.5}$ emissions are more dangerous to human health because they can be transported in the air for longer distances, tend to remain in the lungs, and can enter the bloodstream. Fine particles are mostly created through the interaction of diesel exhaust particles with NOx. Mobile sources (including rail and marine) create approximately 10 percent of $PM_{2.5}$ emissions. Road dust makes up an additional 21 percent of $PM_{2.5}$ emissions.[2]

- **Oxides of Sulfur (SOx)** form a group of highly reactive gasses that includes sulfur dioxide ($SO_2$). The largest sources of $SO_2$ emissions are from fossil fuel combustion at power plants (73 percent) and other industrial facilities (20 percent). The burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment is also an important source of SOx. $SO_2$ can combine with water vapor in the air to create acid rain. In addition, $SO_2$ is linked with a number of adverse effects on the respiratory system.[3]
- **Lead** is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions have historically been fuels for on-road motor vehicles (such as cars and trucks) and industrial sources. As a result of EPA's regulatory efforts to remove lead from gasoline for on-road motor vehicles, emissions of lead from the transportation sector dramatically declined by 95 percent between 1980 and 1999, and levels of lead in the air decreased by 94 percent between 1980 and 1999. The major sources of lead emissions to the

[2]Freight and Air Quality Handbook. U.S. Department of Transportation, Federal Highway Administration. http://ops.fhwa.dot.gov/publications/fhwahop10024/sect2.htm
[3]Sulfur Dioxide. U.S. EPA. http://www.epa.gov/air/sulfurdioxide/

**Exhibit 3. GHG emissions from U.S. transportation sources.**




Source: U.S. Greenhouse Gas Inventory, EPA

air today are ore and metals processing and piston-engine aircraft operating on leaded aviation gasoline.[4]

- **Carbon Monoxide (CO)** is a colorless, odorless gas emitted from combustion processes. Nationally, and particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. Goods movement activities, and diesel engines emissions specifically, are not significant sources of CO emissions.[5]

## 2.2 Greenhouse Gases

Carbon dioxide ($CO_2$), the primary greenhouse gas (GHG) associated with combustion of diesel (and other fossil fuels), accounts for over 95 percent of the transportation sector's global warming potential-weighted GHG emissions. Methane ($CH_4$) and nitrous oxide ($N_2O$) together account for about 2 percent of total GHG emissions from the transportation sector. Both gases are released during fuel consumption (although in much smaller quantities than $CO_2$) and are also affected by vehicle emissions control technologies. Hydrofluorocarbons (HFCs) are the result of leaks and end-of-life disposal of vehicle air conditioners used to cool freight and people. HFCs comprise approximately 3 percent of total transportation GHG emissions.

Exhibit 3 reports GHG emissions by U.S. transportation source in $CO_2$ equivalent units. This metric combines $CO_2$ with all other major transportation GHG emissions ($CH_4$, $N_2O$, and

[4]Lead. U.S. EPA. http://www.epa.gov/airquality/lead/
[5]Carbon Monoxide. U.S. EPA. http://www.epa.gov/airquality/carbonmonoxide/

HFCs). It converts other GHGs into units of $CO_2$ equivalent based on their global warming potential. The exhibit shows that freight-related emissions are a significant share of all transportation GHG emissions. Medium- and heavy-duty trucks are the largest source of GHG emissions associated with freight transportation.

## 2.3 Air Toxics

Air toxics, also known as hazardous air pollutants (HAPs), toxic air contaminants (TACs), mobile source air toxics (MSATs), and non-criteria air pollutants (NCAPs), are contaminants found in ambient air that are known or suspected to cause cancer, reproductive effects, birth defects, other health effects, or adverse environmental effects, but do not have established ambient air quality standards. HAP pollutants broadly fall into two categories—heavy metals and hydrocarbons—and are often calculated as a fraction of PM and VOC emissions. HAPs may have short-term and/or long-term exposure effects. EPA currently has implemented programs to reduce emissions of 188 HAPs; however, 1,033 total HAPs are listed by EPA as related to mobile source emissions. Of these, 644 are components of diesel exhaust, including benzene, cadmium, formaldehyde, and 1,3-butadiene. For freight transportation, the toxic air contaminant of primary concern is typically diesel particulate matter; however, there are currently no specific annual limits on diesel particulate matter.

CHAPTER 3

# Environmental Benchmarking: Overview of the Process and Benefits

Environmental benchmarking is a business tool that helps companies evaluate their environmental performance and identify operating practices that contribute to superior performance. Many companies have begun conducting benchmarking studies for the purpose of identifying work processes and practices that influence the environmental performance of their organizations. Organizations are aware that their operations may have detrimental, mitigating, or even positive impacts on the environment depending upon how the practices are implemented. The impacts of processes can be quantified and thus used as a statistic to evaluate the organization's performance and competitive standing in the industry. For example, there is an increased awareness and interest in the contributions organizations make to climate change and the risks of a variable climate. The Financial Times FTSE4Good Index, the Dow Jones Sustainability Index, and the Carbon Disclosure Project demonstrate the increased emphasis of investors on organizations' practices related to carbon and its association with climate change.

**Benchmarking Defined**

"Benchmarking is the continuous process of measuring products, services and practices against the toughest competitors or those recognized as industry leaders."

—David Kearns, CEO of Xerox Corporation 1982–1990

Although a benchmarking study should be customized with respect to the organization's needs, the general approach to an environmental benchmarking study is as follows:

- Define criteria for establishing practices as best-in-class;
- Define performance metrics/criteria that address the areas of specific interest and allow for comparison across firms;
- Research industry practices and trends, including collecting and analyzing quantitative and qualitative data on the policies, actions, successes, and failures of industry peers;
- Select individual organizations for study based upon specific criteria that position the organization as leaders in the industry (e.g., environmental indices, sustainability report measures, industry awards);
- Evaluate the overall performance of individual organizations included in the analysis relative to the metrics and develop rankings to identify best-in-class;
- Perform a gap analysis to highlight an organization's strengths and weaknesses relative to the field; and
- Provide targeted recommendations for cutting-edge projects, policies, and initiatives that allow an organization to maximize operational efficiencies, improve environmental quality, and reduce operating costs.

**Exhibit 4. Benchmarking to achieve continuous improvement.**


Benchmarking can be viewed as a continuous process (see Exhibit 4). Once a study has been planned, analysis conducted, findings integrated into an action plan, and the plan executed, the process can begin anew to achieve continuous improvement.[6]

## 3.1 What Are the Benefits of Environmental Benchmarking?

Although the primary objective of environmental benchmarking is to reduce a company's environmental impacts (or "footprint"), it can also contribute directly to the business objectives of enhancing profitability and enterprise value for business owners and shareholders. The business benefits of environmental benchmarking include improved information for management, reduced costs, competitive advantage, improved relationships with key business stakeholders, and reduced risk.

### Improved Information for Management

Environmental benchmarking requires a company to collect and understand data on its use of fuel, other resources, and its generation of environmental impacts, which can allow companies to make more informed business decisions.

### Reduced Costs

Because fuel is typically one of the largest contributors to operating costs for freight carriers, fuel economy is a crucial industry performance metric. Because fuel consumption produces emissions of criteria air pollutants, air toxics, and GHGs, fuel economy is also a primary measure of environmental performance for freight carriers. For this reason, improving a company's environmental performance aligns with the business goal of reducing operating costs. Comparative benchmarking can help a company judge how much further improvement in fuel economy may be possible and motivate action to implement additional fuel efficiency strategies. Voluntarily adopting best practices and best technologies can substantially reduce fuel use. For

[6]The benchmarking framework shown here builds on Robert Camp's book *Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance*, which was an early and important work in the field.

instance, studies have suggested that adopting best practices could reduce truck fuel use by 10 to 15 percent in the near term through vehicle technology retrofits and other operational strategies. Savings of as much as 30 percent in the long run would be possible as equipment is replaced. Voluntary adoption of best practices by marine, rail, and aviation carriers has also been estimated to be capable of achieving fuel savings of 20 percent or more industrywide.[7]

## Competitive Advantage

Companies that offer environmentally friendly products or operate in an environmentally conscious manner often have a competitive advantage. Performing environmental benchmarking will assist companies in offering environmentally distinguished products and services or demonstrating environmentally conscious operations and practices. Future business opportunities may also require disclosure of environmental performance and benchmarking (e.g., shippers may prefer to work with carriers participating in EPA's SmartWay Transport Partnership, discussed in Chapter 4). In this case, companies that track environmental performance and benchmark will have a competitive advantage over those that do not.

## Relationships with Stakeholders

Demonstrating environmental stewardship and improved environmental performance through benchmarking can raise the standing of the company with key stakeholders.

- **Customers—**Becoming a good steward of the environment can enhance the reputation of the company with its customers and the public more broadly, which can be of great value.
- **Local communities—**A company that enhances its environmental performance will show the communities in which it operates that it cares about environmental issues. Good relations with the local community can be valuable when a business needs to change or expand its operations.
- **Potential and current employees—**Improving environmental performance can make companies more attractive to prospective employees and help businesses retain the talent they already have.
- **Regulators and licensing agencies—**Environmental benchmarking provides a tool to identify best practices that exceed what is required by regulations. Improving environmental performance beyond compliance with regulations can improve relations with government officials, policymakers, and regulators who have a say in licensing the business to operate equipment or facilities.
- **Investors—**Environmental benchmarking can help companies reduce their environmental impacts and raise their standing with investors. Over the last 10 years, socially responsible investing has grown in importance. Sustainability indexes, such as the FTSE4Good Index Series, are designed to provide investors exposure to companies that are managing their social and environmental risks, while also helping ethical investors avoid companies that are not doing so. To be included in the FTSE4Good Index companies must be shown to be making progress toward becoming environmentally sustainable, among other criteria. Improving environmental performance is an important component of participating in socially responsible investment indexes and attracting investments from socially responsible investment funds or individual investors who track environmental performance.

## Reduced Risk

Benchmarking environmental performance allows a company to reduce risks. Having an environmental performance that exceeds that of business peers will reduce regulatory risk and other uncertainties associated with unknown future policies.

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[7] *Transportation's Role in Reducing U.S. Greenhouse Gas Emissions: Volume 1 Synthesis Report.* Report to Congress, U.S. Department of Transportation, April 2010.

CHAPTER 4

# Steps in Benchmarking Process

The benchmarking process consists of five phases. These phases are as follows: planning, analysis, integration, action, and maturity. Exhibit 5 illustrates each phase of the benchmarking process. These specific phases and the 12 adapted steps that constitute the phases are described in more detail in the following sections.

## 4.1 Planning

The critical steps involved in planning are as follows:

- Identify function to benchmark;
- Identify best-in-class organizations in that function;
- Select performance measures; and
- Identify data collection methods.

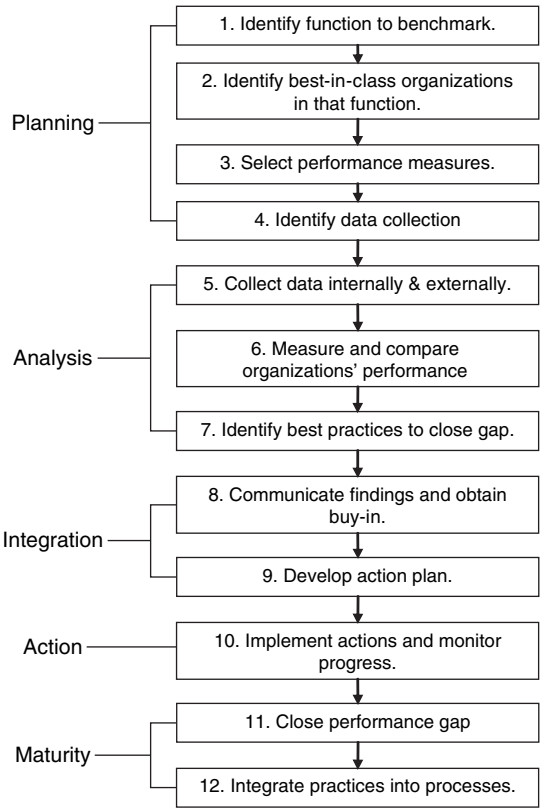
Each of these steps is described in more detail below.

### Identify Function to Benchmark

A key first step in planning a benchmarking study is to identify the function to benchmark. This begins by establishing one or more measures of output to be benchmarked, which could be a product or commodity, an amount of economic output, quantities of commodities shipped, or activity units such as vehicle miles traveled. By identifying a specific output of interest, the benchmarking sponsor (i.e., organization conducting the study) can more easily determine the function responsible for that output. Knowledge of the responsible functional unit guides the comparison of different departments, organizations, or industries on a "one-to-one" basis as opposed to attempting to interpret how data from one functional level translates to another. Furthermore, targeting the functions responsible for a given output allows the sponsor to collect the appropriate data regarding specific processes and supporting practices that contribute to the desired output.

Given that processes are driven by day-to-day practices, benchmarking studies typically focus on identifying the components and operational steps involved in an individual work process. Through a series of deductive steps, the work process studied is the process deemed responsible, at least in part, for the exemplary performance (i.e., desired outcome) of the organization. A work process involves repeated steps that are performed within a particular sequence translating input into output to generate value for the consumer. The way in which this work process is performed or the method used ("the how" of a process) is often referred to as a **practice**. A benchmarking study helps to clarify the practices used to perform

**Exhibit 5. Typical benchmarking process.**




Adapted from Camp, R. C. (1989). *Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance*, ASQ Quality Press, 4–6.

the work process in order to answer the question, "how is this work process conducted?" See Exhibit 6.

In the planning phase of the benchmarking study, the sponsor should also outline questions to clarify such as, "how is success of this work process measured?" which refers to the performance metrics used by the organization and "what resources and behaviors, including the people, technology, and other assets, enable the conduct of this work process?" which are referred to as the "inputs" or "enablers." To answer these questions, sponsors target the process owner for participation in the benchmarking study. The process owner is the employee or group of employees who implement the steps involved in a particular work process.

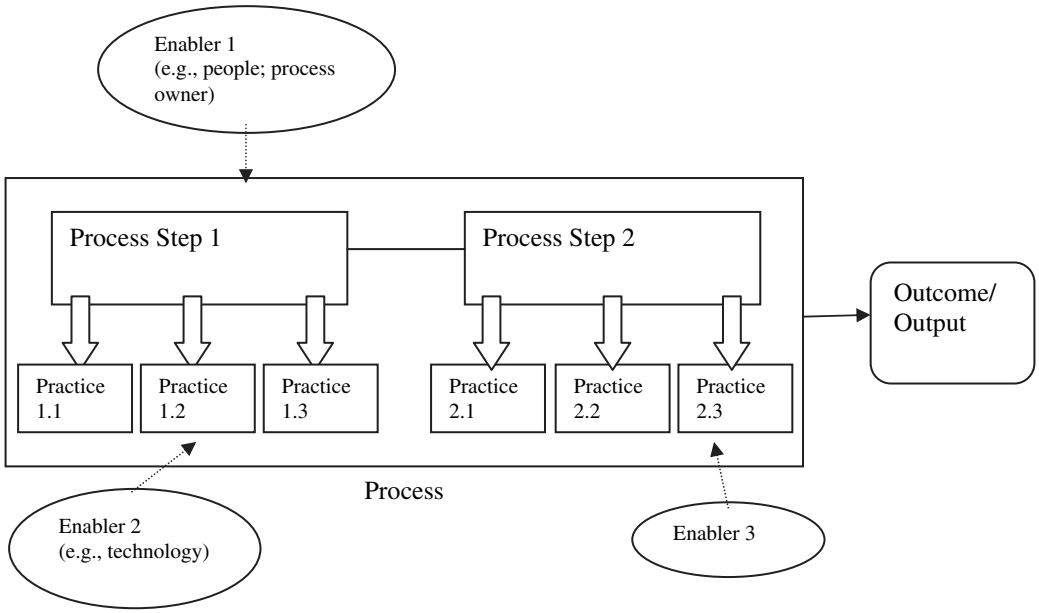
To understand the systematic steps involved in a process, benchmarking sponsors should plan to conduct process mapping. Organizations often use management tools such as Deming's concept of Total Quality Management or the Baldrige Criteria for Excellence to guide process mapping.

The result of process mapping is typically a workflow diagram that helps to clarify the practices or steps involved in a process or series of parallel processes.

The following are the steps that constitute the development of a process mapping flowchart:

**Determine the boundaries—**This refers to where the process begins and ends and which other processes feed into the process.

**Exhibit 6. Relationships among practices, processes, and outcomes.[8]**




**List the steps**—The developer must determine the desired level of specificity in the flowchart. If a benchmarking sponsor is seeking to mimic the process to achieve a specific outcome, typically, the process mapping will detail every decision point and finite action. Each process mapping step or task should begin with a verb to illustrate an action to be taken.

**Sequence the steps**—Once the steps have been documented, the developer typically moves the steps into their proper location in the process flowchart and includes arrows or lines to show the relationship and sequence between steps in the process.

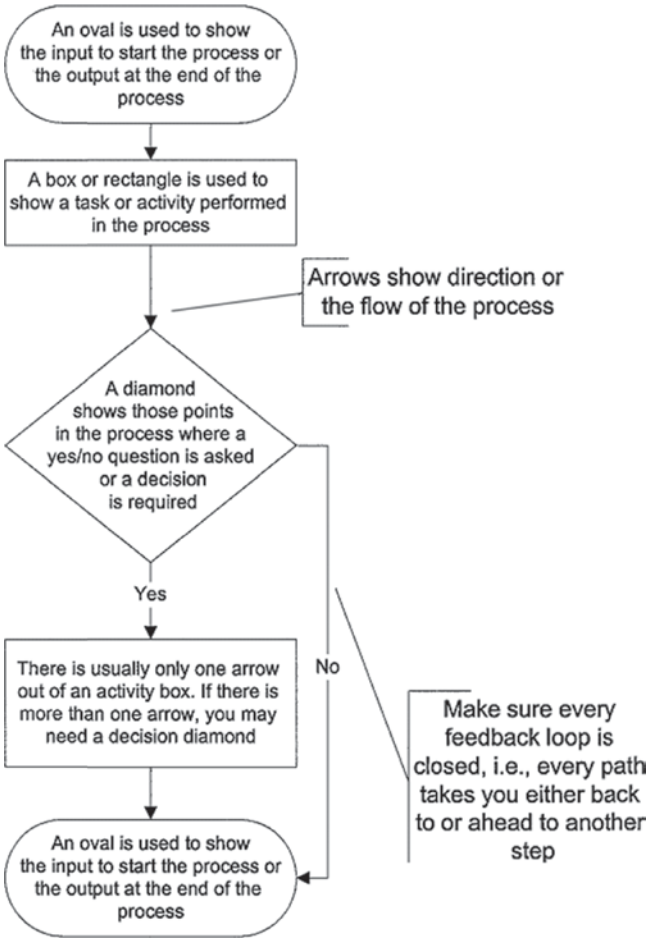
**Draw appropriate symbols**—Each different type of step has its own symbol. For example, ovals are often used to represent the start or end of a process but boxes and rectangles are used for tasks or activities performed as part of the process. Arrows are used to show the direction of the process flow. Multiple arrows leading out of a box/rectangle typically represent a decision point, which is represented by a diamond. Exhibit 7 shows an example of how a process mapping flowchart should be constructed.

**Use a system model approach**—The process mapping flowcharts should be created using a system model approach where the interrelationships among activities, practices, and processes are highlighted. A complete flowchart would illustrate how a series of processes or parallel processes work together to achieve an outcome. Thus, the final chart may include multiple flowcharts like the one presented in Exhibit 7, all constructed in "swimmer lanes" to illustrate timelines and sequencing. Contextual factors that should be included in the flowchart are the input (people, machines, technology, and other materials), output (desired outcome or results), control (rules followed by the best-in-class partners), and feedback (information obtained via data collection).

**Check for completeness**—This includes ensuring all of the information (such as dates and titles) in the chart is accurate. Often, follow-up interviews with key stakeholders or the process owners can help verify the contents of the process mapping flowchart.

[8]Based on concepts described in *The Basics of Benchmarking* by Robert Damelio.

**Exhibit 7. Process mapping flowchart.**




Source: Ahoy, C. (1999), *Facilities News*.

**Finalize the flowchart**—This final development step may include collecting additional data to determine not only whether the process steps have been accurately documented but also whether or not the process is being conducted in the proper way. The flowchart developer should document any recommended deviations so process improvements can be noted.

It is important that the data collector conducting the benchmarking study be intimately familiar with the practices, processes, outcomes, and related enablers within his/her own organization. This information is needed to guide the type of data collected, help define the questions that need to be asked of the benchmarking partner, and determine how the processes might be transferable to the sponsor organization.

Process mapping can be an important tool to examine business operations that affect the environmental performance of a company. For example, a business might want to map its process for vehicle maintenance to improve the operation and emissions performance of in-use vehicles. A railroad might want to map the process by which trains and railcars are handled in a classification yard to reduce locomotive idling. A shipper might want to map the process for how freight transportation is procured and routed to assess whether its environmental footprint can be reduced by using transportation options that are less energy intensive. A receiver could map out how freight is scheduled and handled at its loading dock to determine if there are opportunities to reduce truck idling. A trucking company might want to map procedures for

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vehicle procurement to determine if the company is purchasing equipment that is appropriately sized for its transportation needs, and this could help the company to consider incorporating all appropriate technologies to reduce fuel consumption and emissions.

**Priorities**—Focus on the most important key performance indicators, operating metrics, and attendant environmental and business impacts.

Although a benchmarking sponsor may be interested in studying the processes that drive a number of successful outcomes, it is important that the sponsor prioritize which ones are most important. The sponsor needs to focus its interests in order to conduct a thorough study of a particular outcome. This focus allows the organization to effectively prepare itself in terms of structure, culture, and employee engagement for transformation that will likely occur as a result of adopting new practices and processes that will help achieve a similar desired outcome. Focusing on multiple areas of interest can distract the organization in its study by straining resources, confusing data collection, and segregating the organization in terms of the changes its employees will be willing to accept and implement. Thus, it is important that sponsor organizations identify priorities in terms of which operating metrics and environmental/business impacts are of most importance to target first. The following factors should be considered and weighted in defining priorities relative to environmental benchmarking:

1. Which outcomes will have the greatest positive environmental impact?
2. Which outcomes and processes will be the most cost-effective to replicate?
3. Which processes will be most efficient to implement (i.e., which outcomes will be achieved in the shortest timeframe)?
4. Which outcomes and processes will require the greatest transformation when adopted by the sponsor organization?

In answering these questions, benchmarking sponsors typically find it most advantageous to begin by studying the outcomes and processes that will attain the greatest impact with the least amount of resource allocation and transformation by the organization. In other words, it is recommended that sponsors initially select priorities that will be easily palatable to the organization and demonstrate a clear payoff in the conduct of the benchmarking study. Logistics managers often refer to setting "SMART" goals (i.e., those that are **specific**, **measureable**, **attainable**, with **resources** available for implementation and that are **time-bound**).

**Logistics Center of Excellence Benchmarking Study**

A leading energy company's logistics center of excellence benchmarked itself against its logistics peers and developed a carbon measurement and mitigation program based on this information. Peer firms selected for comparison included Dell Inc., Toyota Motor Corporation, Caterpillar Inc., and Siemens AG. In this context, peer firms were leading manufacturers of industrial and other types of equipment that faced similar logistics challenges. The elements considered in this benchmarking exercise included the commitments of these firms to fuel efficiency and emissions reductions, key performance indicators (KPIs), current environmental performance, and future targets for logistics activities. Among the peer organizations, both Dell and Toyota had made substantial improvements to their logistics operations. Strategies employed included reducing the use of packaging, increasing the loading of containers, and reducing emissions per ton-kilometer by changing the port of entry to reduce truck miles traveled.

The logistics center of excellence used the information obtained from the benchmarking study to implement a carbon measurement program. Mitigation programs were put into place to shift freight to less polluting modes, including a wind turbine supply chain optimization program that shifted the port of entry for parts. In a single year, the supply chain optimization program reduced GHG emissions by 1,000 tons and reduced logistics costs by $5.4 million.

## Identify Best-in-Class Organizations in that Function

An important component of designing a benchmarking study is the selection of organizations to be used for purposes of comparison. This is a particularly important issue in freight transportation, because there are many features that can influence performance, including the weight of cargo, the

geography over which it is moved, the type of service provided, and the level of congestion of the transportation facility. The choice of entities to benchmark against can be driven by a variety of criteria, including a desire to compare against a similar type of operation, the location of innovation, or the availability of willing partners. The benchmarking literature suggests a number of different types of benchmarking and targets for comparison.

In general, benchmarking studies can be classified according to the type of partner that one wishes to benchmark against, the nature and objective of the study, and the purpose of the partnership. A benchmarking study can combine several of these different categories. Exhibit 8 describes these different types of benchmarking studies in detail.

Although benchmarking is often defined as an outward-looking exercise, some firms may have business units that operate independently from each other. In those instances, **internal benchmarking** can be done. Comparing oneself against direct competitors (**competitive benchmarking**) is perhaps the most common conception of benchmarking; however, the desire of firms to protect trade secrets may limit exchange of information among competitors in some cases. Many proponents of benchmarking argue that firms need to go beyond the group of direct competitors to have access to a larger universe of leading companies and innovative practices. **Industry benchmarking** draws comparisons to competitors in the same industry who may not be direct competitors, like truckload and less-than-truckload (LTL) carriers. **Functional benchmarking** examines business functions between dissimilar industries. For instance, the logistics function between a manufacturer and a retailer could be compared. **Generic benchmarking** compares similar processes in significantly different types of firms or organizations. For instance, a vehicle maintenance process in a trucking company could be benchmarked against similar maintenance procedures used by the military.

The nature of the object of study may also vary. Firms may engage in both **process benchmarking** and **product benchmarking**. **Strategic benchmarking** may look at higher level organizational and management practices. **Future benchmarking** is forward looking and seeks to ascertain new technologies and breakthroughs that may eventually become benchmarks. Lastly, the purpose of a benchmarking partnership may be collaborative or competitive.

**Exhibit 8. Typology of benchmarking studies.**

| Classification | Type | Meaning |
|---|---|---|
| Type of Partner | Internal | Comparing best practices within an organization — for instance, a large firm with multiple subsidiaries could have these entities compare their performance |
| | Competitive | Comparing best practices with direct competitors — for instance a large national truckload carrier benchmarking against another large national truckload carrier |
| | Industry | Comparing best practices within the same industry including non-competitors — for instance comparing a truckload carrier to an LTL carrier |
| | Functional | Comparing the same functional units in companies that may not be direct competitors — for instance comparing the logistics function of Ford and Wal-Mart |
| | Generic | Comparing generic processes between organizations that may be in unrelated industries — for instance comparing the generic vehicle maintenance process between a trucking company and the military |
| Nature of the Object of Study | Process | Used to compare operations and work practices |
| | Product | Used to compare products or services |
| | Strategic | Used to compare organizational structures and management practices with a more general and longer term focus on understanding what makes leading companies great |
| | Future | A type of benchmarking that is forwarding looking and seeks to identify industry breakthroughs that will eventually become industry standards and benchmarks |
| Purpose of Partnership | Competitive | Goal of the comparison is to surpass the best in the industry |
| | Collaborative | Goal of comparison is to foster a learning environment & share knowledge |

**Clean Cargo Working Group: Choice of Performance Metrics**

The Clean Cargo Working Group (CCWG) is a business-to-business initiative of more than 30 shippers, carriers, and logistics providers that was formed to measure and reduce the environmental impacts of global goods transportation. The group's efforts to date have focused primarily on the ocean transport of containerized freight. In developing its metrics, CCWG has tried to balance feasibility (i.e., what data carriers are reasonably able to provide) with materiality (i.e., the data that shippers would like to have). At the same time, CCWG strives to align its metrics and methodologies with leading external standards. For example, CCWG recently revised its metrics for waste, water, and chemicals to align more closely with those of the Clean Shipping Index, an environmental performance measurement system that originated in Sweden and is now widely used throughout Europe.

The CCWG metric for $CO_2$ emissions is grams of $CO_2$ per nominal TEU-km. The use of the term "nominal" in the metric means that the maximum container capacity of the vessel is used (i.e., the vessel is assumed to always be full). To enable this calculation, carriers must provide CCWG with vessel-specific data on fuel consumption by fuel type, distance sailed, and cargo capacity. The carrier must also specify the number of refrigerated containers ("reefers") a vessel can accommodate. This information is important because a container ship uses fuel to provide electricity to the cooling units of refrigerated containers. This information allows CCWG to calculate two $CO_2$ emissions factors for each vessel, one for refrigerated containers and one for "dry" containers.

CCWG also asks carriers to identify the trade lane in which a vessel operates. This allows CCWG to assess the average environmental performance of the set (or "string") of vessels that a carrier devoted to a particular trade lane. Comparisons can then be made among the carriers servicing a given trade lane, and an average can be calculated for all carriers servicing a trade lane. The averages are used to benchmark carrier performance in specific trade lanes. In addition, shippers can use the lane-specific emissions factors to produce a more accurate estimate of the $CO_2$ emissions associated with the ocean transport of their shipments. A carrier receives a score for each trade lane based on how its performance stacks up against the average among carriers working in that lane. A carrier's overall score for $CO_2$ emissions is based on its individual trade lane scores.

## Select Performance Measures

Performance measures are used to gauge the results of implementing practices. In a benchmarking study, metrics and measures identified in reports such as corporate sustainability reports (CSRs) may be used; however, as part of planning for a benchmarking study, performance measures may have to be developed. In fact, the current performance measures used by other organizations may indicate what should be benchmarked. In other words, if a partner organization presents specific metrics that speak of best-in-class performance in a particular environmental area, it may be the processes performed within that function that the sponsor organization chooses to benchmark. However, caution should be taken when using the measures presented by another organization. Without knowing all the variables that were incorporated into their computation and the way in which the partner organization operationalizes a concept, there can easily be confusion over what the numbers mean. For example, a metric such as "number of preventable environmental accidents" may suggest an organization is performing well; however, there may be variability in what is deemed "preventable" and what is meant by "accidents."

Metrics may be in the form of qualitative or quantitative outcomes. Typically, in environmental benchmarking, metrics are quantitative and include absolute, relative, and indexed metrics. Absolute metrics would include total quantities of an organization's output, such as total number of hours of idling or total tons of $CO_2$ emissions. Indexed metrics would measure the percentage of improvement from a baseline (e.g., percent reduction of emissions from 2005 levels).

Relative metrics would include metrics such as emissions per mile, emissions per ton-mile or miles per gallon. An important component to interpreting and applying the metrics used across organizations is to know the standards/scales and measurement systems used by the benchmarking partner (the studied organization) in order to make the proper conversions and application to the sponsor organization.

The following provides an example of how the terms **key performance indicators**, **metrics**, and **measures** would be used in a benchmarking context. A carrier might want to examine a key performance indicator (KPI) such as fuel efficiency. Key performance indicators are usually related to an organization's critical success factors and business goals. For freight carriers, fuel efficiency would be an important KPI. Fuel use is one of the most important operating costs and the most important source of $CO_2$ emissions from operations.

For the fuel efficiency KPI, one could specify a metric that would be the criteria used to determine if something was fuel efficient. For example, the metric could specify that fuel efficiency be measured in terms of miles per gallon. One could also specify a measure that would be the format and period used to report the performance metric. For example, one could measure the average miles per gallon of refrigerated long-haul tractor trailers for the month.

## Identify Data Collection Methods

A comprehensive benchmarking study should include a detailed data collection plan. This plan describes existing data and records the sponsor intends to obtain, original data to be collected, and the timeline, methods, and contacts involved in collecting the data. Sponsor organizations should thoroughly research data that is publicly available on benchmarking partners prior to requesting data from the organizations. By reviewing existing data first, the benchmarking sponsor will have a better sense of what is available, what is still needed, and who the process owners are in the organization. This a priori research helps to reduce the demands on the benchmarking partners and ensures that the sponsors are well prepared and can streamline data collection in terms of time and resource requirements.

Although it is helpful to identify the metrics used by partner organizations in order to make noteworthy comparisons, the focus of the benchmarking study should be on identifying the effective practices that allow an organization to meet specific targets and become an industry leader. Thus, it is recommended that multiple data collection methods and sources be used to collect data. The purpose of this is to ensure information collected is comprehensive and deemed accurate because it is verifiable across various sources. Some of the most common means of data collection used in benchmarking are interviews, surveys, and site visits. The means of data collection should not be based solely on convenience but rather on the purpose of the data collection and type of data desired. For example, if depth of data is critical to answering questions such as identifying detailed decision points and steps involved in process mapping, then one-on-one interviews with process owners would be most beneficial. However, if the goal of the data collection is to engage multiple stakeholders and subject matter experts at the beginning of a benchmarking study and to develop a large list of practices that relate to specific processes, the sponsor might wish to use focus groups. Focus groups can engage multiple persons at once and leverage the interaction among participants to help generate data. For the instances in which the goal of data collection is to measure the frequency of a practice and create a large representative sample, paper or electronic surveys are typically used. Exhibit 9 provides an overview of different types of data collection methods that may be used and the advantages and disadvantages of each, as well as resource considerations. The exhibit also includes sources that specify the means by which the specific data collection method could take place.

**Exhibit 9. Benchmarking data collection methods.**

| Methods | Existing Data Review | Survey | Interview | Focus Group | Site Visit |
|---|---|---|---|---|---|
| **Definition** | Analysis and interpretation of information that exists in house or in public domain | Questions sent to sample from partner organization (multiple choice; open-ended; forced choice; scaled) | A one-on-one meeting with a partner conducted either face to face or via telephone | Multiple participants with similar profiles (job title, rank) who are convened to respond to questions from a facilitator | An on-premise meeting at the partner's facility; combines interview with observation |
| **When to Use** | Before engaging partner organization | Need to gather same info from multiple sources; need representative sample to verify data | To gather data at a detailed level; to probe stakeholders on particular topics of interest | Means for gathering data from multiple sources at once; can be used to reach consensus when there are discrepancies in opinion | If observing practices would be valuable (e.g., production line); may be used to help identify enablers |
| **Advantage** | Being prepared/ focused in data collection | Permits extensive data gathering; analysis performed by computer; easy to gather large sample and amount of data; phone interviews are inexpensive and shorter, easier to complete than interviews | Provides flexibility by allowing for probes/follow-up; allows interviewee to ask questions from a live person; helps to obtain buy-in from key stakeholders | Can encourage creative thinking and brainstorming; interaction of participants may reveal new concepts or ideas; can collect data from multiple partner organizations, which can be mutually beneficial for partners and facilitator | Can observe to verify practices, processes, enablers, and metrics |
| **Disadvantage** | Finding the appropriate information can be time-consuming | Response rates may be low (tough to engage participants); may have confusion about terminology; creative ideas will not be captured; difficult to probe for depth; may be difficult to reach participants via phone for phone surveys; phone surveys are time-consuming because have to call multiple persons | Can be time-consuming; interviewees may be reluctant to dedicate 1.0 to 1.5 hours (the typical length of an interview); may need to redirect interviewee to keep him/her on topic | Can be time-consuming; focus group members may be reluctant to dedicate the time necessary; may need to redirect focus group members to keep them on topic | Requires travel and coordinating schedules (may impact multiple persons at site); typically requires more time than other methods |
| **Example Sources** | Internet; financial reports, sustainability reports; journal (trade, peer-reviewed); news magazine articles | Web-based; paper-pencil; e-mailed; phone | In person; phone-facilitated (use Internet meeting software, e.g., WebEx, LiveMeeting) | At client site or conference facility near client | In person |

**Exhibit 9. (Continued).**

| Methods | Existing Data Review | Survey | Interview | Focus Group | Site Visit |
|---|---|---|---|---|---|
| **Expertise Required** | Research skills; knowledge of sources | Analyst; Web survey expert; item development expertise; survey administrator; phone surveyors need interview skills | Knowledge of Internet meeting software; knowledge of interview protocol development; skill in conducting interviews and encouraging participation; need a note taker and interviewer | Facilitator skills require a unique skill set (different from interview skills) — require ability to manage multiple participants and encourage participation from multiple personality types at once; need a note taker and facilitator | Listening skills; technical expertise of processes observed; ability to ask questions and take notes |
| **Cost/Time Needed** | Low to no cost; time-consuming | Development can be costly | Low cost unless travel required; need to account for interviewer practice time and protocol development time | Can be costly especially if arranging travel for participants to meet centrally; extensive preparation required | Travel expenses; extensive preparation needed to arrange logistics |

Source: Adapted from Damelio (1995)

## 4.2 Analysis

The analysis phase includes the initiation of data collection and an assessment of findings. To adequately analyze how practices and processes from partner organizations may be used to enhance the sponsor organization's behaviors, it is essential to collect data within the benchmarking sponsor organization to know what processes and enablers currently exist, as well as data within the target partner organizations. It is important to understand not only what best practices are being implemented within the partner organization(s), but also where the greatest performance gaps exist between the partner and sponsor organizations and which practices and processes will be most effective in addressing that discrepancy in performance.

The following steps are involved in the analysis phase:

1. Collect data internally and externally;
2. Measure and compare current performance "gap"; and
3. Identify best practices to close the gap.

Each of these steps is described in the following sections.

### Collect Data Internally and Externally

As mentioned, it is important that the data collector of the benchmarking study first be well educated on the needs, practices, processes, metrics, and enablers used within his/her own organization. Detailed knowledge provides context to the study and will help determine the receptivity of the organization to new processes and practices. This information is best gained by speaking with the process owners internally prior to collecting data externally from benchmarking partners.

Once the data collector is well versed in the practices within his/her organization, the data collector should then proceed to research information that is available in the public domain. It is both frustrating to a partner and inefficient to ask questions that could have been easily answered

by publicly available data. For environmental benchmarking studies, sustainability reports and company websites often provide a wealth of information. The text box below describes how UPS reports key measures of its environmental performance in its sustainability report.

Once the data collector is ready to begin collecting data from the partner organizations, he/she should develop structured protocols that outline key questions for discussion. These protocols should outline the questions of interest that will inform the process mapping and help identify the variables that contribute to the translation of processes into outcomes. The protocols should be structured according to purpose (e.g., open ended is typically best for focus groups while multiple/forced choice are often used in surveys). Furthermore, in addition to collecting data from the benchmarking partner organizations, it may be important to collect data from organizations with which the partner organizations work closely. This can help to verify the processes and outcomes identified and gain a perspective on the enablers and other contextual factors that impact their business. One of the key challenges with collecting data from partner organizations is identifying the appropriate participants who will be most knowledgeable about the practices and processes being benchmarked. Ideally, the participants should be the process owners. However, it may be beneficial to initiate data collection by hosting an on-site or phone-facilitated (if geographically dispersed) focus group with senior leadership that serves as an initial data collection of the high-level activities involved in a particular process and to communicate that there is buy-in from the top for the study being conducted. Participants are more willing to provide information if they know the study is being supported by their senior management. These broad focus groups may then be followed by more in-depth interviews, surveys, site visits, or some combination of methods.

**UPS Sustainability Report**

UPS is widely recognized as a leader in the drive to reduce the environmental impacts of freight transportation. The company rigorously measures and manages dozens of factors that affect fuel efficiency, ranging from which vehicles it uses to how it maintains, routes, loads, and drives those vehicles.

In its 2010 Sustainability Report, UPS provided an extensive amount of data on multiple facets of its environmental performance, including water consumption, aircraft emissions, energy consumption, environmental penalties, and reportable spills. Much of this data was reported using metrics that would allow internal or external benchmarking. Such metrics include

- $CO_2$ emissions per 1,000 packages,
- Energy consumption per 1,000 packages,
- Aircraft emissions per available ton-mile,
- Water consumption per 1,000 packages, and
- Penalties as a percent of all environmental inspections.

UPS offers its customers the ability to offset the $CO_2$ emissions generated by the transport of their packages within the United States. Rather than use generic GHG emissions factors to calculate the $CO_2$ emissions associated with its customers' shipping activities, the company developed a methodology for allocating its total $CO_2$ emissions across its network according to freight flows.

To encourage participation, it is also beneficial to offer the partner organization something of value in return for its participation. For example, offering to provide to each participant a summary of benchmarking results across partner organizations is often an effective way to encourage participation. It is important that consent to release information is obtained from all partners and the data collector should be clear about the intent and use of the data collected. Furthermore, prior to sharing any data, clearances for confidential information should be obtained from the partner organization. If there is any question regarding the appropriateness of data or release of information, this should be discussed with legal counsel at the partner organization and the sponsor organization to ensure the sponsor organization does not violate any ethics codes or confidentiality requirements.

## Measure and Compare Performance Gap

Since ideally the data collector should have thoroughly researched practices and metrics internal to the sponsor organization, an understanding of the current performance of the sponsor organization should already exist prior to data collection. After data are collected, the performance of the partner organizations should be clearer. As discussed in the planning

section on metrics, conversion formulas may be required to establish proportional metrics that can easily be used to make comparisons across organizations.

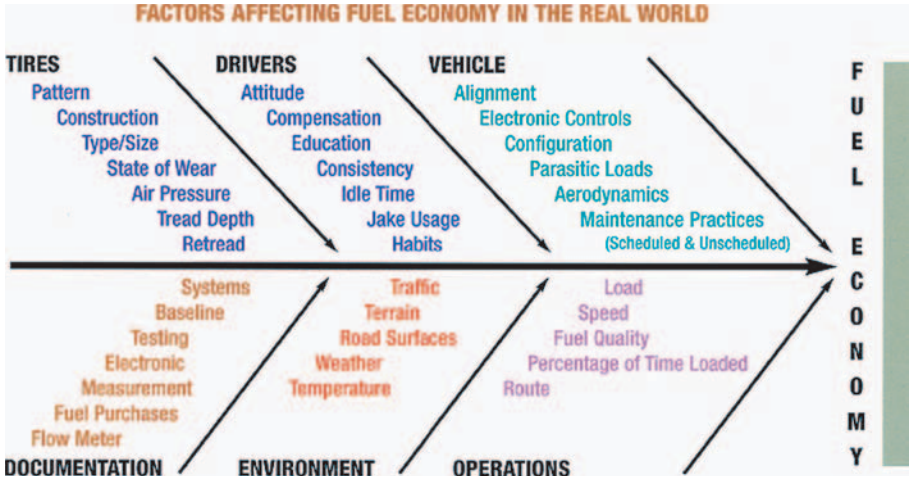
It is important to understand how metrics and measures are defined and to make appropriate adjustments to facilitate comparisons between organizations. For instance, a trucking company benchmarking emissions per mile would need to ensure that the same definition of miles traveled is used (e.g., revenue miles, total miles). The treatment of owner-operators and leased equipment would need to be comparable across organizations to ensure the usefulness of the data developed. In a similar fashion, a railroad benchmarking fuel consumption per ton-mile would need to ensure that standardized definitions for ton-miles are used (e.g., gross-ton miles, trailing ton-miles). A full understanding of how practices and metrics are used by the partner organizations is necessary to appropriately analyze performance data and make comparisons.

Comparative analysis should be used to analyze the performance gaps and indicate where and why gaps exist, as well as the magnitude of the gaps between the partner and sponsor organizations. The analysis conducted to assess the gaps may be a combination of qualitative and quantitative analysis, depending on the type of data collected. The focus of analysis is typically on the differences between practices used in partner and sponsor organizations, especially when external operations by partner organizations are better.

In analyzing performance gaps, it is important to understand the inputs or enablers that may contribute to how the practices and processes are performed. These contextual factors may indicate whether practices can be wholly adopted by the sponsor organization or must be modified with only partial benefits being recognized. For example, if a partner organization has an entire information technology department that is dedicated to the use of specific software but the sponsor organization does not, it may be necessary to spend funds training staff on the basic components of that software or another less costly software application. The software may have reduced capabilities if establishing an entire department is not feasible given resource constraints in the sponsor organization. More discussion on types of enablers is provided in the previous section on planning in which Exhibit 9 provided an illustration of how enablers relate to practices and processes. Exhibit 10 shows a sample map of enabling factors that influence truck fuel economy.

There are three types of performance gaps: negative gap, operations at parity, and positive gap. Negative gaps suggest that practices of partner organizations are more sophisticated and productive than those of the sponsor organization while positive gaps indicate areas where the sponsor

**Exhibit 10. Fishbone chart of fuel economy enablers.**




Source: White Paper on Fuel Economy, Kenworth Truck Company

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organization is advanced in performance of specific practices beyond the partner organizations. Parity, also referred to as a "neutral gap," indicates practices for which there are no notable performance differences between the sponsor and partner organizations. Sponsor organizations make the mistake of solely focusing their efforts and action plans on the negative gaps, but all gaps provide useful information that the sponsor organization should integrate to make effective changes. The distinction between positive, neutral, and negative should be used to prioritize the order with which practice and process improvements are addressed rather than being used to disregard specific processes. For example negative gaps should be categorized as practices and processes that need immediate focus.

Less substantial negative gaps and neutral gaps can be given a "raise-the-bar" status where the focus is on setting higher goals and standards to continue what works well. Some neutral and some positive gaps may need to be on a monitor-and-revisit status because, in some cases, it may be difficult to explain why certain positive gaps exist. If the sponsor organization is unable to articulate what they are doing that is allowing them to perform so well in a given area, then the sponsor organization needs to monitor those areas. The sponsor organization should recognize that the positive gap could quickly change to a negative direction if the organization does not know what factors are allowing for positive performance and is ignorant of how to replicate those factors.

For negative gaps, it is important to understand the contextual factors and enablers that may account, in part, for those gaps. In some cases, there may be a tradeoff between making process improvements to reduce the performance gap and avoiding other losses that could result from those process improvements. For example, a large California utility chose to adopt wind generators to produce energy with the goal of making environmental improvements that were consistent with some of its counterparts. In adopting this new system, the company quickly discovered that the wind generators were potentially harmful to bird populations, thereby, minimizing one environmental hazard at the expense of another. In sum, it is critical that sponsor organizations not only identify where negative performance gaps exist but also weigh the costs and benefits of addressing those gaps.

**SmartWay Transport Partnership**

The EPA SmartWay Transport Partnership provides information on best practices for saving fuel and reducing emissions for truck carriers, rail carriers, and shippers. The partnership publishes information on best practices and certifies the effectiveness of some vehicle technologies. The partnership provides information on a wide range of technological and operational strategies. For example, some of the strategies promoted by the partnership for truck carriers include

- Wide-based tires,
- Weight reduction,
- Low-viscosity lubricants,
- Speed reduction,
- Driver training,
- Idle reduction,
- Automatic tire inflation systems,
- Improved freight logistics,
- Improved aerodynamics,
- Hybrid power trains, and
- Longer combination vehicles.

## Identify Best Practices to Close the Gap

There are a wide range of strategies that can be used to reduce air emissions and other environmental impacts associated with freight transportation. These include new vehicle technologies, improvements in infrastructure, and operational improvements. Vehicle technology strategies can include purchasing new equipment, retrofitting existing equipment, and employing alternative fuels. Operational strategies include reducing equipment idling, shifting freight to less polluting modes, improved training for equipment operators, and improved methods for loading cargo. Infrastructure strategies include electrifying cargo handling equipment and installing equipment to provide shore power. There is no definitive list of best practices that is applicable to all organizations. Each organization must assess which strategies it can employ effectively given the specific markets in which it operates, its business model, and the resources it has available. The effectiveness of a specific

practice may depend on numerous other related organizational attributes and enablers. As such, it is advisable not to generalize that a specific practice is best in all contexts.

### *Project Future Performance Levels*

It is important for sponsor organizations to project future performance levels based on whether the adoption or modification of practices is expected to widen, narrow, or have minimal impact on the performance gap identified. In projecting future performance levels, the sponsor organization must understand how practices will be received internally, the adaptations and resources required to adopt new practices, anticipated changes in market demands, and emerging environmental factors. Making these projections requires estimating the direction and magnitude of performance changes expected within the sponsor organization, as well as changes likely to occur over time in the industry and within partner organizations. To represent the change from the current performance gap to the projected performance gap, it is beneficial to create a "z" chart. A z chart simply shows how performance levels from the sponsor organization relative to the industry will likely change over time. The three components of a z chart include the trends, the benchmark gap as it currently exists, and future trends. Researchers determine the reasons for the gap, both current and projected, by distinguishing between tactical and strategic actions required to close the gap.

## 4.3 Integration

The integration phase of the benchmarking study refers to the activity of establishing operational targets or goals for organizational transformation. It is recommended that sponsor organizations chart a very specific course and set of steps that will be adopted, including the timeline for adoption, as part of determining when and how new practices will be incorporated. The two primary steps to integration are communicating benchmarking findings to gain acceptance and developing action plans.

### Communicate Benchmark Findings to Gain Acceptance

This step is one of the most critical to successful integration of new practices. To gain acceptance and implement change, it is important that all employees understand the rationale for changes, have specific knowledge of how the changes should be implemented, and are given a voice in the process. Thus, acceptance must be obtained from the operational up to the management levels. Support from the top is key to employees adopting new practices. The best way for management to demonstrate to employees that their acceptance of the new strategies is genuine is by providing open and honest answers to employee questions and by demonstrating that management is willing to change its behaviors to welcome the new initiatives. For example, if management expresses to employees that they intend to adopt a blame-free culture when it comes to discussing environmental accidents, then management must demonstrate avoidance of punitive actions when mistakes are reported. Likewise, offering line staff a voice helps them to believe that their contributions to the overall outcome are valuable, thus, those staff are more likely to make the necessary changes to achieve the desired outcome. It is important to keep in mind that the employees are ultimately the people who will implement the new strategies and practices.

It is recommended that sponsor organizations develop a detailed communications plan. This plan should identify the following:

- Audience to whom the message will be sent;
- Content of the message;
- Purpose of the message;
- Medium by which the message will be delivered (e.g., divisionwide meetings, electronic memo);
- Timing of the message; and
- Criteria used to determine receptivity to the message.

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One of the most effective ways to communicate benchmarking findings and encourage acceptance of them is by demonstrating the impact that the practices and processes have had for the partner organizations researched. It is much easier to obtain buy-in to the benchmarking findings if the purpose for conducting the benchmarking study is presented to employees in the planning phase prior to the initiation of the study. This helps to reduce skepticism and prepare employees for upcoming changes by showing employees that changes will be rooted in comprehensive research. Furthermore, sponsor organizations should begin communications by articulating the positive gaps and the factors that have contributed to those gaps. Negative gaps should then be presented within the context of positive performance to show how some of the activities that have resulted in positive performance may be translated into the practices for which immediate improvement is needed. This approach also encourages employees to see how their positive performance is appreciated and can instill a strong sense of ownership for the neutral or negative gaps that exist. Additionally, providing validation through case studies to support the success of specific strategies can help to enhance and convince process owners. Finally, sponsor organizations are encouraged to develop an internal assessment such as an employee survey to determine the degree to which employees are aware of the new strategies and intend to implement new practices. The assessment itself is often a successful communications tool in that it further demonstrates the value of employee initiative to successfully implementing the strategy.

**Con-way Enterprise Sustainability Action Plan**

In 2008, Con-way launched an enterprisewide sustainability initiative with a formal action plan across all business units. The goal of the initiative was to make informed business decisions about sustainability that would have a positive effect on the company, its operations, employees, and customers while reducing the company's carbon footprint. During the first year, the company benchmarked current operations and researched methods and best practices for advancing sustainability. Con-way has established a framework for a sustainability evaluation for every functional process in its shared services organization.

All of Con-way's operating companies—Con-way Freight, Con-way Truckload, and Menlo Worldwide Logistics—are members of the SmartWay Transport Partnership, and both Con-way Freight and Con-way Truckload have won SmartWay Excellence Awards. The company has extensively tested fuel-saving technologies and has implemented many of them, including speed governors, single-wide tires, weight reduction, and idling monitoring. Con-way Freight, the company's less-than-truckload subsidiary, has reduced miles driven and air emissions from its fleet through multiple network redesigns

In 2009, Con-way implemented new recycling and waste reduction practices, launched a major re-lamping project at its freight terminals to save electricity, piloted solar electric generating installations, and instituted use of "green" suppliers.

### *Establish Functional Goals*

Management needs to establish long-term targets and business plans that will support new strategies. These targets should be functional goals that have clear timelines, specific milestones, and measurable results. These goals should be based on new strategies from benchmarking findings, a thorough review of data on employee perspectives concerning the benchmarking findings, and an outline of factors to consider in the implementation of practices. These goals should then be clearly communicated throughout the organization and used in the communication approach discussed.

## Develop Action Plan

The process of developing an action plan begins with the construction of operating principle statements. These operating principle statements are integrated into performance goals. The sponsor organization should then outline specific strategies and tactical decisions that help to implement new practices from benchmarking findings by initiating a series of projects. The performance targets established for those projects should become an essential part of the organization's daily business and corporate goals.

An important component of action plans is the identification of the factors that may serve as facilitators or barriers to successful implementation of the benchmarking practices. The sponsor organization can then leverage this information to determine which factors should be maxi-

mized and which require additional intervention to mitigate them. An action plan should also include the impact the benchmarking practice is anticipated to have, the timeframe for implementing the new practice, the timeframe for a change in output to be recognized, resources needed for implementation, the extent to which the effect of the practice is expected to be positive, and the degree of effort and management control required to implement the practice.

## 4.4 Action

Process team/process owners who actually perform the work should be engaged in the action planning process to help determine the best way to encourage implementation of work processes. Although the action plan establishes the foundation for what steps and resources will be required to implement practices, this phase refers to the process of taking those steps and acquiring necessary resources. This phase includes translating the benchmarking findings into language employees will understand. While it may not be difficult to translate a best practice into the specific steps involved in the practice and the roles and responsibilities of those performing it, it is important to keep in mind the number of different factors (barriers and facilitators) that may impact how well practices are implemented. Sponsor organizations should engage in a comprehensive analysis as part of the action phase. This analysis includes articulating ways that acceptance of practices can be obtained from multiple parties. This phase also includes anticipating the possible objections employees may have toward implementing the new practices and the assistance (e.g., consultant) the sponsor organization will need to implement the practice. Furthermore, the location and timing of implementation should be well articulated so employees at all levels of the organization are "on the same page" regarding when and how to implement the benchmarking practices. To identify potential stumbling blocks to implementation, the sponsor organization should consider pilot-testing practices prior to full implementation.

Another key element of this phase is the frequent measurement of performance and change in outcomes to ensure the practices are being implemented true to their intent. To help track implementation, the sponsor organization should maintain a continuous reporting system that allows progress toward the benchmarking findings to be shared across the organization.

### Implement Specific Actions and Monitor Progress

To monitor progress regarding specific actions, it is important to look at both task and behavioral changes. Although implementing the tasks properly is essential to achieving the desired outcome, it is also important to obtain attitudinal support from employees to ensure that tasks are performed at the level they should be and with the integrity intended.

#### *Recalibrate Benchmarks*

One of the primary reasons that benchmarking should be continuous is that the timeliness of the practices identified may be affected as behaviors, attitudes, and marketplace demand shifts. It is important that sponsor organizations do not continue to target outdated benchmarking findings. If the sponsor organization maintains an ongoing benchmarking approach, practices that have lost their value can easily be spotted and benchmarks can be recalibrated if needed. By recalibrating benchmarks when needed, the sponsor organization stays on the leading edge of changes in the industry and the organization can be in "ready mode" to quickly anticipate and adapt to necessary changes.

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## 4.5 Maturity

This phase in the benchmarking process refers to the point at which benchmarking becomes institutionalized within the sponsor organization and is viewed as a critical component of the management process. Maturity also refers to the phase in which change is beginning to be realized and desired outcomes begin to manifest themselves. The two key steps to maturity include closing the performance gap and integrating practices into processes.

### Close Performance Gap

By applying best practices, negative performance gaps are eliminated. A litmus test for whether effective strides have been made in achieving desired outcomes (e.g., reducing environmental impacts, instituting efficient practices) is if the sponsor organization is being recognized through requests for participation in other benchmarking studies or through the receipt of industry awards. The sponsor organization can communicate its success by creating a system for sharing knowledge gained with others in the industry. Vocalizing success allows the sponsor organization to acknowledge the leadership position the organization has obtained in the industry and encourages employees to continue to improve performance.

### Practices Fully Integrated into Process

In order for the sponsor organization to become a leader in the industry, best practices identified via benchmarking must be fully incorporated into business processes and desired results realized. Once practices have been successfully implemented, the organization may seek to conduct benchmarking and make comparative assessment of other operational areas within the company. As part of institutionalizing benchmarking, those that use the results can become educated on the process for conducting benchmarking and thus, use those steps to continuously assess processes internally and make practice improvements. Thus, maturity is achieved when benchmarking is conducted at all levels within the organization and not solely by trained facilitators. Ultimately, by fully integrating practices into processes, the organization demonstrates the value of benchmarking to its employees and benchmarking becomes a part of essential business conduct. The case study that follows illustrates how the Canadian National Railway Company (CN) has applied the benchmarking concept to reduce GHG emissions.

#### CN's GHG Benchmarking Program

The Canadian National Railway Company (CN) is Canada's largest railway and has extensive trackage in the central United States. CN has implemented a program to benchmark their carbon emissions. CN participates in the Carbon Disclosure Project (CDP) and uses this program to support their benchmarking program. The following is a brief description of each step of the benchmarking process and how they implemented it at CN. The major phases of a benchmarking process include planning, analysis, integration, and maturity. Each of these steps, and their subcomponents, are described in detail.

**Planning**

In the planning phase, corporations select the function to benchmark, establish performance measures, and develop data collection methods.

***Identify function to benchmark*—**As a participant in the CDP, CN has selected GHG emissions as one of its environmental benchmarks. In the CDP methodology, GHG reporting is measured in Scope 1, Scope 2, and Scope 3 tiers, which are defined to include direct (Scope 1) and indirect (Scope 2, Scope 3) emission sources. Scope 1 includes GHGs directly emitted from the corporation's goods movement activities. For CN, the primary source is locomotive emissions through fuel consumption. Also included are GHG emissions from non-locomotive transportation sources, including the CN intermodal trucking fleet and marine shipping fleet. Scope 2 includes indirect emissions associated with corporation activities. CN chose to include electricity consumption in this tier, as reported by utility invoices. This represents emissions from power plant fuel consumption to provide electricity for powering CN's buildings, supply yards, and other facilities. As of 2011, CN extended its quantitative measurements to include Scope 3 emissions, which include emissions from business travel including air, rail, and road travel.

***Identify best-in-class organizations*—**The CDP allows companies to compare themselves against their peers. CN can compare itself against other Class I railroads and others in the transportation industry in general. The CDP reporting protocol allows a company to identify the top performer in its industry and see the magnitude of emissions from that performer. In addition, the public report allows any registered member to access the top performer's submitted survey, which includes emission sources, goals, and strategies to achieve those goals. With this information, CN can set realistic benchmarks according to the achievements of its peers. Within CN's peer group of seven North American Class I railroads, four of the companies report GHG emissions to the CDP.

***Select performance measures*—**CN has defined two performance measures for reducing GHG emissions and set reduction targets for these measures. Both measures relate directly to Scope 1 emissions through goods movement, the first specifically targeting locomotives and the second encompassing all goods movement modes.

**Target 1:** Carbon intensity of locomotive activities, which account for more than 85 percent of total GHG emissions. This intensity is measured in kg of $CO_2$-e per gross ton-mile (GTM) of rail movement. Between 2008 and 2011, this performance measure has dropped from 12.8 to 11.9 kg $CO_2$-e per GTM.

**Target 2:** Fuel consumption from all goods movement modes. This performance measure is more expansive than the first and includes locomotives, the intermodal trucking fleet, and the marine vessel fleet. Fuel consumption is normalized to cargo volumes and is measured in GTM per gallon of fuel consumed.

***Identify data collection methods*—**The Scope 1 and Scope 2 emissions are directly related to the amount of fuel or electricity purchased and consumed by CN's operations. Because the company uses an enterprisewide business management package to track expenses, Scope 1 and 2 emissions are calculated with a high degree of precision. CN estimates that Scope 1 and Scope 2 emissions are accurate to within a 1 percent precision. Scope 3 emissions are related to activities outside the direct financial control of the organization. For the 2011 submission, CN includes employee business travel as contributors

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to Scope 3. These data were compiled directly by the transportation service providers.

Fuel consumption data is determined from two data sources: invoice statements, which show the amount of fuel purchased, and storage tank measurements, which show the amount of fuel on reserve in individual project sites. In combination, these measurements allow the company to determine the amount of fuel consumed (not just purchased) within a year. In order to develop ton-mile metrics, CN collects mileage and traffic data to determine the total gross ton-miles of shipments. Although these measurements are not needed to report total GHG emissions to the CDP, they are needed to evaluate progress against the company's selected performance measures. Data for Scope 2 emissions are measured from electric utility invoices, provided through the same enterprise management system as the Scope 1 data. The invoices provide data on electricity purchases, which are converted to megawatt-hours (MWh) of consumption using utility rate price rates.

**Analysis**

In the analysis phase of the benchmarking process, CN calculates the total annual GHG emissions, measures progress against internal performance measure goals, and identifies strategies in order to achieve the emission targets.

**Collect data internally and externally—**Because the majority of CN data collection methods rely exclusively on internal, quantitative data sources, the process of collecting and aggregating fuel consumption information is straightforward. However, the Scope 3 data, included as of the 2011 report, relies on external sources for collection. For locomotives, on a monthly basis, the corporation compiles the available fuel purchasing data and reconciles this data with purchase invoices and storage tank inventory measurements. Traffic data is compiled on an ongoing basis. For non-locomotive sources, CN assembles data in several ways. Shipping fleet data is compiled on an annual basis and reconciled with purchase records from CN's shipping department and supply management department. Trucking data on fuel consumption is compiled on a monthly basis primarily from operators' fuel charge cards. Mileage data is self-reported by operators using a mobile electronic system based on Blackberry cell phones. This data is audited on an annual basis. Compared to data on locomotive fuel, consumption from these sources is not as accurate. For the CDP reporting, the fuel consumption data from the prior step are combined with certified emission factors from the Intergovernmental Panel on Climate Change (IPCC) to determine the overall Scope 1 GHG emissions. Electricity consumption measurements are paired with provincial or state emission factors to determine Scope 2 emissions.

**Measure and Compare Performance—**These results are used to track progress against internal goals. CN compares the fuel consumption and emission intensity results internally against goals set for the two performance metrics defined above. Emission results are also shared externally through the CDP for comparison against other peer companies in the rail industry. To aid in comparisons, the CDP calculates two scoring metrics for each submission: the Carbon Disclosure Rating scores the extent and detail of information provided in a company's CDP response; the Carbon Performance Rating scores a company on the activities, actions, and strategies used to mitigate or adapt to climate change

(it is not intended as a comprehensive metric of a company's GHG footprint and is based solely on responses in the CDP questionnaire).

In order to compare the company's environmental performance against its peers, CN can reference the Carbon Disclosure Rating and Carbon Performance Rating of other companies in its industry. However, these scores are not necessarily related to CN's performance metrics of carbon intensity and fuel efficiency. To access more meaningful comparison metrics, CN can download the original reporting submissions from each company, which includes the same quantitative data as supplied by CN for CDP certification. Using these submissions, CN can compare its quantitative efficiency performance against that of its peers.

**Identify best practices to close gap—**CN has sought to reduce GHG emissions from company operations by purchasing energy-efficient equipment, making logistical improvements, and implementing employee training. They have also sought to increase energy efficiency from buildings and equipment and initiated an energy efficiency plan that has sought to optimize data centers, consolidate computer servers, and initiate an employee telecommuting program. In industrial settings, CN has identified several strategies, including more efficient air compressors, yard lighting, and HVAC systems. One unique strategy that applies to rail operations in a northern climate is the development of efficient "switch heaters" that keep track switches (locations where trains can move from one track to another) operational in the winter.

**Integration**

In the integration phase of benchmarking, a company applies the goals and strategies previously identified in order to obtain buy-in throughout the organization. The two primary steps to integration are communicating benchmarking findings to gain acceptance and developing action plans.

**Action**

In the action phase of the benchmarking process, the strategies and action plans are implemented throughout the organization in order to achieve emission reduction goals. Action plans require that the teams responsible for meeting the performance metric benchmarks work directly with the teams responsible for implementing specific reduction strategies.

**Maturity**

When entering the maturity phase, a benchmarking program has been institutionalized within the sponsor organization and is viewed as a critical component to the management process. Since launching the CDP process, CN has achieved several internal goals and benchmark milestones. The company has made progress toward its performance measures, exceeding targets in some areas. The CDP process has allowed CN to integrate environmental stewardship throughout the company. The CDP surveys were originally completed by staff in the Investor Relations Department, because investors were the stakeholder group initially pushing for action. In recent years, the CDP process has been integrated into a new Sustainability Department, which implements and coordinates environmental initiatives throughout the company.

CHAPTER 5

# Benchmarking Framework for Addressing Air Quality Impacts of Freight Transportation

## 5.1 Benchmarking Framework Overview

The freight transportation system is composed of a diverse network of actors. For the purposes of this handbook, it is necessary to group them in such a way that the types of environmental impacts are similar and the metrics and methods described are broadly applicable. This section of the handbook presents metrics for each of the following groups of actors in the freight transportation system

- Carriers
  - Truck
  - Rail
  - Air
  - Marine
- Freight transfer points
  - Marine ports
  - Airports
- Shippers and receivers

This framework divides those who pay for freight movement (shippers) from those who are engaged in moving the freight (carriers). Carriers are further divided by mode. Shippers with private fleets fall under both the carrier and shipper categories. Many metrics for shippers are also applicable to third-party logistics providers (3PLs), because non-asset-based 3PLs are primarily involved in arranging for the purchase of freight transportation services. In the case of asset-based 3PLs (i.e., 3PLs with their own truck fleets), many of the truck carrier metrics will be applicable.

Some large freight transfer facilities that are independently operated (e.g., marine ports, airports) are broken out as separate framework components because of their typically large scale and the importance of their environmental impacts. Other freight facilities are addressed under the organization type that owns them. For instance, intermodal rail terminals are covered under the rail carrier section.

The different types of organizations in the freight sector are mapped into the most applicable framework component. Because of the complexity and variety of different business relationships, this fit is not always perfect. Nonetheless, this framework encompasses, and is applicable to, most organizations involved with freight transportation.

This benchmarking framework is focused on specific types of organizations and the processes that these organizations control. The level of control an organization exercises and the amount of information that is available to it affect the types of functional units and metrics that can be used to benchmark environmental performance. Those that pay for others to move freight

**Exhibit 11. Framework organization.**

| Framework Components | Fleets | Facilities | Organization |
|---|---|---|---|
| **Truck Carriers** | • Combination trucks<br>• Single-unit trucks | • Hubs/distribution centers for LTL and express carriers<br>• Truck terminals | • For-hire carriers (truckload, less-than-truckload, specialized, parcel, drayage, etc.)<br>• Shippers with private fleets<br>• Asset-based third-party logistics providers<br>• Carriers offering dedicated service |
| **Rail Carriers** | • Line-haul locomotives<br>• Switching locomotives | • Intermodal distribution centers<br>• Rail yards/transload parks | • Carriers (Classes I, II, and III, switching railroads) |
| **Marine Carriers** | • Oceangoing vessels (dry bulk, tanker, container, break bulk)<br>• Inland waterway vessels | • *(See Marine Ports)* | • Carriers (oceangoing, inland waterway, short sea) |
| **Air Carriers** | • All-cargo aircraft<br>• Passenger/cargo aircraft<br>• Ground-service equipment | • *(See Airports)* | • Carriers (all-cargo, express, passenger/cargo) |
| **Marine Ports** | • Freight vessels<br>• Tugboats & other harbor craft<br>• Cargo-handling equipment | • Seaports<br>• Inland waterway ports<br>• Freight terminals | • Public port authorities<br>• Freight terminal operators |
| **Airports** | • All-cargo aircraft<br>• Passenger/cargo aircraft<br>• Ground-service equipment | • Passenger/cargo airports<br>• All-cargo airports<br>• Airport freight terminals | • Airport authorities<br>• Freight terminal operators |
| **Shippers & Receivers** | • Forklifts & other freight handling equipment | • Loading/unloading facilities<br>• Warehouses<br>• Distribution centers | • Shippers<br>• Receivers<br>• Non-asset-based third-party logistics providers |

often have less control over specific environmental impacts than the carriers who purchase and operate vehicles and equipment. Because there are many different types of organizations, each framework component includes many different types of metrics.

Because every organization is different, the benchmarking process and the metrics described for each framework component should be considered as a starting point for a benchmarking effort. This framework would need further customization for application to specific organizations, freight industry segments, and freight service markets. Exhibit 11 shows the framework components and where different fleet types, facility types, and organization types fall within this framework.

## Benchmarking Levels

For each group of actors identified in Exhibit 11, Chapter 6 presents metrics to be used in benchmarking at four different levels: fleet, facility, organization, and corridor. These four levels are described below.

### *Fleet Level*

At the fleet level, a benchmarking study would compare the environmental performance of fleets of vehicles, vessels, or aircraft within the same mode. For example, a performance measure might be the amount of $CO_2$ emissions per ton-mile transported. From such a study, a carrier

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could learn how its choice of equipment (e.g., age, aerodynamic features, type of tires, use of alternative fuels), logistics patterns (which could affect empty miles), and operator behavior (e.g., engine idling habits) affect its comparative environmental performance.

As discussed in greater detail below, it may be advisable to focus a fleet-level environmental benchmarking study on fleets of vehicles, vessels, or aircraft that perform similar types of operations (e.g., long-haul truckload service vs. pick up and delivery).

### *Facility Level*

At the facility level, a benchmarking study would compare the environmental performance of ports, airports, rail yards, warehouses, or other freight-related facilities. For example, in the case of marine ports, the comparison could consider $CO_2$ emissions per ton of through cargo (both inbound and outbound). Factors influencing the environmental performance of marine ports would include the availability of on-dock rail, efficiency of terminal operations, availability of cold-ironing, and type and age of cargo-handling equipment.

The mix of freight handled by a particular facility (e.g., bulk vs. container, refrigerated vs. non-refrigerated) will affect its environmental performance. This issue can be handled through the selection of performance metrics or the choice of facilities to be included in the benchmarking study.

### *Organization Level*

At the organization level, a carrier, shipper, or receiver could benchmark the environmental performance of its total operations against the performance of other organizations. At this level of benchmarking, the environmental performance of an organization's fleets and facilities would be aggregated. For example, a performance metric for this level of benchmarking could be $CO_2$ emissions per package (a metric used by UPS). Benchmarking at this level would take into account factors such as the number and location of an organization's facilities and its usage of different transport modes.

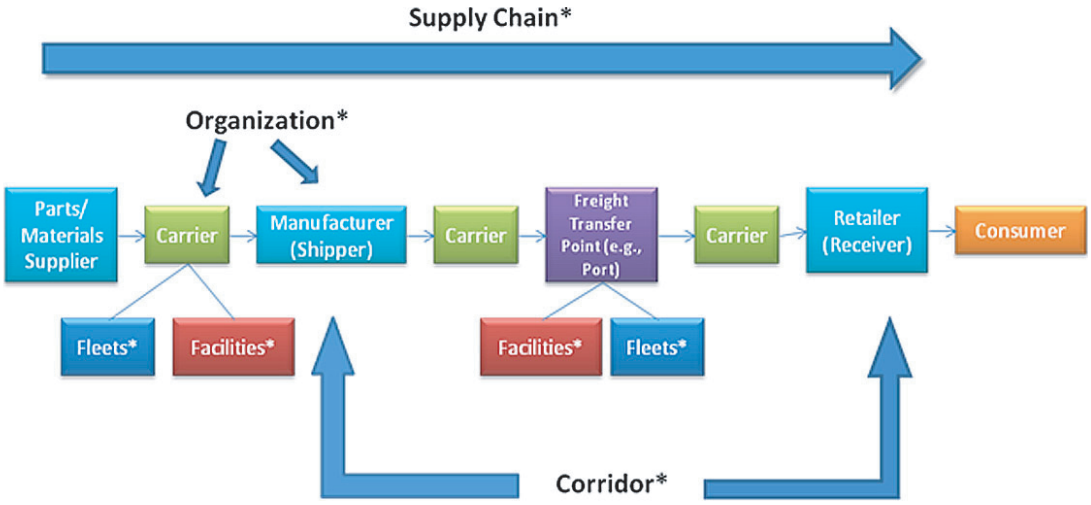
As with the other benchmarking levels, differences among organizations must be considered and can be accounted for, at least in part, by the choice of performance metrics and the selection of peers to be included in the analysis.

### *Corridor Level*

This framework labels as "corridor-level" those benchmarking efforts that have a geographic focus or that extend across organizations and modes. For example, one could benchmark carriers (or combinations of carriers) that offer service on a particular trade lane or origin-destination pair. For example, the Clean Cargo Working Group, a coalition of shippers and ocean carriers, is calculating average $CO_2$ emissions per 20-foot equivalent unit (TEU)-km for each trade lane being served by containership operators. For the truck and rail modes, route length, mode availability, terrain grade, and availability of backhaul traffic could all affect the environmental performance of a corridor.

Alternatively, a corridor-level analysis could also assist in the configuration of a supply chain. If an organization is evaluating locations for a new manufacturing facility, it would be beneficial to understand how that choice would affect the environmental performance of the new logistics and transportation patterns that would arise from the facility in question. For example, if rail connectivity is very different in two corridors, that fact would likely be a strong determinant of the comparative environmental performance of those corridors. Exhibit 12 shows how the different benchmarking levels used by the framework (facility, fleet, organization, corridor) are related to each other and the supply chain.

**Exhibit 12. Framework overview.**




** Denotes benchmarking level*

## Defining the Scope of the Environmental Impacts Considered

To benchmark environmental performance, it is necessary to establish the scope (or boundary) within which environmental impacts will be considered. For each organization type (truck carrier, rail carrier, shipper, etc.) and benchmarking level (fleet, facility, company, corridor), this framework considers impacts that are under the control of the organization studied. To explain this concept further, it is useful to consider how widely accepted protocols for reporting GHG emissions address this issue.

The World Resources Institute and the World Business Council for Sustainable Development (WRI/WBCSD) provide widely accepted protocols for preparing GHG emission inventories for corporations and other like entities in *Greenhouse Gas Protocol: Corporate Accounting and Reporting Standard (WRI/WBCSD Revised Edition)*. These protocols classify GHG emission sources into three scopes, as follows:

- Scope 1—Direct GHG emissions,
- Scope 2—Indirect GHG emissions from purchased electricity and steam, and
- Scope 3—All other indirect GHG emissions.

Scope 1, direct emissions, are generally those emissions that result from activities or sources over which the organization has direct ownership or operational control, such as on-site combustion of fossil fuels in company-owned vehicles and facilities. Scope 2, or indirect emissions, are emissions that are a consequence of activities of the company, but which occur at sources owned or controlled by another company. This would typically include purchased electricity.

Scope 3 emissions are usually not included in individual emissions inventories. Scope 3 emission sources include transportation of purchased and sold goods, business and commuter travel of employees, and life-cycle emissions (e.g., emissions associated with the production and disposal of materials used). Some of the Scope 3 activities listed may appear under Scope 1 if the pertinent emissions source is owned or controlled by the company.

In general, this handbook discusses metrics that are relevant to the freight transportation entities that control the emissions source. Emissions metrics may vary depending on the

level of control exercised. For instance, a truck carrier or private fleet has more control over transportation operations than a shipper who hires a truck carrier to move goods. The functional units, metrics, and available data are also different for different types of freight-sector entities and the specific contractual and organizational methods they use to manage freight transportation. For example, a shipper with a private fleet may be able to easily obtain data on the percent of empty miles travelled by its own fleet. A shipper that hires a carrier to move its product may not have access to this information if the carrier considers the information proprietary.

## 5.2 Types of Indicators and Metrics

ISO 14031, the ISO guidance for environmental performance evaluation, describes three basic types of indicators that can be used to support environmental management. This ISO standard distinguishes between indicators of environmental conditions and indicators of environmental performance. It then subdivides the latter category into management performance indicators and operational performance indicators as follows:

- **Environmental condition indicators** provide information about the local, regional, national, or global condition of the environment.
- **Management performance indicators** provide information on the activities of an organization's management that may affect the environmental impacts of its operations (e.g., audits, training, policies, and procedures).
- **Operational performance indicators** provide information on the environmental performance of an organization's physical operations; these are often related to inputs (e.g., materials, energy), physical processes, and outputs (e.g., shipments, emissions, waste).

The sample benchmarking metrics offered in this handbook are primarily operational performance indicators (e.g., pounds of emissions per ton-mile). However, for environmental benchmarking at an organizationwide level, there are examples of both management and operational performance indicators. Although environmental condition indicators may be valuable in some contexts, they are typically not very helpful in a benchmarking context, because environmental conditions are virtually always subject to many influences beyond those of a single vehicle, fleet, or organization.

ISO 14031 also provides the following typology for quantitative performance indicators:

- **Absolute indicators—**data representing total quantities of inputs or outputs (e.g., tons of $CO_2$ emissions from truck operations).
- **Relative or normalized indicators—**those that relate inputs or outputs to some measure of business service provision (e.g., gallons of fuel consumed per revenue ton-mile).
- **Indexed indicators—**these link the data to a chosen standard or baseline (e.g., percent change in annual $CO_2$ emissions compared to emissions from a base year).
- **Aggregated indicators—**those that combine data of the same type from different sources (e.g., $CO_2$ emissions from all transport activities).
- **Weighted indicators—**those that sum different output indicators through the use of conversion factors (e.g., Wal-Mart's proposed Product Sustainability Index).

Of these types of quantitative performance indicators, relative or normalized indicators are the most valuable for the purposes of benchmarking, because they allow comparisons among fleets, facilities, organizations, or corridors. Therefore, most of the sample performance metrics presented in this document are normalized in some way.

Some of the sample metrics presented in this handbook measure the extent to which a particular environmental technology or practice has been adopted. At first glance, these metrics do not appear to lend themselves to a benchmarking exercise; after all, benchmarking is premised on measuring performance first and then uncovering the practices that contribute to superior performance. However, this type of metric is included because in some cases it may be too difficult or too expensive to quantitatively measure the environmental performance of freight movement. In those cases, assessing whether a carrier or shipper is using specific energy efficiency or environmental management practices is a "second-best" means of judging environmental performance. The next chapters present overviews of each mode, major facility (ports, airports), and shippers/receivers and provide some of the metrics that can be used at different scales of benchmarking analysis.

CHAPTER 6

# Environmental Benchmarking Approaches and Metrics by Sector

This handbook presents metrics and benchmarking approaches in separate sections for truck carriers, rail carriers, air carriers, marine carriers, marine ports, airports, and shippers and receivers. Each of these is described in the following sections. For each section, key issues, benchmarking metrics, and programs and tools for environmental benchmarking are discussed.

## 6.1 Truck Carriers

### Key Issues

The various types of vehicles, routes, and operations make benchmarking the environmental performance of truck carriers challenging since the differences make it difficult to compare "apples to apples." Specific challenges are discussed below.

**Vehicle classes.** There are six different classes of freight trucks, categorized by vehicle weight (Class 3 to Class 8B), as shown in Exhibit 13. The Class 8B 5-axle combination truck is most commonly used in long-haul freight movement.

The weight of these vehicles alone influences fuel economy, which determines, in part, vehicle emissions rates. Fleet-level environmental performance benchmarks would thus typically account for truck classes.

**Vehicle and cargo type.** It is important to recognize differences within vehicle classes. For example, a reefer will produce more emissions than a comparable vehicle in its class because it uses additional fuel to regulate the temperature of the refrigeration unit. Exhibit 14 shows the fleet segments used to benchmark performance in the SmartWay Transport Partnership. The partnership provides data to benchmark different carrier segments. Vehicle types include dry vans/chassis, reefer, flatbed, tanker, specialized, and mixed. Each of these types has different aerodynamic profiles and typical cargo characteristics and differs in many other ways that affect their average fuel economy and emissions profile.

Additionally, the payload of the vehicle will affect the emissions rate. Vehicles used to haul heavy freight will emit more than those that typically haul lighter loads. The model year of the engine used has a large impact on the emissions profile of the vehicle.

**Vehicle routes.** Vehicle routes will greatly affect the level of emissions produced. For example, routes with steep terrain or routes within climates with extreme temperatures will produce greater emission levels than routes on flat terrain and routes in regions with moderate temperatures. Additionally, a long-haul truck traveling on uncongested highways will produce fewer

**Exhibit 13. Vehicle classes.**

| Class | Weight (lbs) | Vehicle Type |
|---|---|---|
| Class 3 | 10,001 to 14,000 | Walk-in, conventional van, city delivery |
| Class 4 | 14,001 to 16,000 | Conventional van, city delivery, large walk-in |
| Class 5 | 16,001 to 19,500 | City delivery, large walk-in |
| Class 6 | 19,501 to 26,000 | Beverage, single-axle van, rack |
| Class 7 | 26,001 to 33,000 | Refuse, furniture, medium conventional |
| Class 8A | 33,001 to 60,000 | Dump, refuse, concrete, other straight trucks |
| Class 8B | 60,001 & over | 5+ axle combination trucks |

**Exhibit 14. SmartWay Carrier Segmentation**

**Truck carriers**
- **Truckload dry van**
- **Less-than-truckload dry van**
- **Package delivery**
- **Moving**
- **Expedited**
- **Drayage**
- **Tanker**
- **Flatbed**
- **Refrigerated**
- **Auto carrier**
- **Heavy/bulk**
- **Specialized**
- **Mixed (no predominant operation or equipment type)**

**Logistics companies**

**Multimodal carriers (truck and rail intermodal operations)**

emissions per mile than a similar truck that operates in stop-and-go traffic to deliver freight in an urban area.

**Truck service type.** Trucks perform different types of services—TL, LTL, parcel delivery, drayage, etc. The very nature of service will affect the emissions rate of the vehicle so it may be desirable to segment the services for benchmarking. The same truck operating in a TL highway environment would tend to emit less per mile than the same LTL vehicle making multiple pick-ups and deliveries. Additionally, comparing idle time across all types of services can be difficult, since an LTL and parcel delivery service is likely to accrue more workday idling, while a TL service will average more overnight idling.[9] Empty miles/travel time performance across different truck services would also be expected to differ. LTL services tend to have fewer empty miles because the density of their business operations allows them to design more efficient pick-up and delivery routes. Private fleets can also be segmented by operation type, including long haul, interplant, direct store delivery, or other types.

[9]*Workday idling* refers to idling at pick-up and delivery stops. *Long duration idling* refers to idling a vehicle overnight or for a long period of time to operate air conditioning or heating.

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**Exhibit 15. Truck carrier metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| Total Miles | Average emissions ($CO_2$, NOx, PM) per mile | ✓ | ✓ | | ✓ |
| | Average MPG | ✓ | ✓ | | ✓ |
| | % empty miles | ✓ | ✓ | | ✓ |
| | Average customer density per route | ✓ | ✓ | | ✓ |
| Revenue Miles | Average emissions per revenue mile | ✓ | ✓ | | ✓ |
| Ton-Miles | Average emissions per ton-mile | ✓ | ✓ | | ✓ |
| | Average gallons of fuel consumed per ton-mile | ✓ | ✓ | | ✓ |
| Revenue | Average emissions per unit of transportation revenue | ✓ | ✓ | | |
| Volume of Goods Moved | Emissions per cubic foot-miles | ✓ | ✓ | | ✓ |
| Truck/Trailer Improvements | % trucks with transmission and drivetrain improvements | ✓ | ✓ | | |
| | % trucks with engine improvements | ✓ | ✓ | | |
| | % trucks with aerodynamic improvements | ✓ | ✓ | | |
| | % trucks with rolling resistance improvements | ✓ | ✓ | | |
| Engine Operating Hours | Idling hours as a % of total engine-on hours | ✓ | ✓ | | ✓ |
| Truck Terminal | Total annual emissions from truck terminal per average number of trucks serviced at the terminal | | | ✓ | |
| | LEED certification score | | | ✓ | |
| | % of facilities LEED certified | ✓ | | ✓ | |
| Year of Company Operation | SmartWay Rank | ✓ | ✓ | | |
| | DOW Jones Sustainability Index | ✓ | | | |

## Metrics

Exhibit 15 shows environmental performance metrics for truck carriers and identifies the level of analysis at which each could be used.

## Programs and Tools

**The EPA SmartWay Truck Carrier Model** collects data on fuel use for a company's individual operating unit level, which allows each operational unit to be compared against similar units (e.g., flatbed to flatbed, auto carrier to auto carrier, LTL to LTL, tanker to tanker, etc.).

See http://www.epa.gov/smartway/partnership/trucks.htm for further information.

**EPA SmartWay DrayFLEET Model** assesses truck emissions and various technical and management options for reducing emissions and fuel consumption from truck drayage activity. These might include virtual container yards, chassis pools, or on-dock rail. The user can also assess technological options targeted to drayage trucks (such as diesel particulate filters or oxidation catalysts, idle control technologies, etc.).

See http://www.epa.gov/smartway/documents/partnership/trucks/drayage/smartway-dray-fleet-v1-0f-users-guide.pdf for further information.

**The Truckload Carriers Association,** with the assistance of the company Decisiv Best Practices, conducts a benchmarking program that enables truckload carriers to compare operating

benchmarks and identify best practices that contribute to superior performance. Participating carriers are segmented into groups of 12 to 20 companies according to carrier specialties (e.g., refrigerated, dry van, flatbed). Every month, participating carriers submit their financial statements to Decisiv, which in turn produces a financial composite that ranks the carriers according to key factors. Decisiv sends each member a copy of its group's composite that contains the comparative statistics compiled from their statements. The groups meet three times per year for a period of 1 to 2 days each to share their best practices and processes that aid them in reducing costs and improving efficiencies.

See http://www.truckload.org/About-The-Program for further information.

**The Diesel Emissions Quantifier (Quantifier)** is an interactive tool to help state/local governments, fleet owners/operators, school districts, municipalities, contractors, port authorities, and others estimate emission reductions and cost effectiveness for clean diesel projects. Estimates are made using specific information about a fleet. For those applying to EPA or some other federal or state/local funding assistance program, this site will help with preparing and submitting diesel emissions data. EPA has built the Quantifier based on existing EPA tools and guidance and it can be used by potential grantees, state and local governments, metropolitan planning organizations, and fleet owners and operators, among others. The Quantifier uses emission factors and other information from EPA's MOVES 2010 Model and the NONROAD 2008 Model.

See http://www.epa.gov/cleandiesel/quantifier/index.htm for further information.

## 6.2 Rail Carriers

### Key Issues

Benchmarking the performance of rail carriers requires consideration of various different factors, including differences between classes of railroads, equipment, facilities, cargos, geography, and rail lines.

**Variation in class.** Freight railroads may be divided into three classes based on operating revenue, which is influenced by the size and function of the railroad. The size of a rail carrier may determine the scale of resources that may be available to invest in equipment, operational improvements, and infrastructure to improve environmental performance. In addition, some operational and equipment strategies that are appropriate for a large Class I carrier may be unavailable to smaller regional or short-line carriers.

**Variation in equipment.** Different types of equipment are used in railroad locomotive and car fleets and this equipment produces varying levels of pollution.

- **Switch locomotives,** typically 2,000 hp or less, are the least powerful locomotives and are used in freight yards to assemble and disassemble trains or for short hauls of small trains. Some larger road switchers can be rated as high as 2,300 hp.
- **Freight line-haul** locomotives are the most powerful locomotives and are used to power freight train operations over long distances. Older line-haul locomotives are typically powered by engines of approximately 2,000–3,000 hp, while newer line-haul locomotives are powered by engines of approximately 3,500–5,000 hp.[10]

[10]EPA, *Locomotive Emission Standards,* Regulatory Support Document, April 1998.

**Exhibit 16. Emission standards for locomotive engines (g/hp-hr).**

| | | Line Haul Engines | | Switching Engines | |
|---|---|---|---|---|---|
| **Emission Standard** | **Applicable Year** | **NOx** | **PM** | **NOx** | **PM** |
| **Uncontrolled Emissions** | | 13.0 | 0.32 | 17.4 | 0.44 |
| **Tier 0 rebuild** | 2001 | 9.5 | 0.60 | 14.0 | 0.72 |
| **Tier 0 rebuild*** | 2008 / 2010 | 8.0 | 0.22 | 11.8 | 0.26 |
| **Tier 1** | 2002 – 2004 | 7.4 | 0.45 | 11.0 | 0.54 |
| **Tier 1 rebuild*** | 2008 / 2010 | 7.4 | 0.22 | 11.0 | 0.26 |
| **Tier 2** | 2005 | 5.5 | 0.20 | 8.1 | 0.24 |
| **Tier 2 rebuild*** | 2008 / 2013 | 5.5 | 0.10 | 8.1 | 0.13 |
| **Tier 3** | 2011 – 2012 | 5.5 | 0.10 | 5.0 | 0.10 |
| **Tier 4** | 2015 | 1.3 | 0.03 | 1.3 | 0.03 |

Note:
*These are retrofit standards at the time of rebuild and phased in as retrofit kit availability allows.
Source: *Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder.* EPA420-R-08-001. March 2008.

Exhibit 16 shows U.S. EPA emissions standards for line-haul and switch locomotives.

Because EPA has phased in emissions standards over time, the age of the equipment has a large impact on the air emissions generated.

### CN's GHG Benchmarking Program

CN has participated in the climate-change reporting program of the Carbon Disclosure Project (CDP) for the past 5 years; CDP recently recognized CN for excellence in climate-change reporting among Canadian companies. In addition, CN has worked with the provinces of Alberta and British Columbia to enable companies to generate carbon offsets by shifting freight from truck to rail.

CN has also conducted several corridor-based analyses of the energy and environmental impacts of shipping freight via alternative rail routes. These studies have modeled the fuel economy and fuel consumption of double-stack intermodal trains using four different but complementary metrics. Each route was analyzed both for locomotive efficiency, which measures the fuel economy of a train from origin to destination, and corridor efficiency, a broader metric that captures efficiency of the overall freight movement including drayage trips, intermodal equipment operation, and empty railcar movements. The GHG emissions' impact on each corridor was also estimated. One purpose of these corridor analyses is to demonstrate to shippers the fuel economy and environmental benefits that CN's routes hold over competing corridors, routes, and railroads.

Railcar characteristics may also affect fuel efficiency and environmental performance. For instance, covered hopper cars and tank cars achieve higher levels of gross ton-miles per gallon than auto rack cars. Based on these equipment differences, it may be desirable to segment equipment by locomotive type, age, and railcar characteristics.

**Variation in facilities.** Various facility types are employed in rail freight movement, including intermodal facilities and classification yards. Intermodal terminals, located at the origin and destination of an intermodal rail corridor, are used to store and transfer container shipments between truck and rail. Containers are handled by various equipment, including gantry cranes and yard tractors. Additionally, drayage trucks are required at most origins and destinations to transport intermodal containers between the intermodal terminal and the ultimate origin or destination. Since most shippers are not located at the rail yard, the drays complete the first or last legs of the container shipment. Drayage trucks are typically older, having been retired from short-haul or long-haul service, and have a lower fuel economy in many regions. The emissions generated from yard equipment and the operation of drayage trucks at the facility are included in the total emissions generated from the facility. The overall effect of yard equipment tends to be small since the fuel consumed in the rail yard is dwarfed by other sources of consumption. Drayage trucks may not be used if a rail yard receives cargo from a port with on-dock rail facilities.

Classification yards are used to sort cars onto different tracks so the cars can be assembled into trains. There are two types of classification yards—flat yards and hump yards. In a flat yard, cars are organized by flat switching or

kicking. In flat switching, cars are coupled and decoupled by moving the train forward and backward to switch the cuts. In kicking, trains are uncoupled by rapid engine acceleration, which kicks cars forward. In hump yards, trains are pushed up hills to store energy, which is used to sort the cars.

Intermodal terminals and classification yards will differ in the level of emissions produced. For example, intermodal terminals have idling emissions from trains and trucks, whereas classification yards will also have emissions from switch locomotives. Regional differences in congestion and the drayage truck population serving intermodal facilities will likely affect the overall environmental impact of operating the terminal.

**Variation in haul.** Railroads provide three distinct types of services: (1) unit train service, (2) intermodal service, and (3) carload service. These haul types will differ in the level of emissions produced. For example, unit train service is likely to produce fewer idling emissions than carload service because unit train service can provide point-to-point service. Trains that provide carload service transport commodities for shippers who load one or a few cars at a time, resulting in more stops and the need to move cars to different trains. Because intermodal service involves loading trailers and containers onto railcars, it may involve idling emissions from trucks.

**Variation in rail lines.** The variation in rail lines can affect fuel efficiency. Typically, railway corridors are laid out to minimize grades, which are typically less than 1 percent and rarely in excess of 2 percent. Depending on the rail alignment and altitude profile, the effort to overcome grades can account for a significant portion of fuel consumed along a route. In addition to grade differences, track curvature, route circuitry, and other rail line characteristics also affect fuel use and air emissions.

## Metrics

Rail carrier metrics are provided in Exhibit 17.

## Programs and Tools

**The SmartWay Transport Partnership** helps rail carriers assess, calculate, and track their fuel consumption and find ways to improve efficiency. SmartWay Rail Carriers (Class 1, 2, or 3) improve fuel efficiency by implementing strategies such as double stacking railcars, reducing idling at switch yards, and reducing empty hauls.

EPA will soon release a new SmartWay Rail Tool that will enable rail carriers to individually benchmark multiple divisions and/or fleets, define fleet composition, characterize fleet activity, and track annual changes in performance.

See http://www.epa.gov/smartway/partnership/rail.htm for further information.

**Association of American Railroads (AAR)** developed the Train Energy Model (TEM) under the AAR's Energy Program. This model is a train performance simulator used to predict fuel consumption and emissions for any train on any route.

**CSX and BNSF** have carbon calculators that allow a shipper to compare its carbon footprint by shipper commodity type for rail versus other transport modes.

See http://www.csx.com/index.cfm/customers/tools/carbon-calculator/ and http://www.bnsf.com/communities/bnsf-and-the-environment/carbon-estimator/ for further information.

**Exhibit 17. Rail carrier metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **Ton-miles** | Average emissions ($CO_2$, SOx, NOx, PM) per ton-mile<br>Average fuel use per ton-mile<br>Average revenue ton-miles per gallon | ✓ | ✓ | | ✓ |
| **Tons** | Average gallons of fuel per revenue ton | ✓ | ✓ | | ✓ |
| **Equipment in operation** | % of equipment by EPA emissions standard tier<br>% of Tier 2 locomotives compliant with Tier 2 rebuild standards<br>% of locomotives equipped with Automatic Engine Start Stop (AESS) devices | ✓ | ✓ | | ✓ |
| | % of switching locomotives using clean technology/hybrids<br>% of forklifts that are electric at facility | ✓ | ✓ | ✓ | |
| **Hours of operation** | Average % idle time | ✓ | ✓ | ✓ | ✓ |
| | Average emissions per hour of idling | ✓ | ✓ | ✓ | ✓ |
| | Idling hours | ✓ | ✓ | ✓ | ✓ |
| **Car miles** | % empty carload miles<br>Emissions per car-mile | ✓ | ✓ | | ✓ |
| **Intermodal train loading** | Slot utilization<br>Train feet per unit<br>Slot efficiency | ✓ | | ✓ | |
| **Day of operation** | Total annual emissions ($CO_2$, SOx, NOx, PM) from facility per number of outgoing trains<br>Total emissions per facility | | | ✓ | |
| **Containers** | Emissions per container<br>Truck wait time per container<br>Truck idle time per container | | | ✓ | |
| **Year of operation** | SmartWay Rank<br>Total annual emissions ($CO_2$, SOx, NOx, PM) | ✓ | | | |
| **Corporate initiatives** | SmartWay Membership<br>Environmental management system implementation<br>Public reporting of environmental/sustainability info<br>Environmental enforcement and compliance task forces | ✓ | | | |
| **Community or public perception** | % of community with positive views toward corporate environmental performance | ✓ | | ✓ | |

**Carbon Disclosure Project (CDP)** is a database of publicly disclosed greenhouse gas emissions from organizations around the world. Companies disclose this information to set reduction targets, make performance improvements, and benchmark against their peers. CDP groups companies into different categories. CN and CSX both participate in this program.

See https://www.cdproject.net/en-US/Pages/HomePage.aspx for further information.

## 6.3 Air Carriers

### Key Issues

There are a number of different segments to the air cargo market. The environmental performance of carriers is affected by the market segment in which they predominantly operate. DOT certificates define the type of service that a carrier may conduct (passenger and cargo or cargo only, scheduled or charter, foreign or domestic). The U.S. air freight industry has four major sectors:

- Express consignment air carriers (operate as scheduled),
- Scheduled passenger airlines that handle cargo,
- Scheduled cargo-only carriers, and
- Charter air cargo carriers.

The types of cargo services the air carriers provide overlap. Scheduled passenger carrying airlines generally carry freight as extra cargo on passenger flights. Many passenger airlines provide express service for cargo. The express carriers provide both express and standard freight carriage and conduct some charters. Express companies also use other air carriers for some shipments. Many scheduled carriers also provide charters.

These overlaps in types of services can complicate efforts to compare environmental performance. For instance, to include the environmental impacts from the transport of belly cargo in a benchmarking study, one would need to allocate the environmental impacts of passenger aircraft activity between passengers and cargo. For a particular segment of travel for a passenger aircraft, this division is typically done on the basis of the weight of the air freight carried versus the weight of passengers and luggage.

## Metrics

Exhibit 18 shows metrics that can be used by air carriers to benchmark environmental performance.

**Exhibit 18. Air carrier metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **Available tons** | Emissions per available ton | ✓ | ✓ | | ✓ |
| | Kg of landing & take-off emissions per 1,000 kg of available tons | ✓ | ✓ | | |
| **Available ton-miles** | Emissions per available ton-mile<br>Fuel use per 100 available ton-miles | ✓ | ✓ | | ✓ |
| **Equipment inventory** | % of fleet having specific energy-efficient or aerodynamic technologies | ✓ | ✓ | | |
| **Energy content of fuel used** | kg-km per mega joule[11] | ✓ | ✓ | | |
| **Aviation fuel consumption** | % of aviation fuel consumed that is "second-generation" biofuel (made from inedible feed stocks) | ✓ | ✓ | | |
| **# of packages or shipments** | Emissions per package / shipment | ✓ | | | ✓ |
| **Tons** | Emissions per ton | ✓ | ✓ | | ✓ |
| **Ton-miles** | Emissions per ton-mile | ✓ | ✓ | | ✓ |
| **Revenue** | Emissions per $ of revenue | ✓ | | | |
| **kWh of electricity consumption** | % of electricity used that is from renewable sources | ✓ | | ✓ | |
| **Employees** | % of employees working in facilities certified to ISO 14001 standards | ✓ | | ✓ | |
| **Facilities** | % of facilities certified to ISO 14001 standards | ✓ | | ✓ | |
| **Environmental inspections** | % of environmental inspections resulting in penalties | ✓ | ✓ | | |

[11]Hileman, et al., 2008.

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### Programs and Tools

UPS and FedEx have published environmental performance data for their aircraft fleets and for their operations more generally. The European Union (EU) is incorporating aviation activities into its Emissions Trading Scheme (ETS) for GHGs. All airlines with operations to, from, or within the EU will be required to participate in the trading scheme. As part of this process, airlines began reporting to the EU annual data on $CO_2$ emissions and tonne-kilometers traveled. This data can inform benchmarking studies of air freight operations.

## 6.4 Marine Carriers

### Key Issues

Benchmarking the performance of marine freight movement requires companies to account for differences in the types of cargo, ship, and vessel characteristics.

**Ship type.** The air emissions associated with freight transport differs across ship types. Key vessel types are shown in Exhibit 19.

**Vessel characteristics.** The size, age, and engine type have a large impact on air emissions. Larger and newer vessels are more efficient, but the channel depth of ports and cargo volumes in specific corridors can limit the opportunities of marine carriers to deploy the largest vessels. There are a variety of engine technologies used for marine freight transport. For instance, residual fuel is used primarily in ocean-going vessels. Ocean-going vessel engines can be classified as propulsion (those that drive the ship) and auxiliary (those that generate electricity for on-board electricity needs). Propulsion engines can further be defined by four types of engines, namely slow speed diesel (SSD) engines, medium speed diesel (MSD) engines, gas turbines (GTs), and steam turbines (STs). Auxiliary engines are typically MSDs.

### Metrics

See Exhibit 20 for marine carrier metrics.

**Exhibit 19. Types of vessels used in marine transport.**

| Ship Type | Description |
|---|---|
| **Auto carrier** | Dry-cargo vessels that carry containerized automobiles. |
| **Barge carrier** | Vessels that tow lashed barges. |
| **Bulk carrier** | Dry-cargo ships that carry loose cargo. Includes dry bulk and break bulk. |
| **Container ship** | Dry-cargo vessels that carry containerized cargo. |
| **General cargo** | Cargo vessels that carry a variety of dry cargo. |
| **Tugs/tows** | Tugboats and towboats that tow or push cargo or barges. |
| **Reefer** | Dry-cargo vessels that allow refrigeration of freight. |
| **Roll-on/Roll-off** | Vessels (including ferries) that handle cargo that is rolled on and off the ship. |
| **Tanker** | Liquid-cargo vessels including chemical tankers, petroleum product tankers, liquid food product tankers, and tank barges. |

**Exhibit 20. Marine carrier metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **Ton-km, TEU-km** | g/ton-km<br>g /TEU-km (container) | ✓ | ✓ | | ✓ |
| **Vessel fleet operation** | Environmental Ship Index | ✓ | ✓ | | |
| | % of vessels equipped for on-shore power while in port | ✓ | ✓ | | ✓ |
| | Energy Efficiency Design Index (EEDI) | ✓ | ✓ | | |
| | Energy Efficiency Operational Indicator (EEOI) | ✓ | ✓ | | |
| **Year of operation** | Clean Shipping Index | ✓ | ✓ | | |
| | Environmental and Energy Efficiency Rating Scheme (DNV Triple-E) | ✓ | ✓ | | |
| | Green Marine environmental performance score (scale of 1-5) | ✓ | | | |

## Programs and Tools

**International Maritime Organization (IMO).** The IMO is coordinating the development of two indices that will allow benchmarking of the carbon intensity of freight transportation provided by individual ocean-going vessels. The Energy Efficiency Design Index (EEDI) is a fuel-efficiency tool intended for use at the design stage, enabling designers to compare the fuel efficiency of different ship designs or a specific design with different inputs such as design speed or choice of propeller. In the future, new ships will have to exceed a minimum EEDI score, but currently its use is voluntary. In June 2010, a new container ship owned and operated by Hapag-Lloyd became the first vessel to obtain an EEDI certification.[12]

Another metric, the Energy Efficiency Operational Indicator (EEOI), is a tool for measuring the fuel efficiency of an existing ship and, therefore, for gauging the effectiveness of any measures adopted to reduce energy consumption. Since 2005, the EEOI has been applied to hundreds of ships on a trial basis. The tool provides a figure, expressed in grams of $CO_2$ per ton-mile, for the efficiency of a specific ship, enabling comparison of its energy or fuel efficiency to that of similar ships.[13]

**Clean Cargo Working Group.** The Clean Cargo Working Group (CCWG) is a private partnership of shippers and containership operators that is managed by Business for Social Responsibility (BSR). According to BSR, the participating carriers move more than 70 percent of global container cargo. Participating carriers complete an annual survey covering the following areas of environmental performance:

- Emissions of $CO_2$, SOx, and NOx;
- Waste management;

[12]"GL Issues the First EEDI Certificate," press release issued by Germanischer Lloyd AG, June 30, 2010, http://www.gl-group.com/en/press/news_18943.php, accessed Sept. 9, 2010.
[13]IMO, http://www.imo.org/newsroom/mainframe.asp?topic_id=1773&doc_id=11176, accessed Sept. 16, 2010.

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- Water effluents;
- Chemical use;
- Environmental management systems;
- Vessel recycling; and
- Transparency.

Aggregated environmental performance data is released to the group's membership annually, allowing shippers and carriers to compare a carrier's performance against its peers.

**World Ports Climate Initiative.** The World Ports Climate Initiative (WPCI) has developed an Environmental Ship Index (ESI) that is intended to identify ocean-going vessels that exceed current standards for reducing air emissions.[14] As currently designed, the ESI only takes a vessel's NOx and SOx emissions directly into account. It also provides a small score improvement if a carrier reports on the vessel's energy efficiency. The overall ESI ranges from zero for a ship that merely meets current environmental performance regulations to 100 for a ship that emits no SOx or NOx and for which a carrier has reported energy efficiency data.

**DNV.** In June 2009, DNV, a Norway-based classification society and consultancy, introduced an environmental rating system for ocean-going vessels called the Environmental and Energy Efficiency Rating Scheme, or DNV Triple-E. The rating system looks at the following features of a vessel and the carrier that operates it:

- Comprehensiveness of a carrier's environmental management systems;
- Fuel-efficient operation as part of policies, action plans, and daily operations;
- Energy-efficient ship design; and
- Verifiable monitoring, measurements, and documentation schemes.

Each element is audited and given a score of 1 to 4, with 1 as the highest rating. Although several of these areas of assessment are related to a carrier's overall management systems for its fleet, final ratings are given to individual ships and documented in the form of a stamped and signed DNV Declaration.[15] As of December 2011, six vessels had received a Triple-E rating.

**Clean Shipping Project.** The Clean Shipping Project started in Sweden in 2007. The project developed a Clean Shipping Index to help Swedish cargo owners select carriers with superior environmental performance. The project is beginning to receive more international attention and will likely be expanded beyond Sweden. In 2010, the project received an award for Green Shipping Initiative of the Year at a Sustainable Shipping awards ceremony in London.[16] As of June 2010, the classification company Lloyd's Register began offering verification of Clean Shipping Index scores.[17]

The Clean Shipping Index is based on data collected through a survey of 20 questions on a carrier's environmental performance. Data is collected for individual vessels, but the resulting

[14]World Ports Climate Initiative, "Environmental Ship Index: An Instrument to Measure a Ship's Air Emission Performance," June 2010, http://www.wpci.nl/projects/environmental_ship_index.php.
[15]DNV, "DNV Triple-E: Environmental and Energy Efficiency Rating Scheme," http://www.dnv.co.za/industry/maritime/publicationsanddownloads/publications/dnvcontainershipupdate/2009/02/dnvtriplee.asp, accessed Sept. 9, 2010.
[16]More information on the winners of the 2010 Sustainable Shipping awards is available at http://www.sustainableshipping.com/events/2010/london/winners.html.
[17]Lloyd's Register Group, " 'Clean Shipping Index' Verification Service Offered by Lloyd's Register," press release dated June 24, 2010, http://www.lr.org/news_and_events/press-releases/199666-clean-shipping-index-verification-service-offered-by-lloyds-register.aspx, accessed Sept. 16, 2010.

scores are for a carrier's fleet. The index is focused on environmental impacts in the following five areas:

- SOx and PM emissions,
- NOx emissions,
- $CO_2$ emissions,
- Chemicals, and
- Water and waste control.

**Green Marine.** The Green Marine Program is an environmental initiative of U.S. and Canadian companies and organizations active in the marine industry operating on the St. Lawrence Seaway and the Great Lakes. These include both carriers and operators of ports and terminals. The program has developed a system for assessing and scoring the environmental performance of its members.

Participating carriers receive scores in the following areas of environmental impacts:

- Air emissions of SOx, NOx, and GHGs;
- Invasive species/ballast water management;
- Cargo residues; and
- Oily water.

For each of these areas, carriers are given a score of 1 to 5, which are defined as follows (note that a particular level can only be attained if all the criteria of the previous levels have been fulfilled):

- Level 1—Regulatory compliance;
- Level 2—Systematic use of a defined number of best practices;
- Level 3—Integration of best practices into an adopted management plan and quantifiable understanding of environmental impact;
- Level 4—Introduction of new technologies; and
- Level 5—Excellence and leadership.

To a large extent, the Green Marine scoring system is based on whether carriers have adopted a set of pre-defined practices. This is evident in Exhibit 21, which shows the scoring criteria for SOx emissions. For that reason, it is not useful in its entirety for a benchmarking exercise, which would first measure carriers' performance and then seek to uncover the practices contributing to superior performance.[18] However, to obtain the highest scores on some measures, carriers do have to meet performance criteria. For example, to obtain the highest score in the area of SOx emissions, a carrier must allocate 75 percent of the company's annual fuel consumption to fuel with sulfur content of 1.5 percent or less or use technologies to attain the same level of sulfur emissions. For carriers that meet that criterion, a benchmarking analysis could be used to determine how they did so.

**The Total Energy & Emissions Analysis for Marine Systems Model (TEAMS)** is the first-ever model able to calculate total fuel-cycle emissions and energy use for marine vessels. TEAMS captures "well-to-hull" energy use and emissions—that is, energy and emissions along the entire fuel pathway (extraction → processing → distribution → use in vessels). TEAMS conducts analyses for six fuel pathways as follows:

1. Petroleum to residual oil;
2. Petroleum to conventional diesel;
3. Petroleum to low-sulfur diesel;

[18]In fact, although Green Marine publishes the scores for participating carriers and ports, the program explicitly states that it does not wish to invite comparison among participants.

**Exhibit 21. Green Marine carrier scoring levels for SOx emissions.[19]**

| Level | Requirements |
|---|---|
| 1 | Comply with existing regulatory requirements. |
| 2 | Distribute an internal directive to ensure that a set of five specified practices is applied on all its ships. |
| 3 | Complete an annual SOx emissions inventory for the company's entire fleet.<br>For at least one ship, use marine diesel or a fuel with sulfur content of 0.5% or less when ship is docked. |
| 4 | Allocate 25 % of the company's annual fuel consumption to fuel with sulfur content of 1.5% or less, or use technologies to attain the same level of sulfur emissions.<br>For a majority of fleet, use marine diesel or a fuel with sulfur content of 0.5% or less when ships are docked. |
| 5 | Allocate 75 % of the company's annual fuel consumption to fuel with sulfur content of 1.5% or less, or use technologies to attain the same level of sulfur emissions.<br>For entire fleet, use marine diesel or a fuel with sulfur content of 0.5% or less when ships are docked. |

4. Natural gas to compressed natural gas;
5. Natural gas to Fischer-Tropsch diesel; and
6. Soybeans to biodiesel.

TEAMS calculates total fuel-cycle emissions of three greenhouse gases (carbon dioxide [$CO_2$], nitrous oxide [$N_2O$], and methane [$CH_4$]) and five criteria pollutants (volatile organic compounds [VOCs], carbon monoxide [CO], nitrogen oxides [NOx], particulate matter with aerodynamic diameters of 10 micrometers or less [$PM_{10}$], and sulfur oxides [SOx]). TEAMS also calculates total energy consumption, fossil fuel consumption, and petroleum consumption associated with each of its six fuel cycles. TEAMS can be used to study emissions from a variety of user-defined vessels, including cargo ships, passenger ferries, and container ships.

## 6.5 Marine Ports

### Key Issues

When benchmarking the environmental performance of ports (or specific types of terminals or operations at ports), it is necessary to consider the boundaries within which performance will be measured. To make accurate comparisons among ports or port facilities, the boundaries for data collection need to be consistent or the data must be adjusted accordingly. Ports confront the issue of determining an analytical boundary when conducting inventories of their air emissions. For example, when estimating air emissions from heavy-duty trucks that service a port, one may choose to include emissions from queuing at terminal entry gates, from travel and idling within the terminals, and from queuing at the terminal exit gates. Alternatively, for freight leaving the port by truck, one could include the emissions from truck travel to the cargo's first point of rest within the local air basin or up to the basin's boundary, whichever comes first. If the region in which the port is located is not yet in compliance with federal air quality standards, one could use the federally designated boundaries of the non-attainment area.

The same issue arises with regard to ocean-going vessels. A benchmarking study could consider only the emissions produced while ocean-going vessels are docked or "hotelling" at the port. Alternatively, it could also include emissions produced while the vessel is traveling within a certain distance of the port (e.g., 20 nautical miles). Some ports have taken steps to encourage or require vessels to reduce speed or switch to cleaner fuels when within a certain distance of the port. Using a boundary that extends out to sea would capture the effects of such initiatives on a port's environmental performance.

[19]Green Marine, *2009 Self-Evaluation Guide for Shipowners*, http://www.green-marine.org/images/stories/shipownersinteractiveselfevaluationguide2009.pdf

**Benchmarking the Port of Seattle's Performance**

The Port of Seattle Carbon Footprint Study benchmarks the carbon footprint of specific trade gateways and was the first of its kind. The study is an important tool in the larger effort to measure environmental performance and enhance the competitive position of the port. The study was conducted to measure the corridor-level emissions impacts of freight moved through Seattle compared to freight moved through other ports. The study covers shipments from Shanghai, Hong Kong, and Singapore to Chicago, Columbus, and Memphis by vessel and rail through the ports of Prince Rupert, Seattle, Oakland, and Los Angeles/Long Beach. It also analyzes routes via the Panama and Suez Canals through the ports of Houston, Savannah, Norfolk, and New York. Ships sized at 4,500, 6,500, 8,500, and 12,500 TEUs (20-foot equivalent units) were included in the study, as was the year 2014 expansion of the Panama Canal. According to the study, Seattle is the "Green Gateway" to 180 million American consumers. Intermodal shipments moving from Asia to the Midwest through the Port of Seattle produced fewer greenhouse gas emissions compared to East Coast ports.

## Metrics

Exhibit 22 provides marine port metrics.

## Programs and Tools

Increasingly, ports are completing emissions inventories and developing clean air strategies or plans. The most comprehensive of these plans include goals and performance measures for gauging progress toward those goals over time.

**Exhibit 22. Marine port metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **Work units (e.g., container movements, tons handled, hours of operation)** | Emissions per work unit<br>Fuel consumption per work unit<br>Drayage trips per container<br>Drayage VMT per container | ✓ | ✓ | ✓ | ✓ |
| **Equipment or infrastructure inventory** | % of cranes electrified<br>% of yard trucks using alternative fuels<br>% of tugs using low-sulfur fuels<br>% of equipment meeting specific U.S. EPA engine emissions standards | ✓ | ✓ | ✓ | |
| **Vessel calls** | % of vessel calls using shore power<br>% of vessel calls using low-sulfur fuels for auxiliary power<br>% of vessel calls complying with speed reduction program | ✓ | ✓ | ✓ | |
| **Truck visits** | Average minutes of delay at gates per truck visit<br>Port truck VMT per visit | ✓ | ✓ | ✓ | |
| **Kilowatt-hours (kWh)** | % of electricity from renewable sources | ✓ | | ✓ | |
| **Square footage of terminal(s)** | Emissions per square foot related to electricity, heating, and cooling | | | ✓ | |
| **Container movements** | % of containers moving by on-dock rail<br>% of containers moving by near-dock rail | ✓ | | ✓ | |

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In recent years, there has been an outpouring of generalized guidance for conducting greenhouse gas inventories; however, two available documents are tailored specifically to the needs of marine ports:

- U.S. EPA. *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories* (April 2009)[20]
- World Ports Climate Initiative. *Carbon Footprinting for Ports* (June 2010)[21]

**EPA SmartWay DrayFLEET Model.** This model assesses truck emissions and various technical and management options for reducing emissions and fuel consumption from truck drayage activity. This might include virtual container yards, chassis pools, or on-dock rail. The user can also assess technological options targeted to drayage trucks (such as diesel particulate filters or oxidation catalysts, idle control technologies, etc).

See http://www.epa.gov/smartway/documents/partnership/trucks/drayage/smartway-dray-fleet-v1-0f-users-guide.pdf for further information.

**The Diesel Emissions Quantifier.** Quantifier is an interactive tool to help state/local governments, fleet owners/operators, school districts, municipalities, contractors, port authorities, and others estimate emission reductions and cost effectiveness for clean diesel projects. Estimates are made using specific information about a fleet. For those applying to EPA, or some other federal or state/local funding assistance program, this site will help prepare and submit diesel emissions data to EPA. EPA has built the Quantifier based on existing EPA tools and guidance, and the Quantifier can be used by potential grantees, state and local governments, metropolitan planning organizations, and fleet owners and operators, among others. The Quantifier uses emission factors and other information from EPA's MOVES 2010 Model and the NONROAD 2008 Model.

See http://cfpub.epa.gov/quantifier/ for further information.

## 6.6 Airports

### Key Issues

**Determining Boundaries for Performance Measurement.** To make accurate comparisons among airports or air freight facilities, the boundaries for data collection need to be consistent or the data must be adjusted accordingly. Boundary issues related to air emissions from aircraft and from vehicles dropping off or picking up air freight are discussed separately below.

**Boundaries for Emissions from Aircraft.** For attributing aircraft emissions of criteria air pollutants to an airport, U.S. EPA has developed standard procedures for estimating emissions from aircraft landings, ground activity, and takeoffs. This set of activities is collectively referred to as the "landing and takeoff (LTO) cycle." EPA procedures call for including all aircraft emissions that occur in the "mixing zone," the vertical column of air that ultimately affects ground-level concentrations of pollutants. The height of the mixing zone is roughly 3,000 feet, but it varies according to local meteorological conditions.[22] This boundary could be used to estimate and benchmark the emissions of criteria air pollutants associated with freight activity at a particular airport.

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[20]http://www.epa.gov/cleandiesel/documents/ports-emission-inv-april09.pdf

[21]http://www.wpci.nl/docs/presentations/PV_DRAFT_WPCI_Carbon_Footprinting_Guidance_Doc-June-30-2010_scg.pdf

[22]EPA, Procedures for Emissions Inventory, Vol. 4, Chapter 5, http://www.epa.gov/oms/invntory/r92009.pdf. See also FAA, Air Quality Procedures for Civilian Airports and Air Force Bases, April 1997, Appendix D: Aircraft Emission Methodology, http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/App_D.pdf

Determining the appropriate boundaries for estimating GHG emissions from freight operations at an airport is less clear-cut because the effects of GHG emissions are global rather than local in nature. For the preparation of national GHG inventories, the Intergovernmental Panel on Climate Change (IPCC) guidance calls for attributing GHG emissions from international aircraft trips to the country of departure.[23] In keeping with the IPCC guidance, *ACRP Report 11* suggests that for an airport GHG inventory, each flight's GHG emissions should be attributed to the departure airport only.[24] However, alternate approaches may be appropriate for a particular benchmarking study. For example, one could exclude all aircraft emissions during flight and focus only on emissions from all ground operations (including aircraft taxiing and idling). Selecting the appropriate boundary for a benchmarking study of GHG emissions from air freight operations will depend on the organization conducting the study and the purpose of the study.

**Boundaries for Emissions from Ground Access Vehicles.** When benchmarking the air emissions related to an air freight facility, one may decide to include emissions from vehicles dropping off or picking up freight at an airport, also known as "ground access vehicles." The same conceptual issues that arise when considering aircraft emissions also arise when considering emissions from ground access vehicles. For criteria air pollutants, one could include emissions from all travel of ground access vehicles within the boundaries of the local air basin. If the region in which the airport is located is not yet in compliance with federal air quality standards, one could use the federally designated boundaries of the non-attainment area. Alternatively, for a more narrow focus, one could benchmark using only on-airport emissions from ground access vehicles, including any resulting from engine idling.

Because of the global nature of the impact of GHG emissions, *ACRP Report 11* suggests that GHG emissions from ground access vehicles be estimated based on each vehicle's point of origin, regardless of its location. This recommendation is based on the assumption that the vehicle would not have traveled to the airport unless the driver needed to conduct some activity there.[25]

**Accounting for the Environmental Impacts of Freight Carried by Passenger Aircraft.** To include the environmental impacts from the transport of belly cargo in an airport benchmarking study, one would need to allocate environmental impacts of a passenger aircraft activity between passengers and cargo. This division is typically done on the basis of the weight of passengers and luggage versus the weight of air freight.

## Metrics

Exhibit 23 lists airport metrics.

## Programs and Tools

The ACI-NA Environmental Benchmarking Survey is an important resource on comparative environmental performance for airports. The ACI-NA survey covers a wide range of airports, but the data is not specific to freight facilities at airports.

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[23]Intergovernmental Panel on Climate Change, *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* Volume 2, Chapter 3, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[24]TRB, *ACRP Report 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories,* http://www.trb.org/Main/Public/Blurbs/160829.aspx

[25]TRB, *ACRP Report 11,* Appendix E, p. 73, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_webdoc_002.pdf

**Exhibit 23. Airport metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **Work units (e.g., tons handled, # of landings or take-offs, hours of operation)** | Fuel consumption per work unit<br>Emissions per work unit | ✓ | ✓ | ✓ | |
| **Equipment or infrastructure inventory** | % of ground vehicle and ground service equipment fleet that is low-emission (e.g., electric, natural gas, LNG, CNG, E85, M85, hydrogen, biodiesel)<br><br>% of equipment meeting specific U.S. EPA engine emissions standards | ✓ | ✓ | ✓ | |
| **# of aircraft visits** | % of visits using auxiliary electrical power and/or pre-conditioned air | ✓ | | ✓ | |
| **Ground access vehicle trips** | Average idling time per freight-related visit to airport | ✓ | | ✓ | |
| **Tons of freight handled, landing/take-off (LTO) operation** | Air emissions per ton of freight handled or per LTO | ✓ | | ✓ | |
| **Infrastructure inventory** | % of freight docks or loading bridges equipped with auxiliary electrical power and/or pre-conditioned air | ✓ | | ✓ | |
| **Equipment** | % of ground vehicle and ground service equipment fleet that is low-emission (e.g., electric, natural gas, LNG, CNG, E85, M85, hydrogen, biodiesel) | ✓ | ✓ | ✓ | |
| **# of aircraft gate visits** | % of visits using auxiliary electrical power and/or pre-conditioned air | ✓ | | ✓ | |
| **# of LTOs** | Average number of minutes of runway delay per take-off of cargo aircraft | ✓ | | | |
| **Kilowatt-hours (kWh) of electricity consumption** | % of total energy used that is from renewable sources | ✓ | | ✓ | |
| **Ground access vehicle trips** | On-airport VMT traveled per visit<br><br>Average idling time per visit | ✓ | ✓ | ✓ | |

Public reports available from individual airports are another important resource. For example, Massport's *2008 Environmental Data Report for Boston Logan International Airport* provides detailed environmental data for air cargo operations at its airport. Such data can be useful for comparative purposes.

In 2009, TRB published *ACRP Report 11: Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories.* This document discusses approaches to, and methods for, estimating GHG emissions from airport operations.

## 6.7 Shippers and Receivers

### Key Issues

There are a variety of factors that could contribute to differences in the environmental performance of shippers and receivers. These factors should be acknowledged and accounted for when

benchmarking companies. This could be done through the selection of peers or through the design of the performance metrics used. The factors that should be considered include the following:

- **Use of private/dedicated fleets vs. outside carriers—**Private/dedicated fleets may be operated differently than for-hire fleets. For instance, private/dedicated fleets often have a greater percentage of empty miles than for-hire fleets, but the owners of private fleets bear this cost to provide a higher level of service to their customers.
- **Type of commodity—**The type of commodity will influence the choice of transportation mode and the level of service provided. Therefore, when performing a benchmarking study, it may be desirable to segment companies by types of commodities shipped and received.
- **Geography—**Geographical location has multiple influences on freight environmental performance. Access to transportation modes varies by geographical location. Topography along the routes to customers or suppliers will affect the fuel efficiency of truck or rail operations. The distance of company facilities from suppliers and customers will also affect the amount of freight activity (e.g., miles, ton-miles), as well as the types of transportation mode selected.
- **Company size—**Some companies may coordinate thousands of different types of products and shipments from various companies, while others coordinate only a handful of goods. The number and amount of commodities received will influence the frequency and type of transportation service needed. It will also affect activity at the loading docks and facilities. Additionally, larger companies may be able to implement operational changes that smaller companies cannot make. Therefore, when doing benchmarking, some consideration should be given to company size.
- **Facility size—**Some receivers have space to accept deliveries when carriers arrive with cargo, while others may have limited loading space at docks, or limited parking areas to drop and hook trailers, which will result in more idling while the truck waits to unload.
- **Inventory management practices—**Companies whose business model depends on lean or "just-in-time" inventories, such as manufacturing and retail operations, will require different transportation services than companies that maintain larger inventory buffer stocks.

## Metrics

See Exhibit 24 for shipper and receiver metrics.

## Programs and Tools

**The SmartWay Partnership Shipper Tool** is a measurement tool that can be used to evaluate the actions that shippers or third-party logistics companies are taking to save fuel and reduce emissions through their choice of carriers.

See http://www.epa.gov/smartway/partnership/shippers.htm for further information.

**Chainalytics** works with shippers to define, measure, and reduce the environmental impact of their supply chains. Chainalytic's services will help companies to determine a GHG emission baseline and subsequent energy reduction goals. Once the baseline and goals are developed, Chainalytics will work with the supplier to identify opportunities for GHG reductions within the supplier network, inventory, transportation network, and customer policies.

See http://www.chainalytics.com/services/sustainability.asp for further information.

**Supply Chain Council (SCC)** developed the Supply Chain Operations Reference (SCOR) Model to assist companies with supply chain management systems and practices. SCC offers a supply chain benchmarking service with APQC based on SCOR Model metrics. Through this service, shippers can set performance goals, calculate performance gaps, and develop company-specific roadmaps.

See http://supply-chain.org/scormark for further information.

**Exhibit 24. Shipper and receiver metrics.**

| Functional Unit | Environmental Performance Metric | Level of Analysis | | | |
|---|---|---|---|---|---|
| | | Organization | Fleet | Facility | Corridor |
| **$ of revenue, $ of purchases** | Total emissions per $ of revenue or $ of purchases<br>Electricity consumption per $ of revenue<br>Electricity consumption per $ of purchases | ✓ | | | |
| **Tons<br># of shipments** | Total emissions per ton or per shipment | ✓ | | ✓ | ✓ |
| **Square footage** | Electricity-related emissions per square foot<br>Electricity consumption per square foot | ✓ | | ✓ | |
| **Electricity** | % of electricity purchased from renewable sources | ✓ | | ✓ | |
| **Year of operation** | # of people exposed to a specific concentration of emissions from facility | | | ✓ | |
| **# of truck visits** | Average truck wait time at loading dock<br>Average truck idling time at loading dock | ✓ | | ✓ | |
| **# of forklifts** | % of forklifts that use alternative fuels (e.g., electric, propane) | | | ✓ | |
| **# of vehicles** | % of alternative-fuel vehicles in light-duty fleet | ✓ | | ✓ | |
| **Year of company operation** | Percentage of SmartWay carriers | ✓ | | | |
| **# of shipments** | Average miles traveled per shipment<br>Average emissions per shipment | ✓ | | | ✓ |
| **Fleet in operation** | % of trailers with specific fuel-efficiency features (e.g., aerodynamics, weight reduction) | ✓ | ✓ | | ✓ |
| **$ of revenue** | Total purchased truck and air miles of transportation per $ of revenue | ✓ | | | |
| **$ of transportation expenditure, $ of revenue** | % of transportation expenditure by mode<br>% of revenue shipped by mode | ✓ | | | ✓ |
| **Ton-miles, miles, volume, trips** | % of ton-miles by mode<br>% of transportation miles by mode<br>% of volume by mode<br>% of trips by mode | ✓ | | | ✓ |
| **# of employees or facilities** | % of employees working in facilities certified to ISO 14001 standards<br>% of facilities certified to ISO 14001 standards | ✓ | | ✓ | |
| **# of inspections** | % of environmental inspections resulting in penalties | ✓ | | ✓ | |
| **Length of supply chain** | Average distance to shippers or receivers from nearest facility location | ✓ | | | ✓ |
| | Regional density of customers | ✓ | | | ✓ |

**The Council of Supply Chain Management Professionals** offers an online benchmarking service in areas including customer order management and logistics.

See http://cscmp.org/resources/benchmark-tool.asp for further information.

**Carbon Disclosure Project (CDP)** is a database of publicly disclosed greenhouse gas emissions from organizations around the world. Companies disclose this information to set reduction targets, make performance improvements, and benchmark against their peers. CDP groups companies into different categories, including a supply chain category.

See https://www.cdproject.net/en-US/Pages/HomePage.aspx for further information.

CHAPTER 7

# Benchmarking Implementation Issues

## 7.1 Customer Demands

One of the primary reasons to implement an environmental benchmarking program is to meet the needs of customers. Increasingly, customers are requesting data on the environmental performance of freight transportation. Many shippers and receivers are interested in understanding the environmental footprint of their supply chain. A benchmarking program can generate the data needed to allow companies to understand their own environmental footprint and share this information with customers.

For instance, Wal-Mart is collecting data and measuring the environmental performance of its suppliers and contract carriers. Wal-Mart collects data from carriers and suppliers on energy use and greenhouse gas emissions, and encourages carriers to join SmartWay to set goals and improve performance. Wal-Mart uses a supplier sustainability questionnaire to request data on the carbon footprint of their suppliers and their goals for improvement.

DHL has implemented a "green carrier scorecard" to rate the airlines to which it subcontracts to transport the goods of DHL customers. This scorecard allows DHL to use environmental performance as one of the criteria for selecting carriers. Fleet-level measures of carbon efficiency are a key component of this.

Another example of a company providing information to customers is Stonyfield Farms. The text box describes how they can provide data on the environmental performance of product transportation. Based on this data, they work with customers to reduce $CO_2$ emissions associated with transportation. Understanding the types of information that customers may need and designing a benchmarking program that collects this data is of the utmost importance.

**Stonyfield Farms Customer Benchmarking**

Stonyfield Farms is a New Hampshire-based manufacturer of organic yogurt products. The company has always had a strong commitment to social responsibility; for example, in 1997 it became the first U.S. manufacturing operation to offset 100% of the $CO_2$ emissions from its facility energy use. It also participates in EPA's SmartWay Transport Partnership and won a SmartWay Excellence Award in 2009.

In 2006, Stonyfield began working with Ryder System, Inc., to reduce the $CO_2$ emissions from its supply chain, including transportation and logistics. Integral to this initiative was a new information system that allows Stonyfield to calculate $CO_2$ emissions in multiple ways, including per case of product and per customer. In response to customer requests, the company can benchmark customers based on $CO_2$ emissions associated with product deliveries. Based on this data, they can work with customers to reduce $CO_2$ emissions by changing the frequency of deliveries or implementing other strategies. When managing its transportation operations, the company uses $CO_2$ emissions per ton of product delivered as a metric.

## 7.2 Cost and Level of Commitment

The cost of conducting environmental benchmarking is often considered a major barrier. Benchmarking studies can be implemented at different levels of sophistication, depending on the resources available. For instance, a detailed benchmarking study

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**Con-way: Obtaining Comparative Benchmarking Data on Truck Fuel Efficiency**

Con-way has detailed data on its own internal fuel economy performance by tractor, engine, transmission, and trailer type. This data includes information from the truck computer on driver behavior (shifting and acceleration), the gross weight of the truck, and the origin and destination for each shipment. While the company cannot obtain data on a competitor's fuel economy in anything like the detail it has for its own performance, the company is able to gather enough information to make useful comparisons about fuel efficiency in the rest of the industry.

Managers at Con-way obtain information on competitors' performance through a variety of informal contacts. Important sources are salesmen for original equipment manufacturers (OEMs) and discussions through industry groups such as the Technology and Maintenance Council (TMC) of the American Trucking Associations. OEM sales representatives usually have a good idea of the fuel consumption their customers are achieving with the tractors, engines, or transmissions that they sell. The fuel efficiency of their customers' fleets is usually part of the dialogue between the sales representatives and potential buyers. The sales representatives need to know what they can offer buyers by way of improvement, and potential buyers are willing to share some information on the point, because they want to test what is being offered. "We're averaging 6.05 MPG now, what can your [tractor, engine, transmission] do for us?"

A similar conversation takes place between Con-way's marketing people and private carriers. As do other significant truckload firms, Con-way Truckload offers dedicated contract service to large shippers that have private fleets. Dedicated contract service is essentially outsourced private carriage. Under a contract, a truckload carrier places a specified number of trucks and drivers at the complete disposal of a shipper, which uses them just as it would a private fleet—delivering goods to their customers or moving goods from their factories to their warehouses. Con-way marketers want to show the private carriers the economies they can realize by augmenting their own fleets with dedicated service from Con-way or dropping their own fleets altogether. The private carriers want to show Con-way what it has to do to get their business.

Off-the-record exchanges and discussions at meetings of groups like TMC are also helpful. Maintenance vice presidents or their staff attend these meetings, and there is usually considerable discussion of specifics of fuel efficiency. Useful public information is also available through EPA's SmartWay Transport Partnership program, for example, and from other sources.

with a number of other market leaders, site visits, and extensive data collection and analysis could involve substantial costs for a company. If resources are not available for a major in-depth study, desk benchmarking can be used to collect publicly available information.

The scale of resources expended on a benchmarking study can be balanced against the scale of the organization and the likely cost savings. Reducing fuel consumption is an important way that environmental benchmarking can contribute to the bottom line, and benchmarking studies can often be justified based on the large potential benefits that accrue from implementing best practices that save on fuel costs. Less rigorous and time-consuming methods to collect data can be used in cases where the size of the opportunity is not as great.

## 7.3 Obtaining Comparative Data

Obtaining comparative data is often identified as a major challenge for benchmarking studies. In many cases, detailed data on equipment populations, efficiency, and operations is considered proprietary by companies. There are numerous approaches to overcoming this barrier. In some

cases, it is possible to find individual companies that are not direct competitors but that have comparable operating features. For instance, in the trucking industry, private fleets owned by major shippers may be more willing to share data on their transportation operations, since they do not compete directly with for-hire truck carriers. In many cases, companies that are in different industries may serve as a source of new ideas and best practices.

Industry associations can also provide opportunities to learn about the latest technologies and network with technical staff from other companies. Even if these relationships do not yield detailed data on the performance of equipment or operations at other companies, these informal contacts can provide some guidance on what the benefits of new technologies may be and what types of performance may be achievable. Industry associations often conduct surveys or have other data in-house on industry operations. Many of these resources are highlighted in Chapter 6.

Manufacturers of transportation vehicles, engines, and equipment are another source of comparative data on fuel efficiency performance or other aspects of environmental performance. They often have an understanding of both the performance that the equipment is rated to achieve, as well as the performance that major customers have been achieving in the field. While data obtained from equipment sales representatives would require ground truthing, it can be an important supplementary source of valuable comparative data.

Benchmarking programs provide an additional source of data. Some of these programs are supported by public funding. Programs such as the SmartWay Transport Partnership collect data from individual partners on the environmental performance of transport operations and publish aggregated data on the performance of individual carrier industry segments. This data protects the confidentially of members while providing comparative performance data.

Programs such as the Carbon Disclosure Project or the Clean Cargo Working Group release detailed data on member performance to the public. This can serve as a resource for both members and non-members alike. Private benchmarking services such as the Supply Chain Consortium make it their business to collect detailed data on participating members' operations and to disclose aggregated industry performance data for purposes of comparison. While much of this data relates to business operations, improving the efficiency of supply chain performance, such as improving vehicle utilization, has environmental benefits. This data can be useful for environmental benchmarking.

A "desk benchmarking" process can be used for a less complex and rigorous benchmarking exercise. Publicly available data from industry trade publications, company websites, or sustainability reports can be used to compare performance. Benchmarking exercises can draw from a wide range of sources to obtain a more complete picture of the range of environmental performance achievable in different market contexts.

**SmartWay Transport Partnership: Source of Comparative Data for Benchmarking**

SmartWay is a major program for improving fuel efficiency and reducing greenhouse gases and air pollution from the freight sector. The program has over 2,900 participants, including most of the largest truck carriers, all Class 1 railroads, and many logistics companies. The program assesses emissions ($CO_2$, NOx, PM) of carrier fleets and benchmarks them against peers. The primary metrics are grams of emissions per mile and grams per ton-mile. Truck fleets are ranked in 1 of 5 performance "bins" for $CO_2$, NOx, and PM. These rankings can be used as a source of comparative data.

APPENDIX A

# Glossary

**Air Toxics:** Contaminants found in ambient air that are known or suspected to cause cancer, reproductive effects, birth defects, other health effects, or adverse environmental effects, but do not have established ambient air quality standards. Air toxics broadly fall into two categories—heavy metals and hydrocarbons.

**Activity:** A series of actions or steps that are conducted using available resources (i.e., inputs) to perform work requirements and produce a specific outcome. *Activity* and *process* are terms that are sometimes used interchangeably.

**Benchmark** (noun)**:** The operating statistic or measurement standard used to compare an organization's performance with that of other organizations.

**Benchmark** (verb, "to benchmark")**:** The process by which an organization compares one of its work processes, functions, practices or standards to that of other organizations based on data collected through a benchmarking study.

**Benchmarking:** The process of applying specific methodologies to conduct a study of other organizations' practices in comparison to one's own organization by collecting data from partners (i.e., other organizations, associations, or industries that are comparable). This refers to a continuous search for best practices and operating procedures that will allow an organization to improve performance and address the deficiencies noted according to specified benchmarks. The focus of a benchmarking study may be on the business processes, operating practices, and strategies that make other organizations successful, as well as the metrics other organizations use to evaluate their performance of a particular activity.

**Benchmarking Gap:** The difference between the practices of the organization/entity conducting the study and the practices of "best-in-class" organizations. The gap may refer to a quantitative gap (e.g., number of times an activity is conducted), a structural gap in how the organizations structure themselves, a process gap in how practices are executed, or a performance gap that results from these.

**Best in Class:** Practices that have been ranked as best-in-class practices among other generic or even effective practices due to their means of implementation and superior results. These practices are only best in class with respect to particular organization types and cultures. The determination of practices as best in class should be based on established criteria and a formal evaluation conducted by subject matter experts.

**Business Process Modeling:** The act of revealing and systematically describing the sequential activities that contribute to specific processes of an organization in order to improve process efficiency and quality. This term is frequently used in systems engineering and

software engineering. Business analysts may engage in a benchmarking study to analyze the business processes of another high-performance organization in order to determine areas where process improvements can be made.

**Criteria Air Pollutants:** Pollutants for which the federal government has established ambient air quality standards based on short- and/or long-term human health effects. U.S. EPA has established national ambient air quality standards (NAAQS) for the following six pollutants:

1. Ground-level ozone ($O_3$),
2. Carbon monoxide (CO),
3. Particulate matter (PM) less than 10 ($PM_{10}$) and 2.5 ($PM_{2.5}$) microns,
4. Nitrogen dioxide ($NO_2$),
5. Sulfur dioxide ($SO_2$), and
6. Lead (Pb).

**Culture:** The established values and norms shared among employees that serve as the contextual factors that encourage or inhibit organizationwide receptivity to change.

**Collaborative Benchmarking:** The conduct of a benchmarking study on behalf of multiple companies. The companies unite and often share the costs associated with collecting data through an integrated methodology (e.g., via a single survey) with the sample often being organizations from another industry.

**Competitive Advantage:** The factors that differentiate an organization from its peers within its industry.

**Competitive Analysis:** Calculating the size of the gap between the *performance* of one's own organization and that of another organization being benchmarked.

**Competitive Benchmarking:** Comparing performance with, and identifying, best-in-class practices of firms or entities that are direct competitors of an operation.

**Continuous Process Improvement:** The effort to maintain ongoing improvement to business processes by engaging in a constant benchmarking search for means of increasing quality and efficiency through investment in specific practices.

**Corridor:** This framework labels as "corridor-level" those benchmarking efforts that have a geographic focus or that extend across organizations and modes.

**Critical Success Factors:** The areas of a business where a minimum of average performance is required for the business to remain successful. The factors often include the quantitative measures of cost and time efficiency and organizational effectiveness.

**Enabler** (also referred to as a "business driver"): The methods or behaviors that facilitate the implementation of a "*best-in-class*" *practice.* Resources such as people, technology, and financial assets are often thought of as enablers in that they allow for the conduct of specific work *processes.* The enablers explain the cause behind specific performance outcomes.

**Environmental Benchmarking:** The conduct of a benchmarking study for the purpose of identifying work processes and practices that influence the environmental performance of organizations.

**Exploratory Benchmarking:** The process of broadly studying other organizations' processes and structure based on their competitive advantage in the industry without a clear "best-in-class" target practice in mind.

**Facility:** A fixed location at which freight activity takes place, such as a marine terminal, intermodal yard, or warehouse. A particular type of freight facility could serve as the point of comparison for environmental benchmarking.

**Fleet:** A group or class of vehicles that is used to complete similar tasks (e.g., long-haul tractor-trailers). The fleet is one scale at which environmental benchmarking can be conducted for freight transportation.

**Functional Benchmarking:** The study of best-in-class practices among companies within different industries that are functional competitors; for instance, comparing the logistics function of Ford and Wal-Mart.

**Generic Benchmarking:** The study of specific generic processes between organizations that may be in unrelated industries—for instance, comparing the generic vehicle maintenance process between a trucking company and the military.

**Global Benchmarking:** The act of maintaining a strategic partnership among organizations across the globe to enable an ongoing, shared learning experience that will contribute to continued improvements.

**Goals:** The specific targets for *performance* that specify the desired direction of the organization.

**Greenhouse Gases (GHGs):** Gases that contribute to global climate change. Carbon dioxide ($CO_2$) is the primary GHG associated with the combustion of diesel and other fossil fuels, but methane ($CH_4$) and nitrous oxide ($N_2O$) are produced in smaller quantities. Hydrofluorocarbons are GHGs that are used as coolants in vehicle air conditioners and cargo refrigeration units; they are sometimes leaked during equipment operation, servicing, and disposal. GHGs other than $CO_2$ are often converted into "$CO_2$ equivalent" on the basis of their relative impacts on climate change. On that basis, $CO_2$ accounts for over 95 percent of the transportation sector's GHG emissions. Given the importance of $CO_2$, it is usually appropriate and acceptable for transportation GHG analyses to focus solely on $CO_2$ emissions, particularly if resources are limited and if the analysis is designed to provide a general indication of GHG impacts.[26]

**Hazardous Air Pollutants:** See *Air Toxics.*

**Inputs:** Key enablers measured through their contribution to outputs and, by their extension, outcomes. These may include people, technology, and fixed assets.

**Internal Benchmarking:** The study of business processes across divisions or functional areas within the same organization.

**Invasive Species:** A species that is non-native (or alien) to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. One method of dispersal of invasive species is via the uptake and discharge of ballast water by marine vessels.

**Key Business Process:** A process that has the ability to alter customer perceptions of the work product and broader business practices, including ethical and environmental practices.

**Key Performance Indicator** (KPI): A specific metric used to gauge a quantifiable component of an organization's performance at a functional, process, or activity level; typically corresponds to what have been determined to be the organization's *critical success factors* and business goals.[27]

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[26] *NCFRP 16,* pp 30–31.

[27] American Productivity and Quality Center; www.apqc.org

**Measure:** A measure is the format and period that is used to report the performance metric.

**Metric:** The criterion by which success of a work process is measured. It is a numeric value that allows for comparison across organizations. For example, miles per gallon is a metric for fuel efficiency.

**Mission:** A statement that describes the purpose of an organization and indicates an intended level of performance.

**Nitrogen Oxides (NOx):** A group of gases that form quickly from emissions from vehicles, off-road equipment, and power plants. In addition to contributing to the formation of ground-level ozone (or "smog") and particulate matter, NOx emissions are linked to a number of adverse effects on the human respiratory system.

**Outcomes:** Mission- and business-critical results measured from a customer perspective. In the case of environmental benchmarking, the results are measured in terms of environmental impacts.

**Outputs:** The direct effects of day-to-day work activities and broader processes measured as driven by desired outcomes.

**Particulate Matter (PM):** Microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. Small particles of concern include "inhalable coarse particles" (such as those found near roadways and dusty industries), which are between 2.5 and 10 micrometers in diameter; and "fine particles" (such as those found in smoke and haze), which are 2.5 micrometers in diameter and smaller. Diesel engines are one of the largest sources of fine particulate matter.

**Partners:** Organizations that are part of the benchmarking study sampling plan that agree to participate in the benchmarking study for the purpose of sharing practices or business processes that will enhance another organization and possibly contribute to improvements at an industry level.

**Performance:** Accomplishment of a given task measured against preset standards of accuracy, completeness, cost, speed, or other standard.

**Performance Measurement:** The integration of performance measures, benchmarks, and goals in order to achieve optimal results.[28]

**Performance Standards:** The targets established at the individual employee level that identify the level of performance required to meet desired goals and enable the organization to be competitive among its peers in the industry. In addition to indicating the desired level of performance, performance standards often include a description of the operational tasks that exemplify the specified level of performance. In other words, the performance standards state how well the operational tasks need to be performed in order to achieve specific performance levels.

**Practice:** The way in which a work process is performed; the method or techniques used to perform a process. Practice can also be used more broadly to describe the organization's overall business such as the way in which the organization handles itself with the public; the public's perception of how the organization does business (i.e., business practice).

**Process:** A series of repeated steps (or practices) that when performed in a logical order translate input into output.

[28]SCOEA, *Glossary of Evaluation and Accountability Terms,* 2001.

**Process Benchmarking:** The conduct of a study to collect data on the inner workings of a discrete process for the purpose of comparing an organization's own process to the findings.

**Process Owner:** The employee or group of employees who implement the steps involved in a particular work process.

**Project Facilitator:** The person who determines the appropriate methodology for, and oversees the conduct of, the benchmarking study.

**Project Sponsor:** The organization that requests a benchmarking study and provides the financial means to conduct the study. This is the organization that intends to utilize the benchmark data in order to make changes internally.

**Protocol:** In benchmarking, this refers to the tool that includes the questions of interest in the study. Once the sponsor indicates the processes and/or metrics of interest to be studied, questions are articulated in the protocol based on the method of data collection chosen. For example, in a focus group protocol, questions will encourage participant interaction and should be open ended. A survey may include open-ended questions for the purpose of qualitative data collection and closed-ended questions to collect quantitative data for statistical analysis. Quantitative measures are often used to identify trends or ways in which the organizations measure and report their performance.

**Strategy:** A future-oriented systematic plan of action that outlines the direction an organization needs to take by including specific objectives and the steps necessary to meet articulated goals.

**Strategic Benchmarking:** The act of engaging in a strategic alliance with other organizations for the purpose of continuous learning from one another and to aid in the adaptation of effective strategies for implementation with the goal of improving performance.

**Strategic Planning:** The process an organization uses to articulate its desired direction and identify resources required to meet stated goals.

**Subject Matter Expert:** An individual who has direct knowledge of the work requirements and activities within an organization; typically an incumbent of the job or key stakeholder to the organization.

**Sulfur Oxides (SOx):** A group of highly reactive gases, which result largely from fossil fuel combustion at power plants and other industrial facilities. However, the burning of high-sulfur fuels by locomotives and large ships can have a significant effect on local or regional concentrations of SOx. SOx emissions can react with other compounds in the atmosphere to form small particles. These particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease and can aggravate existing heart disease.

**Supply Chain:** The system of organizations, people, technology, activities, information, and resources involved in moving a product or service from supplier to customer. Modern supply chains are often multimodal, including truck, rail, marine, and air modes of transport. Shippers and receivers may conduct environmental benchmarking at the level of the supply chain; in those cases, freight transportation will be only one of several sources of environmental impacts.

**Survey:** An inventory of questions administered to a representative sample of individuals across targeted partner organizations or within a functional area in the organization for the purpose of collecting data on specific activities to help identify processes of interest in a benchmarking study.

**Vision:** A statement about what the organization hopes to achieve; a message of inspiration to its employees that states how the organization wants to be viewed by the public.

APPENDIX B

# Benchmarking Programs

**Exhibit B-1. Freight environmental benchmarking and other related programs.**

| Program | Brief Description, Cost, and Link |
|---|---|
| **EPA SmartWay Transport Partnership** | EPA developed SmartWay Transport—an innovative collaboration between the freight industry and government to reduce air pollution and greenhouse gas emissions, improve fuel efficiency, and strengthen the freight sector.<br><br>SmartWay Transport's goals are to reduce the impact of freight transport on the environment and to help partners see the rewards to their businesses.<br><br>Working together, the partnership will reduce<br>• Fuel consumption from trucks and rail delivering freight,<br>• Operating costs associated with freight delivery,<br>• Emissions of $CO_2$, and<br>• Emissions of NOx, PM, and air toxics.<br><br>Cost: Free<br><br>http://www.epa.gov/smartway/transport/index.htm |
| **Clean Cargo Working Group, Business for Social Responsibility** | Connect with 27 leading multinational manufacturers (shippers) and freight carriers and forwarders (carriers) dedicated to integrating environmentally and socially responsible business principles into transportation management.<br><br>Gain access to the work, tools, and best practices of the group developed over the last 8 years, including a customized, intermodal $CO_2$ calculator and performance survey results.<br><br>Cost: Unknown fee associated<br><br>http://www.bsr.org/consulting/working-groups/clean-cargo.cfm |
| **American Society of Quality (ASQ)** | Offers two benchmarking options: technical and competitive. Although these are not specifically focused on environmental issues, the most relevant is competitive. Through ASQ's competitive benchmarking process, organizations and businesses can compare how well (or poorly) they are doing with respect to the leading competition, especially with respect to critically important attributes, functions, or values associated with the organization's products or services.<br><br>Sample questions asked of participating organizations include, "On a scale of one to four, four being best, how do customers rank your organization's products or services compared to those of the leading competition?" If organizations cannot obtain hard data, marketing efforts may be misdirected and design efforts misguided.<br><br>ASQ certification required, for a fee<br><br>http://www.asq.org/learn-about-quality/benchmarking/overview/overview.html |
| **Eco Responsible Packaging Program, UPS, Inc.** | UPS, Inc. has launched a service it says will evaluate customers' packaging processes based on environmental standards and give a score from its assessment. Under the Eco Responsible Packaging Program, UPS will rate packaging based on damage prevention, the sizing of packaging, and the materials used in the packaging, for shippers who join the program. UPS will then give the shipper a score, and if the shipper meets the program's requirements, the company will allow it to use the program's logo on its packaging. |

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**Exhibit B-1. (Continued).**

| Program | Brief Description, Cost, and Link |
|---|---|
| | The three areas on which the program focuses center on environmental sustainability, UPS said. The service is contractual, and pricing is determined on a project basis.<br><br>Cost: Free<br><br>Relevant Article in Transport Topics: http://ttnews.com/articles/basetemplate.aspx?storyid=24219<br><br>UPS Site: http://www.ups.com/ecoresponsible?srch_pos=1&srch_phr=eco+responsible+packaging+program |
| **Private Fleet Assessment Program** | The NPTC Private Fleet Assessment Program delivers information needed to optimize the performance of a private fleet.<br><br>Businesses can benchmark fleet operations with an interactive, Web-based, confidential resource, using world-class standards derived from hundreds of industry benchmarks and subject matter experts. The program allows firms to improve performance, measuring 40 key metrics across eight pillars: safety and fleet organization, network planning, customer management, fleet management, information management, driver management, continuous improvement, and financial management.<br><br>The assessment program can drive critical improvement with a detailed roadmap from industry experts. Companies can track performance with customized reports comparing individual fleet performance against best-in-class operations.<br><br>Cost: Unknown fee associated<br><br>http://www.nptc.org/index.php?option=com_content&task=view&id=548&Itemid=379 |
| **Carbon Disclosure Project** | The Carbon Disclosure Project is an independent not-for-profit organization holding the largest database of primary corporate climate change information in the world. Thousands of organizations from across the world's major economies measure and disclose their greenhouse gas emissions, water use, and climate change strategies through CDP.<br><br>https://www.cdproject.net/en-US/Pages/HomePage.aspx |
| **Truckload Carriers Association Benchmarking Program** | TCA, with the assistance of the company Decisiv Best Practices, conducts a benchmarking program that enables truckload carriers to compare operating benchmarks and identify best practices that contribute to superior performance. Participating carriers are segmented into groups of 12 to 20 companies according to carrier specialties (e.g., refrigerated, dry van, flatbed). Every month, participating carriers submit their financial statements to Decisiv, which in turn produces a financial composite that ranks the carriers according to key factors. Decisiv sends each member a copy of its group's composite that contains the comparative statistics compiled from their statements. The groups meet three times per year for a period of 1 to 2 days each to share their best practices and processes that aid them in reducing costs and improving efficiencies. Environmental performance is not an explicit focus of this benchmarking initiative, but the program monitors fuel efficiency as an operating metric and thus has relevance to air emissions. |
| **Supply Chain Consortium** | Tompkins Supply Chain Consortium is a supplier of supply chain benchmarking and best practices knowledge. With more than 500 participating retail, manufacturing, and wholesale/distribution companies, the consortium sponsors a comprehensive repository of 17,000-plus benchmarks complemented by search capabilities, online analysis tools, topic forums, and peer networking for supply chain executives and practitioners. The program focuses on operations, but includes metrics relevant to environmental benchmarking. |
| **Dow Jones Sustainability Index** | The Dow Jones Sustainability Indexes were launched in 1999 as the first global sustainability benchmarks. The indexes are offered cooperatively by SAM Indexes and Dow Jones Indexes, the marketing name and a licensed trademark of CME Group Index Services LLC. The family tracks the stock performance of the world's leading companies in terms of economic, environmental, and social criteria. The indexes (1) serve as benchmarks for investors who integrate sustainability considerations into their portfolios and (2) provide an effective engagement platform for companies who want to adopt sustainable best practices. |
| **American Productivity and Quality Center (APQC)** | APQC is the leading source for best practices and performance benchmarks. APQC has one of the world's largest databases that is based on more than 8,500 benchmarking and best-practice studies. Although not specifically focused on environmental issues, some of APQC's productivity metrics are relevant to environmental performance. |
| **International Organization for Standardization** | ISO (International Organization for Standardization) is the world's largest developer and publisher of international standards. The ISO 14000 family of standards addresses various aspects of environmental management. The very first two standards, ISO 14001:2004 and ISO 14004:2004 deal with environmental management systems (EMS). ISO 14031 deals with environmental performance evaluation. These standards are applicable to designing appropriate benchmarking measures and managing environmental performance. |

## Exhibit B-2. International freight environmental benchmarking programs.

| Program | Brief Description, Cost, and Link |
|---|---|
| **Transport Canada, ecoFreight** | The ecoFreight program is intended to help the freight sector in finding solutions to help reduce GHG emissions, thereby contributing to meeting Canada's target of a 20 percent reduction in GHG emissions by the year 2020.<br><br>As part of this program, the Canadian government and several freight industry associations have established voluntary agreements with emission reduction targets, action plans to achieve those targets, and mechanisms for reporting on progress. The Air Transport Association of Canada has agreed to assist its members to improve their energy efficiency by an average of 1.1 percent a year. Through the Railway Association of Canada, the major Canadian railroad companies agreed to meet aggregate GHG emissions intensity levels (emissions per productivity unit).<br><br>Cost: Free<br><br>http://www.tc.gc.ca/eng/programs/environment-ecofreight-about-voluntary-voluntaryagreementsrail-83.htm<br>and<br>http://www.tc.gc.ca/eng/programs/environment-ecofreight-about-voluntary-racemissions2007-executivesummary-382.htm |
| **Clean Transport (Transporte Limpio), SEMARNAT, Mexico** | Sister program to US SmartWay program. Clean Transport is a voluntary national program developed by the Department of Environment and Natural Resources (SEMARNAT), the Ministry of Communications and Transport (SCT), the National Commission for Energy Efficiency (CONUEE), and industry representatives with the aim of transporting cargo and passengers traveling on the country's roads. Goals are to reduce:<br>1. Fuel consumption,<br>2. Emissions of greenhouse gases and criteria pollutants (NOx and $PM_{10}$), and<br>3. Operating costs of transport.<br><br>This is achieved with the adoption of strategies, technologies, and best practices that make transport more efficient, safe, and sustainable, thus enhancing the competitiveness of the sector.<br><br>Cost: Free<br><br>English Translation of Semarnat Site: http://www.semarnat.gob.mx/English/Pages/home.aspx<br><br>English Translation of Clean Transport Site: http://translate.googleusercontent.com/translate_c?hl=en&ie=UTF-8&sl=es&tl=en&u=http://app2.semarnat.gob.mx/Transporte/&rurl=translate.google.com&twu=1&usg=ALkJrhiiUWYVxzqWb8VCdQdRswNpoKpYuQ# |
| **Sustainability Covenant, Victorian Transport Association, Australia** | Australian-based "SmartWay" program launched in September 2009.<br><br>Designed for VTA member companies and other freight-related business to<br>• Recognize industry leadership and excellence in achieving sustainable outcomes.<br>• Enhance the development and application of sustainability measurement tools in the freight and logistics industry.<br>• Build capacity among VTA members and other freight-related businesses to integrate sustainability principles and continuous improvement processes into core business practices.<br>• Encourage innovation and information on sharing in the industry on best practices to achieve sustainability outcomes.<br>• Identify new services or initiatives that the parties can develop to reduce the freight sector's overall contributions to air pollutant emissions and greenhouse gases.<br>• Identify opportunities and appropriate mechanisms to encourage waste avoidance and waste reduction and improve overall resource efficiency.<br><br>Cost: Free<br><br>http://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256ce90001cbb5/b19c9bfc0e3bcc73ca25760200254e5c/$FILE/1295.pdf<br><br>EPA Victoria Main Website: http://www.epa.vic.gov.au/ |

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**Exhibit B-2. (Continued).**

| Program | Brief Description, Cost, and Link |
|---|---|
| **Natural Resources Canada, ecoENERGY for Fleets** | ecoENERGY for Fleets is a program, offered by Natural Resources Canada, introducing fleets to energy-efficient practices that can reduce fuel consumption and emissions.<br><br>Members have access to training and education tools that help owner-operators, commercial and institutional fleet owners, and managers improve the energy efficiency of their operations, which include the following:<br>• SmartDriver training provides a unique combination of knowledge sharing, coaching, and/or on-the-road training.<br>• The Fuel Management 101 workshop is designed to help the fleet managers prepare a fuel management plan, implement the plan, and measure and monitor its success.<br>• Members receive the *FleetSmart on the Road* newsletter.<br>• Web tools offer support to assist with energy efficiency practices and techniques.<br><br>One study, *Fuel Efficiency Benchmarking in Canada's Trucking Industry*, surveyed private and for-hire trucking fleets based in Canada, focusing on transport fleets operating Class 7 and 8 power units. It aimed to measure the effectiveness of fuel efficiency benchmarking in an effort to help the inter-city trucking industry further reduce its energy consumption and curb GHG emissions. This survey confirmed that fuel efficiency benchmarking is an important and valuable exercise.<br><br>Cost: Free<br><br>ecoENERGY for Fleets Main Page:<br>http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=docs.view&id=5<br><br>Supporting tools: http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=fleetsmart.fuel&attr=16<br><br>Fuel Efficiency Benchmarking Study:<br>http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=docs.view&id=2 |
| **U.K. Freight Best Practice Program** | Freight Best Practice is funded by the U.K.'s Department for Transport to promote operational efficiency within freight operations. The program offers free essential information for truck operators covering the following topics:<br><br>• Fuel saving (fuel efficient truck drivers handbook, fuel saving devices, etc.);<br>• Equipment and systems (routing and scheduling, truck aerodynamics, etc.);<br>• Performance management (key performance indicators, monitoring $CO_2$ emissions, etc.);<br>• Multimodal (multimodal solutions, etc.); and<br>• Developing skills (safe driving tips, freight quality partnerships guide, etc.)<br><br>The program has been extended to the van sector and will be extended to the rail and water freight industries in the future.<br><br>To take the example of external benchmarking, a series of guides have been produced with information gathered by survey from key players in a range of industry sectors. For each, a separate guide has been produced, presenting the results of the same five key performance indicators (KPIs). These are<br>• Vehicle fill,<br>• Empty running,<br>• Time utilisation,<br>• Deviations from schedule, and<br>• Fuel consumption.<br>The results provide best-in-class information for the transport manager to use to compare, contrast, and target their own operations. The variations between different operations efficiency can be significant; for example, in the next-day parcel delivery sector, the proportion of empty running varies between fleets from zero to 50 percent of the time. Once the factors that influence this can be understood, they can be used to help managers modify their operations to achieve benefits.<br><br>The FBPP also provides a mechanism for the fleet manager to accurately measure KPIs within their own fleet or internally benchmark. The program also offers a stand-alone and downloadable Fleet Performance Management Tool. This tool allows carriers to monitor their performance for any number of vehicles over any number of years. In addition to traditional operational performance metrics, it calculates $CO_2$ emissions and will show $CO_2$ emission per kilometer or per unit carried per kilometer (e.g., per ton-km). |

**Exhibit B-2. (Continued).**

| Program | Brief Description, Cost, and Link |
|---|---|
| | A recent addition to the program is a new tool called On Line Benchmarking (OLB). This new system, funded by the Department for Transport, allows truck carriers to benchmark their operations externally and anonymously. This tool includes KPIs related to fuel use and $CO_2$ emissions.<br><br>Cost: Free<br><br>http://www.freightbestpractice.org.uk/<br><br>http://www.freightbestpractice.org.uk/performance-management<br><br>Freight Best Practice Online Benchmarking: http://www.onlinebenchmarking.org.uk/<br><br>Van Best Practice Program: http://vanbestpractice.businesslink.gov.uk/cms/ |
| **Energy Saving Trust, U.K.** | Conducts free Green Fleet Reviews for fleets of over 50 vehicles, as well as providing advice to smaller fleets to help them cut costs and emissions. Works to provide organizations with tailored fleet management advice to help lower running costs, reduce environmental impact, and enhance corporate social responsibility. Funded by the Department for Transport, the Welsh Assembly Government, and the Scottish Executive, Green Fleet Reviews are carried out by specialists with a wide spectrum of experience working with a range of fleets.<br><br>Includes a calculator that allows fleet operators to calculate savings.<br><br>Cost: Free<br><br>Green Fleet Review: http://www.energysavingtrust.org.uk/business/Business/Transport-advice/Advice-for-organisations/Fleets-over-50-vehicles/Green-fleet-consultancy<br><br>Savings Calculator: http://www.energysavingtrust.org.uk/business/Business/Transport-advice/Calculate-your-fleet-savings |
| **Safe and Fuel Efficient Driving (SAFED), U.K.** | Includes eco-driving for van and heavy goods vehicle (HGV) drivers. This program teaches road skills to help industry increase safety as well as reduce fuel costs and emissions. To date, the program has provided most of the cost of training for 800 instructors; 12,000 HGV drivers; and 7,500 van drivers.<br><br>SAFED was originally launched in 2003 for drivers of HGVs in England. It was developed with the backing of the Department for Transport (DfT) and has since been extended to cover drivers of vans and PCVs (Category D only) and to HGV and van drivers in Scotland. Government subsidies are currently available to support the cost of training of van and PCV drivers and of HGV drivers in the aggregates sector. Since its inception in 2003, SAFED has trained in excess of 25,000 drivers of commercial vehicles. It can even form part of the Driver CPC periodic training that is required for HGV and PCV drivers.<br><br>Over 200 commercial training providers are currently authorized to deliver SAFED on behalf of the official DfT SAFED programs. A significant number of organizations have taken the "in-house" route, with nominated individuals delivering SAFED to their colleagues.<br><br>Cost: Free through subsidy<br><br>Main Site: http://www.safed.org.uk/ |
| **U.K., Logmark (Chartered Institute for Logistics and Transport)** | Logmark is the leading logistics and supply chain benchmarking club in the U.K., helping organizations improve efficiency and save money.<br><br>Logmark can enable a company to confidentially and anonymously measure internal performance with other Logmark member organisations. It enables best practice and business improvements to be identified by comparing "best in class." It also provides networking opportunities and the option to discuss widespread business challenges in a non-competitive environment.<br><br>Logmark members can attend quarterly meetings and complete the annual Logmark survey. The survey covers a variety of business operations including: operations, environmental, HR, economic outlook, inventory, business risk, transport, and lean. |

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**Exhibit B-2. (Continued).**

| Program | Brief Description, Cost, and Link |
|---|---|
| | Each Logmark member then receives a confidential, tailored report based on the questions they elected to complete. The report details the average, maximum, minimum, and median responses to each question.<br><br>Cost: Fee associated with becoming a Logmark Member<br><br>http://www.ciltuk.org.uk/pages/logmark |
| **France, Charter of Voluntary Commitments to Reduce $CO_2$ Emissions** | The Charter of Voluntary Commitments to Reduce $CO_2$ Emissions was developed by the Ministry of Ecology and ADEME (French Environment and Energy Management Agency), in collaboration with the main professional organizations and 15 carriers.[29]<br><br>It allows all carriers, regardless of their size and business, to commit to 3 years in a concrete action plan and customized to reduce fuel consumption and hence emissions of $CO_2$ (the main greenhouse gas). This approach provides companies with a consistent methodological framework, reliable and nationally recognized within the framework of the activities of the Centre for Energy Environment Transport.<br><br>The program does not yet rank or rate carriers based on environmental performance, but it is working toward that goal. The program is working on a future environmental label for rewarding companies that have a level of environmental performance above average and ranking them according to their level of performance.[30]<br><br>ADEME also funded the development of an online benchmarking tool called ConsoComparateur, which allows carriers to calculate the fuel efficiency of individual driver-truck pairs to reference values for similar vehicles in similar operating conditions.<br><br>Cost: Free to join<br><br>http://www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=22274<br><br>PowerPoint Overview of Program: http://www.climatetransact.eu/Objectif%20CO2.pdf |
| **Japan, Green Distribution Partnership** | In Japan, the Energy Conservation Law obliges large shippers and carriers (more than 200 trucks) to improve the energy efficiency of their operations by 1 percent annually. They have to submit an Energy Saving Plan once a year and to report their annual energy use. Japan's Green Distribution Partnership was established in 2005 to promote cooperation between shippers and carriers. This partnership includes the promotion of best practices, the establishment of a calculation method for $CO_2$ emissions, and recognition of efforts. Advanced logistics models and freight consolidation projects are funded by the program.<br><br>The program is managed by the Japan Institute of Logistics Systems; Japan Federation of Freight Industries; the Ministry of Economy, Trade and Industry (METI); the Ministry of Infrastructure, Transport and Tourism (MLIT); and the Japan Business Federation (Nippon Keidanren).<br><br>The program has about 2,900 members, including carriers, shippers, and related associations.<br><br>Cost: Free<br><br>www.greenpartnership.jp<br><br>English Article: http://www.japanfs.org/en/pages/026766.html |
| **Netherlands, Sustainable Logistics Innovation Program** | Considered to be a version of the European SmartWay approach. It evaluates ITS, travel information standards for public transport, and logistics. The companies involved in the program are leaders in the network of shippers, carriers, and municipalities in the Netherlands. |

[29]http://www.epa.gov/smartway/transport/documents/international/gerald-lalevee-france.pdf
[30]http://www.epa.gov/smartway/transport/documents/international/gerald-lalevee-france.pdf

**Exhibit B-2. (Continued).**

| Program | Brief Description, Cost, and Link |
|---|---|
| | The freight transport strategy includes ensuring access to and from the main ports, stimulating the industry to improve supply chain management competences, reconciling mobility and environment objectives, and programming sustainable logistics.<br><br>GHG emissions are measured using a "$C0_2$ Ruler," which provides a conceptual reporting scheme to show how participants compare to other co-transporters.<br><br>Cost: Free to join the network<br><br>Main website (in Dutch): www.duurzamelogistiek.nl<br><br>Overview Presentation:<br>http://www.climatetransact.eu/Sustainable%20logistics%20in%20the%20Netherlands.pdf |
| **Finland, Energy and Environmental Accounting and Reporting System** | A voluntary program on energy efficiency in freight transport and logistics was started in 2007 by the Ministry of Transport and Communications, Ministry of Employment and the Economy, Ministry of the Environment, Finnish Transports and Logistics Association SKAL, Association of Logistics Companies, and VR Group Ltd (Finnish Railways).<br><br>The goal is to have 60 percent of companies commit to this voluntary partnership. The program is focused on road and rail transportation and related logistics. This agreement also applies to rail carriers. An integral part of achieving these reductions is measuring improvements through an effective measurement and monitoring system based on emission data collection, analysis, and reporting. The objective is to implement measures that would save fuel consumption in road and rail transport and related logistics.<br><br>Stakeholders in the program are<br>• Transport users (shippers),<br>• Road and rail transport companies, and<br>• Public authorities.<br>This program is supported by the EMISTRA tool. The EMISTRA System is a useful and affordable tool for the transport of energy consumption and emissions monitoring and reporting. By using it, Finnish companies can determine their specific energy consumption and vehicle emissions. Carriers can also compare the results of their own activities to the average results obtained from EMISTRA's statistical database system. The EMISTRA System produces a company database with summary information on a variety of characteristics, including emissions and environmental reports on a schedule specified by the company. It also provides a summary of the individual company's performance relative to all companies included in the database. This enables companies to benefit from benchmarking techniques across the entire transport mode.<br><br>Cost: Free for any Finnish company<br><br>http://www.emistra.fi/index_emistra.asp<br><br>Statistical Database:<br>http://translate.googleusercontent.com/translate_c?hl=en&sl=fi&tl=en&u=http://www.emistra.fi/lj/Emistra/emi/reports/index.asp&rurl=translate.google.com&twu=1&usg=ALkJrhg2SJc-lJxksRrjpmIvsQ1RO-AEFg |
| **Benchmark Freight Productivity, UIC (Paris, France)** | During 2008, UIC offered their members to participate in a rail freight benchmark study. The background of the study was that, over the last years, the competition in the rail freight sector has been increased by the entrance of new private freight companies as well as that incumbent railways expanding their market into an international level. The increased competition has increased the pressure on the railways to reduce costs as well as improve their performance and productivity.<br><br>The project, Benchmark Freight Productivity, compares, in a bird's eye view, the strengths and weaknesses between the participating railway undertakings, with the aim of identifying areas for improvement. The clusters with which the railways compared their productivity were trains, wagons, locomotives, and personnel within the single wagon load and block train transports.<br><br>The study will be offered to the members on a yearly basis. This will enable the railways to measure the impact of production changes between 2 years.<br><br>Cost: Member fee associated<br><br>http://uic.asso.fr/spip.php?article1917 |

APPENDIX C

# Additional Resources

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*Abbreviations and acronyms used without definitions in TRB publications:*

| | |
|---|---|
| AAAE | American Association of Airport Executives |
| AASHO | American Association of State Highway Officials |
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI–NA | Airports Council International–North America |
| ACRP | Airport Cooperative Research Program |
| ADA | Americans with Disabilities Act |
| APTA | American Public Transportation Association |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| ATA | American Trucking Associations |
| CTAA | Community Transportation Association of America |
| CTBSSP | Commercial Truck and Bus Safety Synthesis Program |
| DHS | Department of Homeland Security |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| HMCRP | Hazardous Materials Cooperative Research Program |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991 |
| ITE | Institute of Transportation Engineers |
| NASA | National Aeronautics and Space Administration |
| NASAO | National Association of State Aviation Officials |
| NCFRP | National Cooperative Freight Research Program |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NTSB | National Transportation Safety Board |
| PHMSA | Pipeline and Hazardous Materials Safety Administration |
| RITA | Research and Innovative Technology Administration |
| SAE | Society of Automotive Engineers |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) |
| TCRP | Transit Cooperative Research Program |
| TEA-21 | Transportation Equity Act for the 21st Century (1998) |
| TRB | Transportation Research Board |
| TSA | Transportation Security Administration |
| U.S.DOT | United States Department of Transportation |