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Working to Achieve Sustainable Freight Systems

by James J. Winebrake

The global economy continues to expand, and with it, the worldwide movement of goods has accelerated. Ships, trains, planes, and trucks crisscross our planet in complex supply chains and logistics systems at a scale that is truly phenomenal. Global trade has helped raise standards of living throughout the world, but along with these benefits come significant environmental costs. In this issue of *EM*, you will find a detailed look at emissions, regulations, technology, and environmental management approaches to manage the environmental concerns of trucks, ships, trains, planes, and their supporting infrastructure.

A Harmonized Approach for Calculating Greenhouse Gas Emissions from Freight Transportation

by Suzanne Greene and Alan Lewis, Smart Freight Centre

Reducing Emissions from Freight Transportation the ‘SmartWay’

by Cheryl L. Bynum, Chien Sze, and Matthew Payne, U.S. Environmental Protection Agency’s National Vehicle and Fuel Emissions Laboratory

No Smoking, Please: The Road to Cleaner Trucks and Buses

by John Koupal, Eastern Research Group Inc.

Methane Emissions from Natural Gas Use in the Marine Sector

by James Winebrake, Rochester Institute of Technology; James J. Corbett, School of Marine Science and Policy in the College of Earth, Ocean, and Environment at the University of Delaware; and Daniel Yuska, U.S. Maritime Administration

Game Changer: Next Generation Natural Gas Trucks Provide Near-Zero Emissions

by Erik Neandross, Gladstein, Neandross & Associates

Sustainable Ports—Activities to Promote Green Freight Systems through U.S. Ports

by Michael R. Christensen, Port of Long Beach, CA

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PM File: Summing It Up

by David L. Elam, Jr.

As the year comes to an end, it’s a good time to tackle those summaries of the projects we managed during the year.

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Vol. 66, No. 12
What a year. Everything went by so fast. I can’t believe it is already time for me to write my closing message.

I remember hearing from friends who have served in this role before me that a year as President flies by and that you will struggle to accomplish everything you set out to do. It couldn’t be more true. Goals were set and intentions were high. Yet, not everything was done. It’s funny how matters of the day sometimes force priority over the best laid plans.

Dallas Baker, you did a great job prepping me for this and taking the time to help out when I didn’t know whom else to ask. You are a special person and a lifelong friend. Thank you for everything.

Jeffry Muffat, as a longtime friend and Past President willing to accept the role of Treasurer, you were a steady influence and sounding board for me through the year. Your service to this organization continues at the highest levels.

I am very happy to have grown closer to Incoming President Scott Freeburn. His friendship and insight throughout this year have been meaningful and most appreciated. He will make a strong leader for A&WMA and I look forward to the coming year. He will have all the support he needs.

The team at Headquarters has been truly remarkable. It was my privilege to work with our Executive Director, Stephanie Glyptis. She is a consummate professional and graces this organization with her talents. Lisa Bucher has a special place in my heart for tolerating my near perfect record of tardy submissions for this column. She is truly a saint. And Bill Braun for putting up with all my requests around the financials as he monitors our performance with a watchful eye.

Finally, thank you to the members for trusting me with your organization. I hope that I have not let you down and that you feel we are in a better place at the end of 2016 than we were at the beginning.

Moving into the future, I ask that we all remember why we are here: helping each other grow and develop through professional development and constructive debate. We have a special organization, and I am eager to see what it looks like in the decades to come. em
Working to Achieve Sustainable Freight Systems

A detailed look at emissions, regulations, technology, and environmental management approaches to manage the environmental concerns of trucks, ships, trains, planes, and their supporting infrastructure.
The global economy continues to expand, and with it, the worldwide movement of goods has accelerated. Ships, trains, planes, and trucks crisscross our planet in complex supply chains and logistics systems at a scale that is truly phenomenal.

Global trade has helped raise standards of living throughout the world, but along with these benefits come significant environmental costs. Our modes of freight transportation are powered almost entirely by fossil fuels; and the burning of fossil fuels is a leading contributor to anthropogenic emissions of greenhouse gases (GHGs), criteria pollutants, and hazardous air toxics. Additionally, the physical infrastructure built to facilitate goods movement and modal transfers—for example, ports and their vast array of cargo-handling equipment—represents major stationary and area sources of air and water pollution.

Nonetheless, solutions exist, and this issue of *EM* is directed at exploring the ways and means for achieving more sustainable freight systems. The first article, written by Suzanne Greene (MIT) and Alan Lewis (Smart Freight Centre), provides a uniform approach for calculating GHG emissions for supply chains through the Global Logistics Emissions Council. Standardizing methodologies for GHG accounting is critically important for successful GHG emissions management.

Focusing on the trucking sector, in the second article, John Koupal (ERG) writes about the health impacts of heavy-duty vehicles and the movement toward cleaner vehicles through technology and policy implementation. In particular, the use of after-treatment devices (stimulated by aggressive emissions standards), combined with efforts to retire older trucks, has been a successful model in the United States and one that can be replicated elsewhere.

Another option for cleaner trucks is the use of alternative fuels. In the third article, Erik Neandross (Gladstein, Neandross & Associates) discusses the role that natural gas can play as a fuel for heavy-duty vehicles. The use of low-nitrogen oxides natural gas internal combustion engines is argued as a viable solution for many of the environmental problems the sector faces, especially if the natural gas comes from renewable sources.

The fourth article, written by Cheryl Bynum, Chien Sze, and Matthew Payne (U.S. Environmental Protection Agency [EPA]), describes U.S. government efforts to encourage firms to embrace fuel efficiency and emissions improvements along the entire supply chain through the EPA’s “SmartWay” Program. This program includes more than 3,000 participants who have access to data exchanges and evaluation tools that help them achieve emissions reductions and identify other stakeholders willing to collaborate to achieve similar goals.

Moving onto global shipping, the fifth article, by James Winebrake (RIT), James Corbett (University of Delaware), and Dan
Yuska (U.S. Maritime Administration), explores the advantages and disadvantages of using natural gas as a marine fuel. Air pollution from shipping is currently responsible for tens of thousands of premature mortalities annually and efforts are underway to reduce these emissions through the use of natural gas fuels. However, the article demonstrates that natural gas fueling systems must be carefully implemented to reduce both local pollutants and GHGs.

Lastly, Michael Christensen (Port of Long Beach) describes efforts to curtail emissions at two of the busiest ports in the world: the Port of Long Beach and the Port of Los Angeles. These ports have implemented numerous programs to reduce their emissions profile, including requiring vessel speed reductions near port, providing vessel shore power from the grid, and mandating clean truck operations within the port area. These ports are an exemplar for ports worldwide.

Moving toward a sustainable freight system is one of our greatest challenges. Pressure to improve the environmental performance of goods movement will only increase as global trade continues to expand. This issue of EM provides a playbook of sorts on how different policies, technologies, and fuels can be used to reduce many of these emissions. What is now needed is the will from both the public and private sectors to implement these approaches into supply chains worldwide.

In Next Month’s Issue…

Air Quality in the Western States
Air quality issues in the Western United States can differ from those in the rest of the nation, due to differences in population, energy sources, geography, climate, and other factors. Key issues in Western states include attainment of national ambient air quality standards (NAAQS), especially ozone (including considerations of exceptional events and international emissions), and visibility/regional haze. Interstate transport measures in state plans to meet tighter NAAQS are receiving greater attention. Fire management and wood burning are key issues for Western state air quality.
A Harmonized Approach for Calculating Greenhouse Gas Emissions from Freight Transportation

This article provides a basic understanding of the GLEC Framework, a method to harmonize existing, well-respected, and commonly used approaches to calculate greenhouse gas emissions in the freight transport sector, and how it can be applied by companies and used as a basis for policy development.
Freight transport forms the backbone of today’s global economy. Materials and products manufactured in one region are transported to another region along increasingly lengthy and complex transport chains—and with increasing total greenhouse gas (GHG) emissions. Transport chains are dynamic and changing systems—often involving more than one mode of transport as the product travels to its destination, stopping at warehouses, ports, and terminals along the way. Ever-changing fleets of vehicles or vessels with varying levels of fuel efficiency are powered by different fuels. When a company wants to report their transport chain GHG emissions, finding information on these details is a challenge, one that tends to vary depending on its role in the transport chain.\(^1\)

For companies that conduct their own transportation activities (i.e., direct, or scope 1, emissions\(^2\)), visibility of the elements of the transport chain can be more straightforward; the fuel used, routes traveled amount of goods transported and other information useful for emissions estimates may be readily available. However, for those that subcontract transport (i.e., value chain, or scope 3, emissions\(^3\)), as is often the case for shippers (i.e., the companies that require their goods to be moved) and some logistics service providers (i.e., companies that organize logistics activities), these data can be much more challenging to obtain, leading to a reliance on default data that may or may not accurately represent actual transportation activities.

The GLEC Framework for Logistics Emissions Methodologies

The Global Logistics Emissions Council (GLEC), led by the Smart Freight Centre, has assembled a broad coalition of companies, industry associations, and experts to build a harmonized framework for estimating transport chain emissions. Building on a range of existing best practices, GLEC has blended elements from mode- and region-specific methodologies to create the GLEC Framework for Logistics Emissions Methodologies—the first GHG accounting methodology to be recognized as the logistics sector guidance by the Greenhouse Gas Protocol Corporate Standard, the most widely-accepted GHG accounting practice.\(^4\)

The GLEC Framework, designed to be useful for industry, strikes a balance between accuracy, simplicity, flexibility, and transparency. Such a consistent method can provide a basis for setting and meeting realistic and measurable GHG reduction goals.\(^4,5\) Extending the science-based approach to the logistics sector is increasingly being discussed. This topic was explored in the 2015 GLEC Validation Case Study,\(^6\) which demonstrated the need for additional data to be made available and a common approach to calculation of GHG emissions from the full range of logistics operations that comprise modern supply chains.

Key Elements of the GLEC Framework

GHGs are difficult to measure directly; thus, they are commonly calculated according to accepted standards. The GLEC Framework is a bottom-up, fuel-based methodology that addresses the multi-modal transport chain; emissions from each leg of a transport chain, whether air, inland waterways, rail, road, sea or transhipment centers, are totaled to understand the full transport chain impact (see Figure 1). The full methodology can be viewed online at www.smartfreightcentre.org; this article provides an overview of highlights and unique elements within the GLEC Framework.

Base Methodologies

The GLEC Framework is based on leading industry and government standards, ensuring consistency with higher-level or mode-specific practices, while addressing issues specific to the logistics sector. Building on international protocols from the Intergovernmental Panel on Climate Change and Greenhouse Gas Protocol Corporate and Value Chain standards, the framework systematically addresses the similarities and differences between best practices to build a consensus approach appropriate for this sector.

Transport Service Categories

For companies or industry groups that have ample emissions data, breaking data into meaningful subsets can be a challenge, especially when reporting emissions to clients. Yet, averaging emissions data at a high level, without differentiating between operations, can reduce the ability to understand the actual emissions (e.g., to detect [and reward] sustainability upgrades in fleets or regions; to differentiate the impact of temperature-controlled vs. ambient goods; or to understand how emissions may differ by geographic area). The GLEC Framework puts forth guidance for arranging emissions data into meaningful subsets that can be then individually targeted for reduction, or reported up the supply chain to shippers who can then gather more accurate results.

Tonne–Kilometer

The primary allocation factor for emissions calculated using the GLEC Framework is the tonne–kilometer—the amount of GHG emitted to move one metric tonne of freight one kilometer (or the imperial unit ton/mile). This measurement allows the user to recognize the GHG intensity of the actual work done. Further, knowing the tonne–kilometer allows one to decouple the information to other meaningful metrics such as the emissions per tonne of a product.
Fuel Consumption Factor
Expressed as the fuel use per tonne-kilometer, the consumption factor is essentially a fuel efficiency metric for the freight industry (think miles per gallon). Companies that transport goods more efficiently, with a lower fuel per tonne-kilometer, will have lower emissions. Consumption factors form the backbone of the Framework, which can be calculated separately for each transport service category.

GHG Emission Factors
To reach GHG emissions, the fuel component of the consumption factor must be converted. Various conversion factors, known as emission factors, exist for different fuels, regions, and life cycle phases. The GLEC Framework recommends using well-to-wheel fuel emissions, meaning that the production and distribution phase of fuel production is included in addition to its combustion. Furthermore, emission factors should be selected that are appropriate for the region in which the fuel is procured; for example, fuel produced in China may have higher emissions associated with production than fuels produced for European markets.

Reliable and Informed Reporting
The GLEC Framework provides a structure through which the logistics industry can effectively calculate and communicate their GHG emissions. A significant impediment to increased accuracy in logistics carbon footprinting is the availability of data, or the willingness to share among supply chain partners, leading many companies to rely on default data which may or may not represent actual conditions. Moving away from default data will provide companies with better resolution on the impact of their activities, minimizing risk related to unknown data, and allowing for more transparency with shareholders and stakeholders.

The information gathered using the GLEC Framework can be used for a variety of industry and government needs. First, results can be used for GHG reporting, including corporate and value chain emissions reporting, product carbon footprints, eco-labels, and carbon trading programs. GLEC’s recognition by the Greenhouse Gas Protocol allows companies to maintain agreement with this widely-used standard, as well as other methodologies. Second, reported emissions can be used to inform logistics business decisions, such as emissions reduction strategies, logistics chain design (modal or route choices, location of transfer facilities), carrier selection, and fuel efficiency monitoring. This wide range of uses underlines the importance of moving toward greater accuracy.

As the Paris Agreement shifts responsibility for reaching GHG reduction goals to individual countries, companies may be required to account for the impact of their activities on an international basis. However, introduction of different approaches in different geographical locations would lead to fragmentation in reporting given the global nature of current supply chains.
The logistics industry will certainly be an interesting test for these policies, as the transportation of goods can cross many countries on vessels that may bundle the goods of multiple companies at once. This challenge also presents an opportunity for companies to collaborate to streamline data collection and reporting. As more companies adopt the GLEC Framework, redundant data collection efforts can be eliminated and resources can be put towards improving accuracy and implementing sustainability goals.

**Conclusions**
Consistency, transparency, and assurance about the reality and reliability of the data and approach to GHG measurement and reporting are crucial if all stakeholders are to maintain confidence in the calculation outputs. The GLEC Framework provides the basis to produce results that can be used successfully in the crucial process of driving down emissions from logistics activities.

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3. Corporate Value Chain (Scope 3) Accounting and Reporting Standard; World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), 2011.
8. CEN. EN 16258: Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers); 2012.
Chances are you’ve seen—or smelled—a diesel truck or bus belching smoke. Perhaps you’ve been stuck in traffic behind an odiferous semi-truck, watched children board a school bus with exhaust that doesn’t seem very magical, or been “coal rolled” with a plume of black smoke from a jacked-up pickup truck while walking down the sidewalk.

No Smoking, Please

The Road to Cleaner Trucks and Buses
Perhaps you’ve also noticed a decrease in these “smokers” in recent years; if so, this is no accident, but the result of cleaner trucks that have evolved over the past 20 years in response to tighter emission standards. This article summarizes the contribution of diesel trucks to air pollution and health problems, milestones on the road to cleaner trucks (along with some bumps in the road), and what the future might hold.

**Truck Pollution and Health**

Air pollution from cars and trucks has been linked to premature death and serious illnesses, including respiratory disease, stroke, heart disease, and cancer. The World Health Organization estimates that urban air pollution causes more than one million deaths per year worldwide, and studies have suggested possible links between air pollution and other health problems, including developmental disabilities, Alzheimer’s disease, diabetes, and birth defects. These health problems are caused by different compounds in the air, including ozone, formed from volatile organic compounds (VOCs) and oxides of nitrogen (NOx); fine particular matter (PM-2.5), including black soot, directly emitted or formed secondarily in the atmosphere; toxic compounds such as benzene and acetaldehyde; and carbon monoxide (CO).

In the United States, motor vehicles are among the largest contributors of VOC, NOx, CO, and toxics, and contribute a significant share of PM-2.5. Concern with transport-related pollution is increased because we tend to live, work, and play close to this pollution source; nearly 60 million (or one-fifth) of people in the United States live near a major roadway, with many more spending their work or school day near a major road. Recent studies have confirmed that the concentration of pollutants is much higher within 300 meters of major roadways, and that those living within this distance from roadways suffer higher rates of illness and premature death.

**The Road to Cleaner Trucks… with Some Bumps**

Emission limits for cars were first introduced in the late 1960s, and have since been lowered many times over. Though diesel trucks are by far the largest source of transport-related PM-2.5, and contribute the majority of vehicle NOx emissions, emission limits for trucks and buses weren’t introduced in the United States until the mid-1980s. Emission limits for NOx and PM from diesel trucks were first introduced in the United States for engines built in 1985, with subsequent reductions in emission limits through the 1990s and 2000s (see Figure 1). These limits (along with a desire for improved fuel economy) led to the adoption of electronic engine controls in the 1990s, augmented by emission control systems such as Exhaust Gas Recirculation (EGR), which routes a portion of exhaust gas back into engine cylinders to inhibit the formation of NOx.

While the evolution of emission limits and technology through the 1990s provided a roadmap toward cleaner trucks, bumps in the road soon emerged. Field research showed that on whole, NOx emissions from diesel trucks built in the 1990s were not coming down as expected. Further investigation revealed that loopholes in emissions regulations were being exploited by diesel engine manufacturers to improve over-the-road fuel economy at the expense of NOx emissions, using the engine’s computer to detect when the truck was operating outside of compliance test conditions (the same issue that has recently emerged for some diesel-fueled passenger cars). When this was uncovered, offending trucks required reprogramming, and compliance procedures were tightened to require checks under a broader range of operation.

**Exhaust Aftertreatment: The Game-Changer**

In the United States, stringent PM and NOx limits for engines built in 2007 and 2010, respectively, were 90 percent lower than previous limits, leading to exhaust aftertreatment systems on most new diesel trucks and buses (see Figure 2). Diesel particulate filters (DPFs) and diesel oxidation catalysts (DOCs) have been used to reduce PM. Properly functioning DPFs filter out nearly all elemental carbon-based PM emissions (soot). Figure 3 shows a filter placed at the end of an exhaust pipe without a DPF, and with a DPF (imagine your lungs as this filter!).

Selective Catalytic Reduction (SCR) systems are used to control NOx. These units work similarly to catalytic converters on cars, but require the injection of a reductant (typically ammonia or...
urea) to convert NOx in the raw exhaust stream to nitrogen, water, and carbon dioxide. DPF and SCR systems require diesel fuel with very low sulfur content (e.g., 15 parts per million, ppm) introduced in the United States concurrently with the new emission limits. Europe has adopted “Euro VI” emission limits with similar stringency, along with low sulfur fuel. High sulfur levels in diesel fuel have delayed implementation of these limits in other countries, including China and Mexico.

Due to these standards, the U.S. Environmental Protection Agency (EPA) projects that diesel PM and NOx emissions in the United States will drop substantially in the coming decades (see Figure 4). Drops in gasoline cars and light trucks are also projected from concurrent regulations. PM and NOx from all vehicles are projected to drop nearly 90 percent between 2000 and 2030, despite growth in miles travelled.

These projections assume that exhaust aftertreatment devices are properly functioning and effective under all conditions, however. In reality, DPFs require regular regeneration to burn off accumulated soot, and are vulnerable to clogging or cracking. Recent studies have also shown that some SCR systems lose effectiveness during prolonged idle or low speed operation (typical in urban areas), leading to high NOx emissions. It will be essential to track the emissions of trucks equipped with SCR and DPFs in the field, using newer research methods such as on-board emissions measurement systems, roadside remote sensing and portable field labs, to ensure that projected reductions are indeed becoming reality.

**What about Old Trucks?**

While new emission limits are the most direct road to clean trucks, it is a long road, because older trucks can remain in use for decades until being replaced. Since older trucks are the dirtiest, a concerted effort has been made to retrofit old trucks with DPFs, rebuild engines, or replace older trucks with newer trucks, often funded with federal grants through the Diesel Emission Reduction Act (DERA). In California, the reduction of emissions from older trucks is now required by law, to ensure a timetable for getting dirty trucks off the road.

**How Low Can We Go?**

Though trucks meeting the latest emissions limits are still entering the fleet, further advances are being pursued to achieve clean air goals. California is currently considering new diesel emission limits that are 90 percent lower than the U.S. 2010 NOx limits. Recent greenhouse gas and fuel economy requirements in the United States are expected to result in higher engine efficiencies, lower rolling-resistance tires, and aerodynamic improvements that will lower NOx emissions as well. Advanced technologies and alternative fuels are also playing an important role. Compressed natural gas (CNG) and hybrid transit buses are now commonplace in many major cities, and these same technologies are being applied to delivery trucks and other specialty truck applications.
Conclusions

Stringent emissions limits and major advances in technology have soot-belching trucks and buses on their way to becoming relics of the past, although the wheels are not in motion for this worldwide. While the technology now exists to reduce diesel truck emissions several-fold from pre-control levels, barriers to implementation—be they political, economic, or technical—are slowing progress in some countries. Fuel is one issue; without implementation of clean fuel, truck emissions will remain high, along with serious health effects linked to air pollution in general and diesel exhaust in particular.

Even for countries with clean fuel and trucks in place, continued diligence is needed to ensure that emission reductions projected on paper are realized in the air. Advances in emission measurement technology can be employed to assess the emissions of trucks “in the wild,” to judge whether clean trucks are remaining clean over time and under all operating conditions. Past experience has shown that without this diligence, the road to clean trucks may encounter some detours.

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Figure 4. U.S. NOx and PM emissions from cars and trucks 1990–2040. Source: U.S. Environmental Protection Agency (EPA).
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The A&WMA App is available to all A&WMA members for **FREE** download for use on all Apple, Windows, and Android mobile devices. Remember, interactive content, such as video, audio, animations, hyperlinks, pop-up windows, and slideshows, are only available via the App.
Heavy-duty vehicles (HDVs) are the fastest growing segment of U.S. transportation in terms of energy use, greenhouse gas (GHG) emissions, and smog–forming emissions. To combat global climate change and to restore healthful air quality for the approximately 166 million Americans who reside in areas with exceedingly poor air quality, according to the American Lung Association,¹ the United States must aggressively reduce emissions. This cannot be achieved without a systematic and wide-scale transformation of today’s diesel-fueled HDVs, especially high-fuel-use heavy-heavy-duty vehicles (HHDVs), to zero- and near-zero emission vehicle technologies fueled with low-carbon fuels.
There are four unique fuel-technology combinations that currently hold the most promise to successfully achieve this transformation (see Table 1). They include two types of advanced low-emission internal combustion engines (fueled increasingly by renewable natural gas or renewable diesel); and two types of electric-drive systems (powered by batteries or hydrogen fuel cells). In looking at the next several decades, it is likely that all four of these HDV fuel-technology combinations will contribute to meeting air quality and climate change goals in varying capacities. However, when considering the emissions profiles and the timeline of commercialization, especially in the HHDV application, only one fuel-technology option can immediately begin this transformation: near-zero emission heavy-duty natural gas vehicles fueled by ultra-low GHG renewable natural gas (RNG).

**‘Near-Zero NOx’ HDV**

Earlier this year, Cummins Westport (CWI) installed a 9-liter natural gas engine in a Southern California heavy-duty truck. What was a seemingly routine installation—one that takes place in approximately two out of every three heavy-duty trucks ordered in the United States today—is changing the future of heavy-duty commercial transportation forever.

This engine is the world’s first heavy-duty engine certified to meet the California Air Resources Board’s lowest-tier optional low-NOx emission standard of nitrogen oxides (NOx) emissions of 0.02 gram per brake horsepower hour (g/bhp-hr), or below, making it more than 90 percent cleaner than the most stringent U.S. Environmental Protection Agency (EPA) heavy-duty on-road emission standard on the books today. With such incredibly low emissions, this engine is considered “near-zero NOx.” In fact, it has a similar air emissions profile to that of a heavy-duty battery electric truck plugged into the California electrical grid, one of the cleanest electrical grids in the United States.

**Super Fuel: RNG**

To complement the NOx reductions, replacing diesel fuel with traditional natural gas will reduce lifecycle GHG emissions by approximately 15 percent (see Figure 1). However, when using RNG, which is natural gas produced from renewable...
The combination of near-zero-emission natural gas engine technology and RNG fuel provides the single best opportunity for the United States to achieve immediate and substantial NOx and GHG emission reductions in the on-road heavy-duty transportation sectors.

Sources using either biological or chemical processes, GHG emissions benefits increase.

RNG provides the lowest carbon intensity of any heavy-duty transportation fuel available in the market today with lifecycle GHG emission benefits increasing to 80 percent or more and, in some cases, greater than 100 percent reduction in GHG emissions. Various forms of waste streams that are otherwise environmental hazards requiring costly treatment or processing are instead converted to energy-rich, locally-produced renewable energy sources that ultimately displace higher-pollution non-renewable fuels. This simultaneously generates significant economic value and multiple other benefits.

Even if RNG is not used as a transportation fuel and is instead used to produce electricity, it can offer several important societal benefits; these include reduction of upstream methane leakage and flaring, mitigation of catastrophic wildfires, and improvements to agricultural processes and yields. Additionally, RNG production facilities can help create local jobs and economic development in virtually any community across America.

Near-zero emission natural gas engines using RNG provide a commercially proven strategy to immediately achieve reductions in emissions of criteria pollutants, air toxins, and GHGs from the U.S. on-road HDV sector. The 9-liter,
medium-heavy-duty version of this ultra-low-NOx engine technology is being deployed today in the refuse, transit, and short-haul delivery applications. A 12-liter, heavy-heavy-duty version of the engine will be commercially available in the next year, providing diesel-like performance for tractor-trailer trucks used in goods movement trucking throughout the nation.

The combination of near-zero-emission natural gas engine technology and RNG fuel provides the single best opportunity for the United States to achieve immediate and substantial NOx and GHG emission reductions in the on-road heavy-duty transportation sectors. Equally important, major reductions of cancer-causing toxic air contaminants can immediately be realized in disadvantaged communities adjacent to freeways and areas of high diesel engine activity, where relief is most urgently needed. The alternative fuels industry has always agreed that there is no “silver bullet” when it comes to fuels and advanced transportation technologies. However, it is clear that the commercial introduction of near-zero NOx emission engines fueled by ultra-low-GHG RNG is an achievement for air quality and petroleum displacement goals that is as close to a “holy grail” solution as has ever been seen in the heavy-duty truck sectors.

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5. “LCFS Illustrative Fuel Pathway Carbon Intensity Determined using CA-GREET2.0” discussion presented by California Air Resources Board staff on September 17, 2015; and/or “LCFS Final Regulation Order, Table 6”; Note: “HASD pathway has been EER-adjusted per CARB’s formula (-22.93 base CI divided by EER of .9). For negative CI scores, the formula should require multiplying by the EER. Thus, -22.93 X .9 = -20.64 for the correct EER-adjusted CI score.”
Reducing Emissions from Freight Transportation the ‘SmartWay’

An overview of the SmartWay Transport Partnership, considered by many to be the gold standard of freight carbon accounting.
Freight, including recycled and managed waste goods, is vitally important to our economy. Annually, we move about $18 trillion dollars’ worth of goods in the United States (i.e., 63 tons per person, per year). Although critical for economic robustness, freight activity contributes to air pollution and greenhouse gas emissions. Trucking accounts for the majority of freight-based greenhouse gas emissions in the United States and elsewhere. In keeping pace with growing economies and population, freight-related carbon dioxide emissions across global regions is projected to grow by 300 percent or higher by 2050.

Greenhouse Gas and Fuel Efficiency Standards
The United States leads the world in health-based motor vehicle standards. In 2011, the United States finalized first-ever greenhouse gas and fuel efficiency standards for freight trucks. In August 2016, the United States adopted Phase 2 standards, including first-time requirements for new freight trailers. The Phase 2 standards are cost effective for consumers and businesses, delivering favorable payback periods for truck owners.

While regulations ensure cleaner, more efficient new vehicles, millions of older freight trucks remain in use. Even as new standards phase in, this legacy fleet will continue emitting high levels of greenhouse gases and other harmful air pollutants. For this reason—and because the vehicle is just one aspect of our overall supply chain—there is an urgent need for continuing innovation and collaboration on sustainable freight solutions.

The SmartWay Transport Partnership
SmartWay is a voluntary market-based program, started by the U.S. Environmental Protection Agency (EPA) and 15 “Charter Partners” in 2004, when the concept of sustainable goods movement was just emerging. Together, EPA and this handful of industry leaders formed a vision to improve environmental efficiency in transportation supply chains, while supporting economic growth.

Today, over 3,000 companies are SmartWay-registered. SmartWay’s approach to emissions assessment and reporting is widely accepted, and described by academic institutions such as M.I.T. as the gold standard of freight carbon accounting.

SmartWay catalyzes progress in fuel efficiency and emissions. By listening and working closely with business and environmental communities, SmartWay developed a portfolio of toolkits and information resources to help partners address and improve environmental performance and fuel efficiency in their supply chains.

Supply Chain Complexity and the Need for Collaboration
As transportation emerges as a significant contributor to global carbon, values-oriented consumers and investors have exerted growing influence on the market, to report and reduce carbon. Corporations are becoming more attuned to sustainability reporting, including scope 3 emissions covering freight transportation, as a normal part of business risk and governance.

However, assessing freight’s environmental impact is challenging, because freight is so complex. Countless procurement, production, distribution, delivery, and disposal (or re-use) supply chains transport an ever-growing flow of goods and materials—each managed by armies of producers, suppliers, refiners, assemblers, distributors, and retailers. As businesses strive to improve sustainability, it is critical to provide tools to help assess, coordinate, and optimize across supply chain networks.

SmartWay brings together key supply chain entities to exchange data on carbon and emissions from freight supply chains. Partners include carriers (e.g., truck, rail, barge, air, or multi-modal), shippers (e.g., retailers, manufacturers, distributors, cargo owners), and logistics firms (e.g., third- or fourth-party logistics providers—3PL or 4PL). SmartWay also has affiliates, that is, professional, trade, and public interest groups that promote program goals and educate members and stakeholders (see Figure 1).

Modal-Only Approaches versus Carrier-Specific Data
Despite the business merits of improved efficiency and reporting, companies that hire freight services find it difficult to obtain uniform data from the hundreds of carriers or logistics firms that provide these services. Similarly, carriers may be overwhelmed by multiple shipper requests. As a result, some shippers resort to using modal defaults (i.e., a generic truck factor) to calculate their freight carbon footprints. This approach—while a good start—has limited value in helping companies make the kind of informed decisions that actually improve their carbon footprint.

Carrier-specific data are critical where they’re needed to drive decisions and outcomes. Trucks carry the largest share of freight for all deliveries of up to 750 miles—and trucking is highly competitive. For many cargo routes, shippers and 3PLs can select from among hundreds of truck carriers. Since trucking fleets vary widely in environmental performance, shippers must be able to identify trucking fleets based on carrier-specific performance data in order to effectively manage their scope 3 carbon footprints.
Similarly, without carrier-specific metrics, trucking fleets lack external market pressure to improve environmental performance; they cannot benchmark against the competition or demonstrate improvement. Of course, shippers could request more detailed information from each of their carriers. Competing carriers could agree to share detailed information with each other. However, the information would be inconsistent and difficult to validate. When environmental performance can't be effectively factored into decision-making (i.e., imperfect information), the result is market failure, and we end up with a freight system not optimized for positive environmental outcomes.

SmartWay Environmental Data Exchange Framework
To address this market failure, SmartWay developed a framework to facilitate transparent and uniform exchanges of environmental data to inform the marketplace. SmartWay's assessment tools use a common platform and consistent metrics and methodologies. SmartWay partners use these tools to characterize emissions profiles.

SmartWay collects operational information (e.g., fuel used, miles travelled, cargo weight, vehicle model year, etc.) from trucking, rail, logistics, barge, air, and multimodal companies. The information is used to calculate performance data for
emissions of carbon dioxide, nitrogen oxides, and particulate matter, expressed as grams per mile and grams per ton-mile. For most shippers, the gram per ton-mile method is appropriate, as it normalizes for cargo weight. However, shippers of predominantly lightweight cargo may find the gram per mile method more useful.

SmartWay conducts multiple quality checks to ensure data integrity. These include comparing data to an expected range of values in the tools and database. Additionally, each report is individually reviewed. SmartWay also performs macro analyses to identify and correct outliers and determine industry trends, averages, and expected data ranges. SmartWay publishes information and guidelines to help companies provide accurate data and to understand performance results, so they can use this business intelligence to manage and improve environmental outcomes.

Since SmartWay tools incorporate peer-reviewed methodologies and data subject to rigorous scientific review, businesses can trust the results. SmartWay also compares partner results to national results, using EPA emissions models. This step avoids any duplication of reported carbon reductions, with a certainty unmatched by other carbon protocols or assessment tools.

### Using SmartWay Tools for Business Analytics

SmartWay collects carrier information at the fleet level—the most discrete level at which shippers hire carriers, and thus, the most effective level for decision-making. SmartWay further characterizes fleets by operational and equipment type (e.g., truckload dry van, refrigerated, tanker, and flatbed). So, rather than a generic truck factor, shippers can look at a specific refrigerated truck carrier compared to other refrigerated truck carriers. This allows companies greater transparency into their own freight operations. With this business intelligence, shippers can custom-fit carriers with each shipping need, to optimize freight performance.

SmartWay also enables carriers to see how they compare to industry peers within their market segment. Efficiency is a surrogate for economic performance, so this is valuable business intelligence for carriers. Ranking poorly against one's peers is a sign of lagging competitiveness. It signals that improvement is needed to protect market share and profits, or even stay in business.

In determining the type, amount, and detail of data information reported, SmartWay balances the need for information with the ability and willingness of companies to provide it. SmartWay's data level allows for informed decision-making, while not overburdening companies. Although it is possible to drill down to finer degrees of detail, it would be counterproductive to impose data collection requirements beyond the capabilities of participants' systems and resources, especially for a voluntary program. At some point, the burden would become too great, participation would lapse, and the program would fail to achieve its environmental aims. By focusing on the needs of businesses to have actionable information, SmartWay has identified the optimal balance of data reporting and accuracy versus reporting burden.

### Knowledge Transfer and Thought Leadership

SmartWay provides multiple forums for businesses to share knowledge and information on improving efficiency and environmental performance. For example, SmartWay works with manufacturers and suppliers to test and verify technologies, spurring technical innovation. In addition, SmartWay coordinates with EPA's National Clean Diesel Program on projects to upgrade or replace older diesel vehicles, expanding access to cleaner, more efficient equipment. SmartWay also encourages partners with communication and recognition opportunities. These include partner case studies and profiles; partner stories in articles, reports, presentations; the SmartWay e-update; webinars; and annual SmartWay Excellence Awards. The SmartWay website (http://www.epa.gov/smartway) provides a wealth of information on program offerings and resources to assist partners to improve environmental performance. And, SmartWay serves as a role model for other green freight programs globally.

### Looking Forward

Today, both U.S. and Canadian businesses participate in SmartWay. During the 2016 North American Leaders’ Summit, Presidents Obama and Peña Nieto, along with...
Prime Minister Trudeau, announced plans to expand SmartWay across North America. There is strong demand from Asia, South America, and Europe. EPA encourages and supports global green freight efforts where possible, and is working to align SmartWay reporting with other global carbon reporting systems.

To encourage more small businesses, SmartWay recently launched a new option allowing shippers to engage gradually, prior to becoming partners, and is working on a mobile reporting platform for small carriers. SmartWay covers all freight modes except ocean vessel, and is exploring options with Business for Social Responsibility’s Clean Cargo Working Group to integrate their container vessel emission factors into SmartWay, and on approaches for other ocean vessel categories.

SmartWay evaluates its direction, scope, and performance through stakeholder feedback. Comments are welcome in the partner tools and portal; via the SmartWay helpline and website; at public forums, including webinars, meetings, and conferences; and in consultations with partner account managers. Each year, SmartWay reviews this input and optimizes its tools, systems, processes, and outreach based upon that information.

In its commitment to partners and stakeholders, SmartWay helps set the pace for industry progress and advances SmartWay partner accomplishments. Their leadership and environmental achievements contribute to healthier air, save fuel and money, and help protect our planet from climate change.

Learn more:

- SmartWay. See https://www.epa.gov/smartway.
- SmartWay Transport Partnership: Driving Data Integrity in Transportation Supply Chains; EPA-420-B-13-005; U.S. Environmental Protection Agency, 2013.
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Methane Emissions from Natural Gas Use in the Marine Sector

Results from a case study conducted through the U.S. Maritime Administration’s Maritime Environmental and Technical Assistance Program (META) Program to better understand methane emissions associated with the use of liquefied natural gas as a marine fuel.
Natural Gas as a Marine Fuel

Global shipping—those vessels that cross international waters daily to distribute natural resources and finished goods to consumers—is a leading contributor of greenhouse gases (GHG) and criteria pollutants internationally. A study sponsored by the International Maritime Organization (IMO) estimates that international shipping contributes approximately 3 percent of total GHG emissions worldwide. Although this is a small percentage, emissions from ships are greater than emissions from countries such as Brazil, Canada, Australia, and the United Kingdom.1

Moreover, due to the low quality of conventional marine fuel, researchers have estimated that particulate matter emitted from global shipping could lead to tens of thousands of premature deaths annually.2 Because of these harmful impacts, the IMO and certain nations now require ships to limit their emissions (see “Global Regulations and the META Program”), and the shipping industry has joined other sectors in considering the merits of liquefied natural gas (LNG) as a feasible, economical, and low-emitting alternative to traditional petroleum fuels.

Natural gas can significantly reduce criteria pollutants from vessel operations; however, the advantages from a GHG emissions perspective remain uncertain. Liquefied natural gas production pathways are energy intensive, and the methane leakage that accompanies natural gas extraction and distribution has important GHG impacts. In addition, methane emissions from burning natural gas in marine engines (i.e., “methane slip”) can also have a negative GHG impact.

This article reports on a study conducted through the U.S. Maritime Administration’s META Program to better understand the methane slip and fugitive emissions associated with the use of LNG as a marine fuel. This study not only incorporated methane emissions from slip and bunkering leakage in its analysis, but also included state-of-the-art life-cycle modeling to account for emissions along the entire fuel production cycle (i.e., from raw material extraction to processing to distribution to use).

Bunkering and Methane Leakage and Slip

“Bunkering” represents the process by which ships refuel and store fuel. For conventional fuels, bunkering occurs through a system of hoses, valves, and vents that facilitate fuel oil transfer. For LNG, bunkering takes place in a variety of ways, but four approaches stand out:

1. **Truck-to-ship**, whereby a LNG fueling truck refuels a ship while docked;
2. **Ship-to-ship**, whereby a LNG fueling vessel refuels a ship while in harbor;
3. **Terminal-to-ship**, whereby a LNG storage terminal refuels a ship while docked; and
4. **Terminal-to-ship**, whereby a LNG storage terminal refuels a ship while docked;

Global Regulations and the META Program

The environmental performance standards of ships are largely dictated globally by the International Maritime Organization (IMO) through the International Convention for the Prevention of Pollution from Ships (MARPOL), adopted in 1973. MARPOL has been amended several times since then, with Annex VI adopted in 1997 to address air pollution, specifically sulfur oxides and nitrogen oxides. Subsequent changes have decreased allowed emissions globally and assigned areas designated as Emission Control Areas with even stricter emissions requirements. As marine fuels tend to have high sulfur content, these stricter requirements have led to exploration of different fuels, such as natural gas, for marine transportation.

In the United States, the Maritime Environmental and Technical Assistance Program (META) is actively working to understand environmental issues in the maritime industry and to assist with policy-making decisions to address these issues. Developed in 2010, META is a research and demonstration program housed within the Maritime Administration’s Office of Environment. Projects funded under META focus on emerging maritime environmental issues that impact air and water quality.

With respect to alternative fuels, the META program has supported research studies and demonstration projects on marine vessels in an effort to better understand the benefits and challenges of using non-conventional fuels. Work in this area includes investigating whether alternative fuels meet or exceed emissions regulations; determining the effects of alternative fuels on marine engines; and quantifying financial and environmental costs of alternative fuel use. Regarding liquefied natural gas (LNG), MARAD’s research has taken a comprehensive approach focusing on a range of topics from vessel conversion and bunkering to quantifying criteria pollutant and greenhouse gas emissions at the vessel and throughout the fuel cycle.

The META program partners with federal, state, and local agencies, as well as maritime industry stakeholders and academia. More information on META can be found at www.marad.dot.gov.
4. **Portable tanks**, whereby LNG fuel tanks are loaded onto a ship while docked.

Technical details and the pros/cons on each of these approaches can be found in a 2014 U.S. Maritime Administration report on this topic.

For each approach above there is potential for methane leakage, ranging from 2 to 200 gCH₄/mmBtu, depending on the application of best practices. Leakages occur through static releases (e.g., the venting of storage tanks due to heat absorption or the purging of hoses during refueling) and dynamic releases (e.g., due to external impact to a tank or inadvertent disconnection of hoses). Leakage rates are further exacerbated based on the distance and nature of natural gas transport, as well as the use and type of storage systems employed.

In addition to bunkering leakages, policy-makers are concerned about methane “slip”—defined as methane that escapes the combustion chamber as an unburned hydrocarbon. Methane slip is a function of the type of LNG engine in use, with the following three engine types being most typical: (1) lean burn spark-ignited (SI) engines operating on the Otto cycle; (2) diesel dual fuel (DDF) compression-ignited (CI) engines, operating like a lean burn engine on the Otto cycle but with diesel injection to ignite the methane/air mixture; and (3) diesel injected compression-ignited (DICI) engines, operating with...
natural gas on the Diesel cycle. Each of these is described in more detail in a companion article in this issue.\textsuperscript{4} Compression-ignited LNG engines tend to see the smallest levels of methane slip.

**Analyzing Total Fuel Cycle Emissions**

Total fuel cycle analysis calculates the total emissions profile associated with the use of a given fuel in a vessel by considering emissions along the entire “fuel cycle.” There is an extensive literature on these types of analyses, discussed in other work.\textsuperscript{7} In this article, we present emissions that encompass four main stages of the marine fuel cycle (see Figure 1).

To facilitate our analysis, we applied the Total Energy and Environmental Analysis for Marine Systems (TEAMS) model, which we developed through support from the U.S. Maritime Administration. TEAMS has been discussed in a variety of other articles, so we will not go into details here.\textsuperscript{8} TEAMS can be used as an add-on to the Argonne National Lab Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model, which is the most comprehensive alternative fuel production model publicly available. TEAMS allows modelers to evaluate very specific, user-defined marine shipping operations.

**Case Study Results**

To illustrate the impact of methane leakage and slip on total fuel cycle emissions, we present the results of a West Coast case study that examined the transportation of goods from the Port of Los Angeles/Long Beach to Honolulu, Hawaii. This case provides a good representation of a container vessel operating at two ports that either have or are considering LNG bunkering for maritime transportation. The West Coast case also provides a well-known route that can be easily characterized.

The case involves a container vessel of 32,000 deadweight tonnage with main engine power of 23,860 kilowatts and a rated speed of 22 knots. The route distance is \(\sim 2,200\) miles and takes \(\sim 130\) hours. Four TEAMS analyses were performed for this case study, each involving a different engine and fuel combination, as follows:

1. DICI Diesel-cycle engine operating on natural gas;
2. SI Otto-cycle engine operating on natural gas;
3. DICI Diesel-cycle engine operating on low-sulfur (S) marine fuel (1,000 ppm S by mass, or 0.1% S); and
4. DICI Diesel-cycle engine operating on high-sulfur residual oil (37,000 ppm S by mass, or 3.7%).

![Figure 3](image)

**Figure 3.** GHG emissions results of case analysis for spark ignition LNG engine showing impact of bunkering leakage and slip on overall GHG performance compared to low-sulfur diesel and residual fuel oil.
We applied a range of values to the bunkering process, based on best estimates from the literature. (Specific values for all inputs can be found in the aforementioned report.) We evaluated the following scenarios: (1) no bunkering emissions; (2) 0.065% bunkering leakage; (3) 0.24% bunkering leakage; and (4) 1.0% bunkering leakage. The results of those analyses on a total GHG basis (accounting for methane, carbon dioxide, and nitrous oxide and using 100-year global warming potentials of 30, 1, 265, respectively) are shown in Figure 2 for the DICI LNG case and in Figure 3 for the SI LNG case. Both figures show results for low-sulfur marine diesel and high-sulfur residual oil for comparison.

The results demonstrate the potential for LNG to provide GHG emissions reductions, even when routine (static) bunkering leakage is accounted for. Compression ignition LNG systems have the potential to reduce GHG emissions 6–15% compared to low-sulfur diesel as reported in carbon dioxide-equivalent emissions. However, LNG systems that rely on spark ignited engines face greater challenges, and the results indicate possible increases in GHG emissions 5–13%, depending on bunkering leakage assumptions. This is primarily due to the methane slip that occurs in spark ignited engines, although new engines may be emerging on the market to reduce this slip.

Conclusions
Two key findings emerge from this research. The first is that methane slip is an important factor that can determine whether LNG systems will lead to GHG emissions decreases or increases compared to conventional fuels. In the case of compression ignited LNG systems, methane slip is well controlled, and this research shows clear GHG emissions advantages compared to conventional fuel (even when routine bunkering leakage assumptions are loosened). However, in the case of spark ignited LNG systems, methane slip is more significant, and can negate the advantages of the LNG system.

The second important finding is that routine bunkering leakages can have a disproportionate impact on overall GHG emissions due to the high volume of natural gas throughput and the high global warming potential of methane. This research shows that even small bunkering leakages can have significant effects (e.g., a ~1% leakage of methane in bunkering operations led to a ~10% increase in net GHG emissions). In the compression ignition engine, this 1% bunkering leakage cut the net GHG emissions advantages of LNG from -14.9% benefit down to a -6.7% benefit compared to low-sulfur diesel fuel.

The results discussed here evaluate best available data from the literature. Additional testing and analyses are required to fully characterize methane leakage during different types of bunkering stages, as well as to evaluate methane slip during vessel operations. This is an area that remains an important source of uncertainty in terms of life-cycle releases of methane. Although there are not enough data in the literature to characterize specific types of bunkering operations (e.g., ship-to-ship vs. truck-to-ship), we believe our results can be applied generically to a whole set of bunkering approaches. Leakage issues from any bunkering operation should be carefully considered in infrastructure planning and operational purposes, and leakage emission rates need further testing under actual bunkering procedures.

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In 2006, the U.S. Ports of Long Beach and Los Angeles took an unprecedented joint action to improve air quality in the South Coast Air Basin by adopting the San Pedro Bay Ports Clean Air Action Plan (CAAP). Details of the action plan are outlined below.
The Ports of Long Beach and Los Angeles are the two busiest container ports in the Western Hemisphere, and combined are the tenth busiest ports complex in the world. The two ports handle approximately 40 percent of the nation’s containerized imports and 25 percent of its exports. Trade that flows through the San Pedro Bay ports complex generates more than 3 million jobs nationwide. The ports are capable of handling the largest container ships on the planet.

The economic engines that are the Ports of Long Beach and Los Angeles create more than just jobs. Like any large engine, they also produce significant air emissions. In order to deal with these emissions, in 2006, the ports took an unprecedented joint action to improve air quality in the South Coast Air Basin by adopting the San Pedro Bay Ports Clean Air Action Plan (CAAP, http://www.cleanairactionplan.org/about-the-plan/), a sweeping plan aimed at significantly reducing the health risks posed by air pollution from port-related ships, trucks, trains, cargo-handling equipment, and harbor craft.

The CAAP identifies strategies to reduce pollution from every source: ships, trucks, trains, harbor craft (e.g., tugs and workboats), and cargo-handling equipment (e.g., cranes and yard tractors).

**Ships**

Ships are the largest source of emissions at the ports. Cutting-edge programs have been adopted to target this pollution including financial incentives for ships with the newest engines, which are up to 80-percent cleaner than their predecessors. When ships slow down, they burn less fuel per mile traveled, which results in fewer emissions. Both ports provide financial incentives under their Vessel Speed Reduction programs for ships to reduce speeds to 12 knots when approaching the harbor. More than 95 percent of ships now reduce speed starting at 20 nautical miles (nm) from land, and more than 80 percent reduce speed at the 40-nm mark.

Ships require electrical power while at berth, which is typically generated using large onboard diesel generators. California’s new shore power regulation requires certain ships to plug into the electrical grid while loading and unloading cargo rather than using their auxiliary engines. Shore power nearly eliminates emissions from ships at berth.1 The two ports led the way through early infrastructure funding and installation and in requiring shore power through leases long before the regulation took effect.

**Trucks**

The ground-breaking Clean Trucks Program reduced carcinogenic diesel particulate air pollution from harbor trucks by more than 90 percent in a little over three years—ahead of schedule. Beginning in 2008, the ports banned pre-1989 model-year trucks followed by a progressive ban on all trucks that did not meet 2007 emission standards. This progressive ban used the following milestone dates and was accompanied by grants to help defray the cost of these newer trucks:

- **October 1, 2008:** All pre-1989 trucks were banned from entering the ports. Pre-2007 trucks were charged a clean truck fee to access port terminals.
- **January 1, 2010:** All 1989–1993 trucks were banned in addition to 1994–2003 trucks that had not been retrofitted.
- **January 1, 2012:** All trucks that did not meet the 2007 U.S. Federal Clean Truck Emissions Standards were banned from the ports.

**Trains**

The San Pedro Bay ports complex is home to the cleanest locomotive fleet in the country, operated by the Pacific Harbor Line (PHL), a “switching” railroad that helps assemble and disassemble trains destined for nearby railyards. The CAAP also requires “line-haul” locomotives, which move cargo over long distances, to meet the aggressive replacement schedules under the state’s memorandum of understanding with the railroads and the U.S. Environmental Protection Agency’s tough new locomotive engine standards.

**Cargo-Handling Fleet**

The ports are home to one of the cleanest cargo-handling fleets in the country, thanks to state regulations and grant
funds for equipment replacement. The ports have also secured millions of dollars in federal funding to replace and upgrade older diesel equipment ahead of state regulations, and their terminals are among the first to test out the latest zero-emissions yard tractors and cranes.

Harbor Craft
The Port of Long Beach makes sure harbor craft, like tug boats, work boats, and crew boats, meet California’s stringent engine requirements, which require them to plug into shore power while not in use. In addition, the port is proud to have the world’s first hybrid tugboat, which demonstrates a commitment to reducing harbor craft emissions and to developing innovative technologies.

The Future
The shift to zero-emissions electric cargo movement will boost the demand for energy. That’s why both ports are looking at ways to meet future energy demand in a more sustainable and resilient way. The Port of Long Beach’s Energy Island initiative calls for renewable energy sources, alternative fuels, self-reliance, and energy-related operational efficiencies.

The ports are committed to encouraging the development of cutting-edge emission-reduction technologies and have set aside money each year for the Technology Advancement Program (TAP), which provides funding, guidance, and staff support to test promising air technologies in a real-world port environment. The goal is to introduce successful technologies to the port market as quickly as possible, accelerating these technologies from testing to commercialization and—ultimately—widespread adoption.

Looking toward the future, the ports have released a technology inquiry to obtain information about hybrid, near-zero, and zero-emission cargo handling equipment technologies in preparation for grant opportunities anticipated in fiscal-year 2017. The ports intend to apply for grants as appropriate, working with technology manufacturers and terminal operators as partners. In order to identify potential technology partners, the ports are collecting information about applicable technologies and the associated technology company experience. This information may also be used to connect interested terminal operators to technology companies for future demonstrations. The goal is for the ports to maintain up-to-date information on potential demonstration partners so that as new grant funding programs are released the ports will be able to respond in an effective and timely manner.

It’s not enough to just set aggressive emission-reduction goals. The goals must be met. That’s why the ports track progress on a regular basis through detailed emissions inventories, real-time air monitoring, and extensive reports on our technology demonstrations. Since 2005, port-related emissions have dropped 85 percent for diesel particulate matter, 50 percent for nitrogen oxides, and 97 percent for sulfur oxides—far exceeding the 2014 CAAP goals, well on the way to meeting the 2023 goals.
CAAP 2017
The ports envisioned the CAAP as a “living document,” and have periodically reviewed and updated it. A recently-released draft update, referred to as “CAAP 2017”, includes enhanced emissions reduction strategies in all areas of port operations and is now under review.

Recently, the ports have obtained the necessary federal agency approval and executed a joint-port agreement that allows a CAAP-style joint-port stakeholder-involved program to improve the efficiency of goods movement through the ports. Over 50 working group sessions have been held towards this end, and a number of Supply Chain Optimization initiatives have been launched. Efficiency improvements in port operations not only increase cargo velocity and enhance schedule reliability, they also reduce environmental impact. Fewer truck movements mean less fuel burned, lower emissions, and reduced carbon footprint. California resource agencies are counting on freight efficiency improvements resulting in a 25-percent improvement in goods moved per unit of greenhouse gas emitted.

Furthermore, information technology applications are showing great promise in making intermodal transfers much more efficient, less polluting, and more profitable with minimal investment, so much so that three federal agencies have convened working groups to explore these options.

The Clean Air Action Plan and Supply Chain Optimization initiatives promise to promote green and sustainable freight systems at the ports for years to come, benefiting all stakeholders ranging from local communities to national consumers and all those in between.
As the year comes to an end, it’s a good time to tackle those summaries of the projects we managed during the year. Yes, we planned to write them immediately upon project completion but found ourselves too focused on the next project to spend time reflecting on work that had ended. But as we have discussed in past columns, project summaries are important tools that can serve our clients, benefit our employers, and support our careers. Complete, informative, and accurate project summaries are critically important today, given that so much of what we will do tomorrow depends on what we did yesterday. Accordingly, a project summary must communicate more than the work that was performed, it must also contain information that describes transferrable skills, insights, or benefits.

A project summary can take a variety of formats, but a simple Word template that captures the following information will support a wide range of future uses.
1. **Scope of Work:** Summarize the work that was performed using keywords and acronyms. When using acronyms, take the time to define them, so that project summaries can be searched in a variety of ways by a variety of people. Simply produce a narrative that describes the work that was performed.

2. **Project Objectives:** Describe the project objectives even if you believe they are apparent from the narrative you prepared for the scope of work. When you document project objectives, you will be able to draw on experience when a future assignment requires similar project objectives with a different scope of work.

3. **Project Owner or Client Contact Information:** You’ll need this information if you are asked to provide a reference. When asked for a reference, obtain permission from the project owner or client before sharing their contact information. Instead of sharing the contact information, consider asking the project owner or client to contact the firm requesting a reference, allowing them to maintain privacy and manage the interaction.

4. **Project Location(s):** Past experience in specific project locations can sometimes be more important than the work that was performed at that location. For example, the fact that you were able to mobilize a team to a remote location in Alaska to perform an ambient air monitoring project may be more important than the number of industrial hygiene monitoring projects you’ve performed when you’re pursuing add-on industrial hygiene work in Alaska.

5. **Performance Period or Schedule:** Including the start and end dates allows you to evaluate the relevancy of a historical project to current conditions. A remediation project performed 15 years ago using best practices isn’t going to be as impressive as a project performed 2 years ago using best practices when you are pursuing new work.

6. **Project Value:** Document the project value and provide information about change orders and performance against budget. If you have performed the work under contract, be sure to include the contract type. You’ll be able to use this information to document responsible fiscal management of projects, a metric that is widely transferrable.

7. **Project Benefits:** The benefits the project yields should align with the project objectives; however, you’ll want to go further and detail project benefits in terms that are independent of time or current economic conditions. For example, if the project reduced natural gas consumption, document the results in dollars saved, percent saved, cubic feet of gas saved, return on investment, and payback period. Documenting project benefits in several ways allows you to translate the project experience into metrics that are relevant to future economic conditions.

8. **Special Challenges:** Each project comes with challenges that make it distinct even if you’ve managed the “identical” scope of work several times. Document these distinctions so that you can fold that experience into future opportunities.

9. **Project Participants:** List the project team members and their roles. In addition, include subcontractors or subconsultants and their contact information. In matrixed organizations, the project manager may be the only one who knows the details of an individual’s involvement on a project—important information that can be shared during performance reviews.

10. **Deliverables:** Take time to describe the project deliverables, giving special consideration to items like progress report requirements, project meetings, and project websites. When possible, document delivery performance (e.g., “The project website, available for public review, was updated within 12 hours of owner approval.”).

Although project summaries can be difficult to prepare at project completion, they are much more difficult to prepare months or years later. As project managers, we want our work summaries to reflect our pursuit of quality results. We’re better served by developing timely, but less than perfect project summaries, closer to the period of project performance. We can then mine those “imperfect” project summaries for information that we can tailor to serve the future needs of clients, our employers, and ourselves. 

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**References**

The Saskatchewan Legislature voted along party lines on October 25, 2016, to officially oppose the federal government’s national carbon tax and to support the province’s position on climate change as outlined in its *Climate Change White Paper*.

In the *Climate Change White Paper* released October 18, 2016, Premier Brad Wall said taxation was the most economically harmful and least effective way to combat climate change, compared to adaptation and innovation. Following the vote in the Saskatchewan Legislature, Wall said a carbon tax should not be imposed on Saskatchewan until all jobs lost in the resource sector, estimated at about 12,400, are recovered.

Saskatchewan’s *Climate Change White Paper* calls for, among other things:

- doubling the federal funding for climate change adaptation research, planning, and infrastructure, specifically targeting regions most affected by the impact of climate change;
- supporting the Crop Development Centre and the Global Institute for Food Security as they develop crops better able to withstand climate change while effectively fixing greenhouse gases to the soil;
- working with the federal government to develop “transformational clean energy technologies,” such as the next generation of carbon capture and storage technology for coal plants, that can be exported; and
- increasing renewables to 50 percent of SaskPower’s generating capacity by 2030.

—by David de Jong, EcoLog.com

The federal House of Commons Standing Committee on Environment and Sustainable Development is seeking stakeholder input for its review of the Canadian Environmental Protection Act, 1999 (CEPA, 1999).

Stakeholders may address, among others, the following themes identified by the committee:

- assessment of the Chemicals Management Plan;
- risk management, including pollution prevention planning and virtual elimination;
- integrating environmental justice into assessments and management of substances, and public participation in CEPA, 1999;
- the respective roles of CEPA, 1999 and other federal Acts and programs for managing substances, pesticides, etc.;
- monitoring the National Pollutant Release Inventory;
- air quality and drinking water standards; and
- government operations on federal and Aboriginal land enforcement.

Written briefs should be submitted to Cynara Corbin, the Clerk of the Committee at envi@parl.gc.ca by December 1, 2016.
The Ontario Ministry of the Environment and Climate Change is proposing a number of amendments (http://www.ebr.gov.on.ca, Environmental Bill of Rights Registry Number: 012-7600) to the technical guide that accompanies its Renewable Energy Approval Regulation to take into account a number of amendments to the regulation that came into effect May 1, 2016.

The Technical Guide to Renewable Energy Approvals provides an explanation of how to complete an application for a Renewable Energy Approval in accordance with the requirements of the Renewable Energy Approval Regulation (O. Reg. 359/09) under the Environmental Protection Act.

The Renewable Energy Approval Regulation is part of the Ontario government’s Green Energy initiative to expand renewable energy generation, encourage energy conservation and promote the creation of clean energy jobs. The Renewable Energy Approval process is based on clearly communicated complete submission requirements, whereby proponents of renewable energy projects know in advance what studies and reports are expected of them in preparing a complete application for a Renewable Energy Approval.

British Columbia Fines Total over $250,000 in Q4

The British Columbia (B.C.) Ministry of Environment released recently the fourth Quarterly Environmental Enforcement Summary for 2015.

The fourth quarterly summary reports on enforcement actions taken from October 1, 2015 to December 31, 2015. It outlines four orders, 78 administrative sanctions, two administrative penalties, 589 tickets, and 24 court convictions, resulting in more than $250,000 in fines. Administrative penalties and Orders to Remedy have been added for the first time in the fourth quarterly summary.

The release of the fourth quarterly summary marks 10 years of published environmental enforcement summaries. Since 2006, more than 23,000 enforcement actions have resulted in more than $9 million in fines.
The Year of BIG Changes at IPEP

It has been a year of big changes at IPEP, and as we look forward to 2017, there are even more exciting things to come.

If you haven’t already done so, please note our new location and contact information below, so we can make sure that if you’re paying by check, your 2017 QEP or EPI dues get routed to the correct address. You can always find us online at www.ipep.org.

Among the many benefits IPEP has experienced by our move to the offices of the American Board of Industrial Hygiene (ABIH) this past summer, are moving to a more digitized office, sharing operational services with ABIH, and collaborating on plans for the future, including marketing initiatives. If you happen to be a QEP and/or CIH, we’d like to hear your opinion as we consider even more ways our organizations can work together.

Also look for our new promotional video to premiere on our website and social media in early 2017. If you’d like to see us in person, our next scheduled conference appearance is at the American Industrial Hygiene Conference and Expo (AIHce) 2017 Conference in Seattle, June 4-7, 2017.

Wishing a wonderful holiday season to all A&WMA Members, as well as to our QEPs and EPIs. We look forward to continuing to serve our environmental professionals across the globe by recognizing their high standards of education, practice, and ethics, in 2017 and beyond!

IPEP
6015 West St. Joseph Street, Ste. 102
Lansing, MI 48917
Web: www.ipep.org
E-mail: ipep@ipep.org
Phone: 1-517-853-5761
Fax: 1-517-321-4624
Listed here are the papers appearing in the December 2016 issue of EM’s sister publication, the Journal of the Air & Waste Management Association (JA&WMA). Visit our website for more information.

2016 Critical Review Discussion
Emissions from oil and gas operations in the United States and their air quality implications

Review Paper
A review of the impact of fireworks on particulate matter in ambient air

Technical Papers
Dynamic comparison on the usage of probiotics in organic wastewater treatment under aerobic conditions in a diurnal environment

Laboratory investigation of three distinct emissions monitors for hydrochloric acid

Association of PM2.5 pollution with the pattern of human activity: A case study of a developed city in Eastern China

A fuel-based approach for emission factor development for highway paving construction equipment in China

Adsorption properties of regenerative materials for low concentration toluene removal

Experimental study of cross-flow wet electrostatic precipitator

Effects of aeration frequency on leachate quality and waste in simulated hybrid bioreactor landfills

Characterization of temporal variations in landfill gas components inside an open solid waste dump site in Sri Lanka

Reaction kinetics of waste sulfuric acid using H2O2 catalytic oxidation

Immobilization of Cd in landfill-leachate-contaminated soil with cow manure compost as soil conditioners: A laboratory study

Spatio-temporal analysis of traffic emissions in over five thousand municipal districts in Brazil

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