Sustainability Strategies Addressing Supply-Chain Air Emissions

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 28

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

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FOREWORD

By Joseph D. Navarrete
Staff Officer
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NCFRP Report 28: Sustainability Strategies Addressing Supply-Chain Air Emissions provides insight into the effects of policies and regulations designed to reduce supply chain greenhouse gas emissions. Both public- and private-sector decisionmakers will find the report particularly valuable, given that it provides nine suggested practices based on an extensive literature review, industry interviews, and the research team's experience. In addition, readers can explore the outcomes of actual greenhouse gas reduction initiatives through a review of domestic and international case studies included in the report.

Transportation networks are a key component of the complex, dynamic, time-sensitive, and integrated systems known as supply chains. If a transportation supply chain becomes uncompetitive, it can quickly lose market share and suffer immediate adverse economic consequences. Supply chains also affect the environment in several ways, including air emissions. The increased recognition of the environmental and human impacts of supply-chain activities may lead to public pressure to quickly implement policies to reduce these impacts. These initial efforts can sometimes result in fragmented, conflicting, and multi-layered regulatory structures. Such efforts may also make compliance challenging, impede supply-chain innovation, and, ultimately, may not achieve the desired environmental outcomes. Research was needed to help decisionmakers develop strategies and tools that would lead to sustainable outcomes that both enhance economic development and improve the environment in a socially responsible manner.

The research, led by Halcrow, a CH2M HILL Company, began with a high-level identification and assessment of potential public- and private-sector strategies to advance environmental goals through supply-chain management. These strategies were organized into nine key themes, and in-depth case studies were undertaken to illustrate the benefits of creating a "win-win" environment by incorporating changes in supply-chain tactics (including new technology) and ensuring successful implementation.

Chapter 1 provides background and describes the research method. Chapter 2 explores how stakeholders can collaborate to help balance supply-chain emissions reduction initiatives with environmental, social, and economic goals. In Chapter 3, the benefits of operational improvements are discussed, including an assessment of the extent to which these improvements are attributable to either private-sector efforts or public policy. Chapter 4 focuses on how newly implemented technologies are being used to achieve

both greater supply-chain efficiency and reduced emissions. Many companies improving their supply-chain sustainability are actively promoting their efforts; this concept of the "sustainability brand" is described in Chapter 5. The research also identified several instances of unforeseen and unintended consequences stemming from air emissions regulations; these are discussed in Chapter 6. The research culminates in suggestions that policymakers may want to consider as they address supply-chain emissions (Chapter 7). The case studies are provided in six appendices focused on the international experience, domestic examples, ports and the coastal perspectives, the inland perspective, private-sector initiatives, and supply chain sustainability metrics.

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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.

SUMMARY

Sustainability Strategies Addressing Supply-Chain Air Emissions

Background and Research Objectives

Economic activity and growth are driven by trade. This trade is facilitated by highly complex, dynamic, time-sensitive, and integrated supply chain systems that move goods across the globe between producers, manufacturers, and consumers. To remain competitive, supply chains must offer rapid, reliable, and efficient service that meets the demands of the global marketplace. However, supply chains also affect the environment and local communities as a result of air emissions from freight transportation. These emissions can affect climate change and human health.

Increased recognition of the environmental and human impacts of supply chain activities has led to public pressure for rapid action. In some cases, this has resulted in fragmented and multi-layered regulation aimed at reducing air emissions. The complexity of these regulations may make compliance challenging, impede supply chain innovation, and undermine the realization of air emissions benefits.

The objective of this research is to identify potential strategies for accelerating environmental improvement, enhancing performance, and promoting social responsibility of supply chains. The research outputs are intended to improve the understanding of decisionmakers about the impact of environmental policies and regulations on the supply chain, focusing on the interrelationships between economic drivers and air quality and greenhouse gas (GHG) policy and regulations.

Identifying sustainable approaches to mitigating the environmental and health impacts of freight transportation while supporting economic growth and job creation is a critical, yet complex, challenge confronting both the private and public sectors, neither of which can accomplish this objective on their own. Solutions, therefore, necessitate new ways of collaborating and problem solving that cross conventional jurisdictions and require close cooperation between different public agencies, as well as between the public and private sectors. Alternative approaches capitalize on the private sector's capacity for innovation and their growing commitment to sustainable development.

Study Findings

The research findings were based on a literature review, stakeholder interviews, and case studies. They are organized around five themes described in the remainder of this section.

Partnerships and Win-Win Opportunities

Win-win solutions enable a balanced realization of environmental, social, and economic considerations objectives. GHG emissions reductions present the greatest opportunity for

win-win outcomes because they are directly correlated with fuel consumed (a significant cost for carriers). Public-sector agencies have a role in supporting and reinforcing private-sector emissions reductions initiatives through regulations that establish a level playing field for private-sector emissions reductions efforts and incentivize sustainable practices. Public agencies can promote win-win solutions via a combination of enabling and restrictive mechanisms; by cooperating closely with one another; by actively engaging the private sector; through sharing best practices; and in mitigating adverse impacts on business and the economy, were possible. The research shows that the characteristics of successful public-private collaboration generally include proactive approaches to private-sector and community engagement, shared access to reliable data, careful consideration of the impacts of options and alternatives, the use of performance-based standards, and the provision of funding for emissions reductions initiatives.

Operational Optimization

Operational optimization is in the forefront for private-sector shippers and carriers. These efforts often have emissions reduction benefits. There is scope for the public sector to lend support by coordinating collaborative optimization initiatives (e.g., by helping to coordinate information between multiple intermodal terminals to improve efficiencies).

The research findings indicate that potential for emissions benefits from freight mode shift tends to be limited by the modest overlap between freight markets. In considering how to support mode shift to greener modes (e.g., rail and marine or short sea shipping), public agencies might address private-sector concerns about transit times and reliability of such modes.

Both shippers and carriers alike are realizing benefits from efficient routing and equipment use, reduced packaging, and voluntarily reducing vehicle speeds, which also have emissions reduction advantages. Some ports have incentivized vessel speed reductions in an effort to reduce emissions. However, mandatory speed reductions in one location can result in vessels increasing speeds elsewhere, thereby potentially diluting emissions benefits.

Road and rail carriers have embraced more fuel-efficient driving styles and have reduced vehicle idling. Aimed at reducing at-berth emissions, shore-power requirements at Californian ports evoked strong reaction from ocean carriers due to technology costs, the reported lack of proven alternative emissions-control technologies, limited use of this technology outside California, and questions as to the emissions associated with electricity generation. Where shore power is being considered, the costs and benefits of this approach, as well as options for achieving equivalent emission reduction should be given careful consideration along with the perspectives of the terminal operators, energy providers, and vessel owners.

Equipment and Technology

Transportation technology advances, including energy-efficient equipment, engines, and alternative fuels, have delivered operating cost reductions along with substantial air emissions (primarily GHG) reduction benefits. However, engine emissions and fuel efficiency standards can take several years to take effect due to the slow rates of fleet turnover. Fuels such as natural gas and hybrid or electric vehicles offer alternatives to conventional diesel-fueled vehicles. Key lessons for the public sector are to

- Ensure that regulations are sufficiently flexible to allow for ongoing technological innovation;
- Collaborate with the private sector and research institutions on the testing and demonstration of new technologies;

- Streamline processes for the approval of new technologies and fuels to ensure rapid deployment;
- Provide support for new technologies (e.g., through the promotion of natural gas refueling and charging infrastructure); and
- Offer opportunities for the recognition of innovation via programs such as SmartWay.

The Sustainability Brand

Many U.S. and international corporations are actively working to improve the sustainability of their supply chains, and are measuring and reporting on their progress. The research found that shippers' initiatives tend to be driven by economics (particularly reduced costs) and company policy, and that shippers are increasingly pushing sustainability requirements onto the carriers that work for them. For carriers, business costs along with regulatory and competitive factors are the main drivers for sustainability initiatives. Several carriers participating in the research stated willingness to adopt sustainable practices as long as they do not incur costs or suffer a competitive disadvantage as a result.

Supply chain sustainability is just one of many factors shippers consider in their capital and operating decisions, and air emissions are just one part of the plethora of sustainability considerations. Shippers' supply chain sustainability programs typically address activities across the end-to-end supply chain (including product sourcing, manufacturing, packaging, transportation, warehousing, etc.). Freight transport is typically responsible for only a small percentage (5% to 15%) of total supply chain GHG emissions, and freight emissions are often relatively low on the list of priorities when shippers are setting their overall air emissions reduction strategies.

GHG emissions receive the lion's share of attention in corporate reporting, partly because of the emphasis on GHG emissions in corporate sustainability reporting protocols (e.g., the Carbon Disclosure Project and the Greenhouse Gas Protocol), but also because GHG emissions typically correlate directly to fuel use and shipper and carrier business economics. The research found limited evidence of voluntary carrier and shipper criteria air pollutant (CAP) emissions reductions efforts.

Percent reduction of CO_2 emissions per year is one of the most commonly cited reporting metrics for shippers. The main metrics carriers use include average fuel savings or fuel use per ton-mile moved and percent reduction in CO_2 emissions per year. CAP emissions reductions are not commonly reported outside California.

Annual sustainability reports are generally published by large companies, several of whom disclose results via collaborative forums such as the Carbon Disclosure Project. Public- and private-sector forums play a key catalyzing role in encouraging measurement, reporting, and reduction of air emissions, for example, through recognition and rewards programs. Reducing and reporting emissions can often be more difficult for small companies (that may lack access to expertise, resources, and technology). Public-sector initiatives (e.g., U.S. EPA SmartWay, along with funding and incentive programs under the Diesel Emissions Reduction Act, and statewide programs (e.g., Carl Moyer Program), together with nonprofit initiatives (e.g., Cascade Sierra Solutions) can provide smaller carriers with access to expertise and funding to reduce emissions.

Avoiding Unintended Consequences

Demand for freight transportation, freight miles traveled, and freight air emissions are affected by a diversity of policy and regulations, many of which are external to environmental regulation and policy. Efforts to promote integration across public policy and regulatory

initiatives to ensure that they are supportive of freight air emissions reductions and supply chain sustainability can help to reduce unintended consequences.

Given recent regulatory activity in California, it is not surprising that the carriers and shippers consulted as part of this research provided the most examples of what they perceived to be unintended consequences from their experiences in that state. Although the Clean Air Act allows other states to adopt California standards, it is important that these states fully understand both the context within which California standards and regulations were developed, as well as the unintended impacts that resulted prior to adopting these standards to avoid duplicating any adverse consequences.

Some of the underlying reasons behind the perceived unintended consequences of air emissions regulations in California lie in, for example, specifying technologies that may not be optimal under the circumstances. A further issue is the layering of regulation such as the North American Emissions Control Area (ECA) and California low-sulfur marine fuel requirements that, in combination, require international ocean carriers to use three different types of fuel during a single voyage. This necessitates separate fuel storage, more crew time, and additional recordkeeping. In other cases, regulation has not always resulted in the expected emissions reductions benefits. In some cases, this has occurred because a regulation was developed without the benefit of broad-based industry consultation, was perhaps less responsive to private-sector operations than it might have been, or because compliance was difficult to ensure (e.g., the Port Gates Appointment System at the Port of Los Angeles).

Although the research did not find any indication that California's cargo share has shifted to other locations as a consequence of recent environmental regulation, this may be because the regulations were introduced relatively recently and also due to the uniqueness of the Californian economy and context. Other locations that do not share California's advantages, such as the size of the local market, its proximity to Asia, and its well-established road and rail infrastructure, which reduces the costs of transporting goods to destinations beyond state borders, may run a greater risk of cargo diversion with implementation of "copycat" standards and regulations.

Assessing the cost-effectiveness of regulations can assist in reducing the occurrence of unintended consequences by allowing different approaches to emissions reduction to be compared (e.g., through assessing the cost of compliance per ton of emissions reduced). Pursuing the most cost-effective emissions reductions solutions can enable the benefit side of the cost-benefit equation to be maximized, thereby minimizing adverse impacts on economic sustainability. Further, the effects on the private sector of the cumulative financial, technical, and administrative impacts of the combination of emissions regulations also should be taken into account to better understand the full costs of regulation on industry and the economy.

Suggestions for Policymakers

The research identifies the following nine key factors significant to achieving a balance between environmental, societal, and economic needs:

1. **Consult Closely with Stakeholders to Craft Win-Win Solutions**—Close consultation and collaboration with stakeholders (including vehicle manufacturers, shippers, and carriers) increases public agencies' likelihood of accomplishing public policy goals. Mutual understanding of supply chain sustainability issues and working relationships based on trust are essential. The creation of a culture of consultation and cooperation (rather than simply one-off consultations) among public- and private-sector stakeholders, can result in more informed and effective decision making. Standing freight forums have

been successful in fostering a collaborative culture in some jurisdictions. This collaborative approach often requires proactive public agency outreach efforts to engage industry. It is suggested that public agencies might even consider procuring private-sector inputs in much the same way as consulting services are bought, thereby ensuring mutual commitment to the process and outcomes.

2. **Analyze Trade-Offs and Options**—Regulation of supply chain air emissions presents inherent trade-offs: local air Criteria Air Pollutant (CAP) emissions may need to be weighed against global GHG emissions impacts; costs for shippers, carriers, and consumers may need to be balanced against environmental and community health. The concentration of CAP emissions from less-GHG-intensive modes at critical points along the supply chain (e.g., ports and intermodal yards) can result in health impacts to adjacent communities. However, efforts to regulate and reduce CAP emissions also can result in shifts to more GHG-intensive modes, particularly if the regulations result in increased costs. Further, it is generally recognized that the external costs (including accidents and pollution) of freight transportation are not reflected in freight costs (GAO, 2011). Regulation can provide a framework for balancing the distribution of costs so that all carriers bear a proportional share of these costs, which can then be passed on to shippers and consumers. It is thus important that the potential impacts of emissions regulations are assessed in advance to ensure that trade-offs are well understood, that options and alternatives are considered prior to adoption, and that benefits of regulation are commensurate with costs.
3. **Coordinate Across Jurisdictions**—Supply chains and freight transportation routes cross multiple jurisdictions. Geographic differences in emissions standards and regulations can result in increased costs as well as operational difficulties for carriers, for example, by complicating equipment design and deployment. Consistent standards typically help to streamline private-sector compliance efforts, allowing for more optimal supply chain operations, ultimately benefitting industry and consumers. Nevertheless, uniform national emission standards and regulations are not necessarily a straight-forward or appropriate solution, particularly in respect of CAP emissions that have local impacts. A right-sizing effort is therefore required that considers local or regional emissions issues within the context of broader national and international operating needs. Effective and well-established bodies such as the International Maritime Organization, U.S. EPA, and U.S.DOT, whose remits are multi-jurisdictional, as well as associations of global and national carriers, could provide helpful guidance and global operations perspectives to state and local agencies considering the introduction of customized standards and regulations.
4. **Develop Supply-Chain Sustainability Metrics**—An agreed-upon definition of supply-chain sustainability, and the metrics by which this might be measured, requires public-private resolution. EPA's SmartWay is the most widely recognized success story of public- and private-sector collaboration in U.S. supply chain sustainability. One option may be to fund and task SmartWay (or an equivalent program) with leading a collaborative public-private effort to establish a standard definition for supply chain sustainability and measurement. This assumes SmartWay-specific concerns, such as data submission verification issues, standardization of reporting units, and methods for connecting vessel efficiency to shipper calculations could be addressed.
5. **Set Performance-based Standards**—Performance-based standards and regulations offer broader scope for innovation in air emissions reduction efforts, compared with a prescriptive approach specific to a single technology or solution. Performance-based standards allow businesses to meet emissions requirements via the means best suited to their operations. They tend to better reflect the dynamic nature of the freight sector, the private sector's ability to adapt to new technologies, and operators' propensity to adopt innovative practices. An example is the EPA and National Highway Traffic Safety Administration's

(NHTSA's) recently introduced fuel economy standards for heavy-duty on-road vehicles that leave manufacturers various compliance options and include flexibility such as fleet averaging, banking and trading of emission credits, incentives for advanced technology vehicles, and optional standards for smaller volumes/companies.

6. **Provide Incentives to Change**—Grants, tax credits, and pilot projects are all effective methods by which the public sector can shift shipper and carrier behavior to be more sustainable. Such incentives can stimulate innovation, promote confidence in new technologies, enable small businesses to access cleaner and greener equipment, offset the costs associated with sustainable practices, reward sustainable behavior, and accelerate regulatory compliance. Incentives are especially relevant for Criteria Air Pollutant (CAP) reduction initiatives where there are often few direct economic benefits to the private sector from emissions reductions efforts, but that can require substantial capital investment or involve higher operating costs. Certification programs (e.g., SmartWay and the Environmental Ship Index) also incentivize sustainable practices through their recognition of carriers and shippers.
7. **Push the Boundaries of Technology**—Air emissions standards should be achievable. *Technology forcing approaches*, when adopted, should provide adequate time for an appropriate technology to be commercialized. Inputs from experienced federal, state, and international regulatory bodies, as well as research organizations and the public-private consultative process, can help in the testing and formulation of such standards. Public agencies can play a crucial role in pushing the frontiers of new technology development by partnering with the private sector and research institutions in the technology testing and application phases. The public sector also has a potential role in envisioning, planning, promoting, and enabling a zero emissions (or near-zero emissions) future that accommodates growth in freight transportation without associated air quality, health, and climate change problems.
8. **Redefine Operational Optimization in Metropolitan Areas**—Cities present particular challenges. It is within these urban operating environments that CAP emissions concentrations present the greatest health concerns. Urban environments are typically characterized by a plethora of motor carriers (many of which are small businesses), and tend to lack a coordinating agency that is an engaged supply chain participant. Bringing together the operational expertise of private truck fleets, parcel carriers, and large motor carriers to address the constraints of urban environments offers untapped potential to improve efficiency and reduce air emissions in cities. A partnership of such companies, acting jointly with public agencies in major urban areas, could uncover and drive new practices to raise operating productivity within cities (from which small carriers would also benefit) and could yield environmental benefits.
9. **Promote Sustainable Branding**—Companies are using green programs to differentiate themselves, both with product consumers and corporate clients. The success of the EPA SmartWay program suggests that there may be other opportunities for joint public-private approaches in promoting, verifying, and branding sustainable supply chains. In the absence of such initiatives, potentially misleading efforts may arise that result in a less-than-level playing field or create imbalances between the achievement of environmental, social, and economic benefits.

CHAPTER 1

Research Objective, Method, and Context

Economic activity is driven by trade. Material flows, or supply chains, are highly complex, dynamic, time-sensitive, and integrated systems. Freight transportation networks are used to move goods and must offer rapid, reliable, and efficient service to meet the demands of the global marketplace. If a transportation supply chain becomes uncompetitive, it quickly loses market share and suffers immediate economic consequences. Global supply chains also have significant impacts on the global environment and local communities, most notably as a result of air emissions from freight transportation activity. The increased recognition of the environmental and human impacts of supply chain activities has led to public pressure for rapid action, sometimes resulting in fragmented, conflicting, and multi-layered regulatory structures. The complex nature of regulations can make compliance challenging, may impede supply chain innovation, and, ultimately, may not achieve the desired environmental outcomes. Because an efficient supply chain is a critical component for economic competitiveness at both the regional and national level, it should be a key consideration in the development of environmental policies and regulations. Otherwise, economic growth and job creation may be hampered.

1.1 Research Objective

The objective of this research is to identify potential strategies for accelerating environmental improvement, enhancing performance, and promoting social responsibility of the supply chain. It is intended to provide information to improve the understanding of decisionmakers regarding the impact of environmental policies and regulations on the supply chain, focusing on the interrelationships between economic drivers and air quality and greenhouse gas (GHG) policies and regulations.

As such, the research addresses the interaction of supply chain sustainability regulations and private-sector actions. The questions posed aim to better understand the following:

- What shippers and carriers are currently doing to integrate environmental goals into their business operations;
- What drives private-sector players to implement sustainable practices;
- How industry and the supply chains they run are affected by regulations aimed at improving sustainability;
- Opportunities for further improvement; and
- Implications for policymakers in regard to achieving successful implementation and avoiding unintended consequences.

Within the broad scope of supply chain sustainability, the research focuses on efforts to reduce criteria air pollutant (CAP) and GHG emissions. The goal is to explore how these efforts are addressed within the supply chain by public- and private-sector participants. The results of this effort are intended to be transferable to future studies that address other aspects of environmental and social sustainability in supply chain and transportation activity.

1.2 Research Method

Approach

The research was divided into two phases. Phase 1 identified and assessed, at a high level, potential strategies to advance environmental improvement goals through supply chain management. Phase 2 focused on in-depth case study clusters, illustrating key themes uncovered during Phase 1 and providing further evidence of the impact of environmental regulations on the supply chain and its operators.

Phase 1

Phase 1 consisted of five tasks. Task 1 was a literature review, aiming to scope out the broad range of existing knowledge about the impacts of GHG and CAP emissions policies, regulations, and programs. More than 100 sources were reviewed (including academic journals and research studies; public-sector data and monitoring sources; and published sources from the private sector, industry associations, and conference proceedings).

The Task 2 objective was to obtain initial input from a broad range of stakeholders on current emission reduction practices and areas of opportunity, as well as concerns regarding supply chain impacts of air quality, GHG, and other sustainability regulations. Stakeholders were selected from four categories: shippers, carriers, transportation agencies, and environmental agencies. The research team sought input from a sample of organizations, chosen for their leading-edge practices. Ultimately, 25 stakeholders participated in 26 interviews. The over-representation of progressive organizations and the small sample size limits the applicability of the findings, which are indicative and directional in nature, and are not intended to be statistically valid. Nevertheless, the research team found the interviews crucial to understanding the practical realities facing different types of players.

Task 3 considered the broad range of existing metrics of supply chain performance (as these relate to air quality and GHG emissions) in use by shippers, carriers, and public agencies. The research team also considered the effectiveness of the identified metrics in capturing linkages between environmental, economic, and social costs and benefits from various stakeholder perspectives.

As part of Task 4, the findings of Tasks 1 through 3 were synthesized and key themes (Exhibit 1-1) emerging from the literature survey and stakeholder interviews were identified, to be explored as part of the Phase 2 research.

Case study clusters that allow the themes to be explored further as part of the Phase 2 research were proposed. A metrics map, by which to understand and assess the case studies, was developed. An interim report was produced in Task 5.

Phase 2

Task 6 consisted of an in-depth assessment of the themes, condensed and restructured into five topic areas, explored

Exhibit 1-1. Key themes emerging from Phase 1 research.

Scope of Change, Change Tactics, and Successful Implementation
Theme 1: 'Win-win' environmental-business improvements. This theme encompasses public-sector enabling initiatives and private-sector voluntary initiatives that aim to create win-win opportunities, supporting environmental gains that also are positive from a business perspective.
Theme 2: Radical/transformational change. These initiatives include public- and private-sector participation in developing and testing visions for a non-oil-based future that overcomes conflicts between economic growth and emissions reduction, as well as tensions between CAP and GHG reduction efforts.
Change Tactics
Theme 3: Route optimization. Freight routing that minimizes fuel consumption is a major means of reducing costs, with the benefit of reducing GHG emissions and potentially CAP emissions, as well (although the concentration of freight traffic in populated areas can raise air quality concerns). What initiatives is the private sector undertaking? What impacts are these initiatives having?
Theme 4: Transport mode shifting, from faster, more costly, higher emission modes. This refers to switching to potentially slower, but greener, and less emission-intensive modes—for instance, from air to truck, truck to rail, or air to ocean—and holds significant potential to reduce carbon emissions from transportation and to reduce freight costs. The limitations and lessons learned, as well as the outlook for mode shift was considered.
Theme 5: Fuel-efficient equipment and technology. Fuel is a major cost for carriers who employ a range of equipment and technology-based measures aimed at reducing fuel use. How much can be expected to be gained in terms of cost savings and air emissions reductions?
Theme 6: The sustainability brand. Supply chain sustainability initiatives are being used by shippers and carriers to improve their market share by promoting themselves as environmentally conscious companies. What can government, the not-for-profit sector, industry associations, and individual companies do to link air emissions reduction efforts to customer brand awareness, image, and loyalty?
Successful Implementation
Theme 7: Partnerships in supply chain sustainability. This theme explores ways in which regulators and industry can collaborate to ensure initiatives are optimally designed for impact, balance, and practicality. The aim is to raise the efficiency frontier of the benefit-cost equation through enlightened cooperation.
Theme 8: Cross-jurisdictional consistency. Transportation is a uniquely cross-border activity, most often crossing multiple political jurisdictions within a single freight move. This gives rise to major concerns, particularly by the affected carriers, about meeting sometimes inconsistent regulations in the different jurisdictions served. What are the impacts of inconsistent approaches? Can the differing needs of individual cities, states, and nations be addressed in a rational and comprehensive manner?
Theme 9: Unintended consequences. What unanticipated outcomes have arisen from well-intended regulatory initiatives, and how might adverse impacts be avoided?

through the use of case study clusters. The five themes are as follows:

1. Partnerships and win-win opportunities,
2. Operational optimization,
3. Equipment and technology,
4. The sustainability brand, and
5. Unintended consequences of air emissions regulations.

The following five case study clusters were investigated to provide the raw material for the themes:

1. International/non-U.S. case studies,
2. U.S. national initiatives,
3. Ports and coastal states,
4. Inland perspectives, and
5. Corporate programs.

In total, 30 interviews were carried out during Phase 2 with port authorities, regulatory agencies, public-sector freight planners, public agencies with responsibility for air emissions, shippers, carriers, industry associations, and the nonprofit sector. Summaries of these cluster case studies are provided in the appendices to this report.

As part of Task 7, these case study clusters were assessed. Because of variations in the availability and currency of data, differences in the metrics employed among agencies, and variations in the circumstances under which the initiatives have evolved, like-for-like comparisons of quantitative data on the impacts of emissions reductions efforts (e.g., $/ton of emissions reduced) between case studies is difficult. In many cases, due to differences in local circumstances and assessment methods, such comparisons are not meaningful and can be misleading. The research team has, therefore, employed the broad range of indicators as identified in the supply chain sustainability metrics map to explore different approaches, relying on anecdotal and qualitative data where quantitative data were unavailable or unreliable.

In Task 8, the research team developed a communications strategy for relaying key findings to decisionmakers. Task 9 consisted of the development of a final report.

1.3 Supply Chain Emissions Context

Need for a Sustainable Approach to Freight Transportation Air Emissions

Freight transportation is an essential part of the country's economy, and the U.S. freight sector is forecast to grow significantly in the coming decade. By 2020, 90.1 million tons of freight are expected to move across the country by road, rail, water, and air daily, representing a 70% increase over 2002 freight flows (U.S.DOT, 2006). The movement of goods nevertheless contributes to a range of negative externalities including air pollution (which, in turn, affects human health), climate change, noise, accidents, vibration, and adverse visual impacts.

The significance of such external impacts is highlighted by the fact that emissions from the freight sector account for more than a quarter of the transportation GHG emissions in the U.S. (or about 9% of total GHG emissions) and are a notable contributor to climate change. Fine particle pollution from diesel engines—the most common engines used in freight—is estimated to shorten the lives of nearly 21,000 people each year (Denning, 2010). Future escalation of growth in demand for freight transportation is likely to place even greater strains on infrastructure, public health, and the environment, unless measures are put in place to address these impacts.

Impacts of the Global Economy on Supply Chains and Freight Transportation Air Emissions

Advances in logistics have enabled the globalization of the economy whereby materials and components are shipped worldwide. Products may now be produced offshore and sold in different countries. Economic restructuring and globalization have lengthened supply lines, resulting in more freight being carried over longer distances, with high levels of demand at key nodes (typically ports, airports, and intermodal facilities) within this transportation network. The combination of increased distances and concentrated activity has profound implications for freight transportation air emissions.

This globalized economy is characterized by high levels of freight transport intensity and increasingly complex supply chains. Freight transportation is intimately connected to production, procurement, inventory management, warehousing, and sales activities. These activities may be given priority over freight transport efficiency or emissions considerations by shippers and third-party logistics (3PL) providers. For example, as a result of reduced inventory (which reduces working capital and costs), a growing number of companies apply just-in-time delivery practices. Such practices require reliable, fast, and flexible transportation services to reduce the risks of a mismatch between supply and demand. Just-in-time delivery tends to favor less environmentally friendly modes such as road and airfreight, while savings from just-in-time practices can exceed the additional cost of running trucks only partly loaded (McKinnon, 2010).

Unlike passenger trips, freight trips are not discretionary. Producers need to move their goods to market. Global freight ton-miles had been forecast to grow at 2.3% per annum between 2000 and 2050, as a result of the expansion of production and consumption and of the increase in average distance that each unit of freight is transported (World Business Council

for Sustainable Development, 2004). With the downturn in the economy, annual growth has been substantially less than predicted since 2008. Nevertheless, air emissions from freight transportation remain an environmental and health concern.

Types of Freight Transportation Air Emissions

This study is concerned with two categories of air emissions, both of which are byproducts of fossil-fuel combustion.

- **Criteria Air Pollutants (CAPs)** consist of six main pollutants for which the EPA establishes National Ambient Air Quality Standards (NAAQS). Exposure to these pollutants can result in adverse impacts on human health. Symptoms include chronic heart or lung diseases and even premature death (Exhibit 1-2). EPA establishes human health-based and/or environmentally based criteria for permissible levels of CAPs, including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), sulfur dioxide (SO_2), and lead. Diesel exhaust contains nitrogen oxides (NO_x) and several other toxic components and chemicals that, combined, pose a cancer risk greater than that of any other air pollutant, according to the American Lung Association (U.S. GAO, 2004). Diesel exhaust from freight vehicles is a primary source of PM and NO_x emissions (one of the precursors to O_3), all of which have potential health implications (FHWA, 2010).
- **Greenhouse Gases (GHGs)** are emitted from burning fossil fuels. They trap heat in the earth's atmosphere and contribute to global climate change. Carbon dioxide (CO_2), methane, NO_x, and three groups of fluorinated gases (hydro fluorocarbons, perfluorocarbons, and sulfur hexafluoride) are the major GHGs and are the subject of the Kyoto Protocol. CO_2 is the primary GHG emitted by freight vehicles. Freight GHG emissions have grown by more than 50% since 1990 (FHWA, 2010). Because various GHGs have different impacts on climate change, they are often measured in terms of their carbon dioxide equivalent (CO_{2e}). Throughout this report, GHG emissions are referred to as an emissions category, while actual quantities of GHG emissions are provided in terms of CO_2 or CO_{2e}.

Although both GHG emissions and CAP emissions are a byproduct of fossil-fuel combustion, these groups of gases behave in different ways:

- CAP emissions have the greatest effect in the local area around the emissions source, with the significance of their impact determined by the quantity of emissions, meteorological conditions, and proximity of sensitive receptors. Most CAPs remain in the atmosphere for relatively short periods of time. Thus, their impacts can vary significantly over time and between geographies.
- GHG emissions, by contrast, remain in the atmosphere for long periods of time (up to 200 years in the case of CO_2). Their impacts are global rather than local.
- GHG emissions are combustion-based and directly linked to the amount of fossil fuel consumed, but CAP emissions can vary greatly depending on fuel quality and end-of-pipe emission controls.

Exhibit 1-2. Summary of health impacts associated with transportation CAP emissions.

Criteria Air Pollutant and Impacts	Freight Transportation Source
Particulate Matter with an aerodynamic equivalent diameter of 10 microns or less (PM_{10}) aggravates asthma symptoms and has been linked to cancer and heart disease, chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in individuals with heart or lung disease.	The transportation sector (including road dust) is responsible for about 54% of PM_{10} emissions. Freight movements produce 51% of transportation emissions, with marine vessels accounting for 29% of transportation emissions, heavy-duty trucks and buses for 17%, and locomotives for 5%.
$PM_{2.5}$ is smaller and considered more hazardous to human health than PM_{10}, these particles can travel over very long distances, remain in the lungs if inhaled, and can enter the bloodstream.	On-road vehicles and non-road equipment (including rail and marine sources) contributed about 10% of total $PM_{2.5}$ emissions in 2005, or about 550,000 tons. Road dust made up another 1.2 million tons (21%).
SO_2 combines with water vapor in the atmosphere and contributes to the formation of acid rain; is associated with breathing difficulties and respiratory illness.	Burning of high sulfur-containing fuels by locomotives, large ships, and non-road equipment is a source of SO_2 emissions. All transportation sources combined accounted for 11% of the total SO_2 emissions.
NOx contributes to air pollution in urban and rural areas; reacts with volatile organic compounds to form O_3 (the primary component of smog); and is linked to respiratory problems, asthma, and bronchitis.	Freight transport (heavy-duty trucks, marine, rail, and air cargo) account for approximately 57% of transportation NO_x emissions, with heavy-duty trucks and buses accounting for 26%, marine vessels for 22%, locomotives 9%, and freight aircraft less than 1%.

Source: FHWA, 2010

Impacts of Freight Mode on Air Emissions

Air emissions vary by freight mode. The variation in CO_2 emissions between modes is described in Exhibit 1-3. Note that there is a considerable range in estimates of emissions within each mode, making generalization difficult. The carbon intensity of maritime shipping and rail freight modes is substantially less than that of air freight and road freight. However, this carbon advantage is dependent on technologies employed, fuel and power source, operating conditions, and other factors.

CAP emissions also vary by mode, with the range in emissions within each mode dependent on vehicle technology, age, operation, after treatment, etc. Generalization is particularly difficult, and the impact of CAP emissions (particularly on human health) is largely dependent on factors such as the proximity of sensitive receptors, background concentrations, and weather patterns rather than on mode alone.

- Although maritime shipping is the most efficient freight mode by ton-mile in terms of fuel use (and GHG emissions), ocean-going vessels typically burn heavily polluting bunker fuel. This dirty fuel, combined with high volumes of port traffic and the extensive freight movements associated with port activity, can negatively affect the local environments surrounding ports, which are often subjected to disproportionately adverse impacts associated with congestion, air pollution, and noise (Denning, 2010). The North American Emissions Control Area (ECA) effective in 2012 applies to ships operating in U.S. (and Canadian) waters and requires ships operating within 200 nm of the coast to use fuel oil with a sulfur content that does not exceed 10,000 parts per million. This is intended to reduce NO_x, SO_x, and PM emissions, primarily from large marine engines.
- In the United States, rail accounted for 12% of freight tonnage in 2007 (Mintz, 2010). Rail freight is typically more fuel efficient than trucking. It is a cheaper and more efficient way to move containers long distances, given that containers can be moved from ship to rail to truck relatively easily, where facilities exist. On average, rail locomotives can move a ton of freight more than 400 miles on a single gallon of fuel (U.S. EPA Office of Transportation and Air Quality, 2009). However, despite recent improvements in diesel locomotive emissions standards, fleet turnover is typically slow. CAP emissions from diesel locomotives at ports and intermodal yards can adversely affect air quality and human health at these freight nodes.
- Trucks inevitably play a role in some part of every supply chain journey. In the United States, trucks moved an estimated 75% of freight tonnage in 2007, and various intermodal combinations moved an additional 7% (Mintz, 2010). Despite significant progress made in fuel efficiency and emissions reductions from heavy goods vehicles, trucking remains the most polluting and least GHG-efficient of the surface freight modes. However, it is also the most flexible, well suited to just-in-time and last-mile deliveries. The Environmental Defense Fund (EDF) reports that more than 80% of U.S. towns and cities are served exclusively by trucks (EDF, 2010). Trucks are thus a critical component of the logistics system.
- Sources differ as to estimates of freight tonnage moved by short sea shipping and inland waterways in the United States. For example, Denning (2010) estimates that the United States moves just 2% of freight by water, while Mintz (2010) estimates that 4% of U.S. freight tonnage was moved by short sea shipping in 2007. Short sea and inland waterway shipping is promoted as being greener than other types of freight transport, with similar benefits as those of long-haul ocean shipping. However, the full assessment of environmental benefits has been limited. Organizations such as Friends of the Earth contend that threats related to expanded operations—such as air emissions, ocean noise, and strikes of marine mammals—have yet to be thoroughly addressed (Kaltenstein, 2010).

Exhibit 1-3. CO_2 emissions by mode.

Mode	Emissions (kilograms CO_2 per ton-km)	Emissions (kilograms per ton-mile)
Air freight (U.S. EPA)	0.6649	1.7005
Trucking (U.S. EPA)	0.1845	0.297
Railroad (U.S. EPA)	0.0156	0.025
Maritime shipping (U.S. EPA)	0.0497	0.08
Maritime shipping (BSR, assuming an 11-tonne load per TEU)	0.008	0.0049

Source: U.S. EPA, 2008b; BSR Clean Cargo Working Group

- Air freight accounts for a small proportion of overall freight volumes. However, on a ton-mile basis, air freight is the most polluting of all freight modes. Aviation (encompassing passenger and air freight) accounts for an estimated 2% of GHG emissions. The integration of passenger and freight services makes such differentiation between freight and passenger GHG emissions extremely difficult, but freight emissions from belly cargo and freighters are estimated to account for up to 20% of aviation emissions (McCarthy, 2010). Aircraft engines and airport equipment generate noise and air pollution, while emissions from road vehicles bringing passengers and freight to the airport also affect the environment and health of surrounding communities.

1.4 Defining Supply Chain Sustainability

In pursuing the research, a working definition of supply chain sustainability was developed, as follows:

Sustainable supply chains connect a competitive economy in an efficient manner, consistent with human and ecosystem health, at the same time reducing reliance on fossil fuels. Specifically, they

- Enable efficient, safe, reliable, and cost-effective freight distribution by a choice of transport modes;
- Reduce unnecessary freight movements, minimize distance traveled, and maximize loads with effective planning; and
- Are supported by public policy, regulation, infrastructure, and financial incentives that optimize land-use configurations, promote promising technologies, and minimize the impacts of harmful air and noise emissions on communities.

1.5 Supply Chain Sustainability Metrics Map

As part of the research, the team developed a supply chain sustainability metrics map intended to provide a framework to assist in the assessment of different approaches to managing supply chain air emissions by placing them in context.

The map is intended to provide a quick reference to illustrate the multiple considerations that affect supply chain air emissions (e.g., mode shares, congestion, fleet composition, fuel use, facility location, and vehicle miles traveled). These, in turn, affect GHG and CAP emissions outputs and air emissions outcomes (e.g., in terms of ambient air quality and human health, as well as energy security and ultimately global warming).

Given the complexity of the relationships and considerations within supply chains, the plethora of metrics used by various agencies and companies, together with gaps in data, the research team used this metrics map as a guide to infer causal relationships and linkages between different parameters. The metrics map also assisted in the development of case studies where the research team used qualitative assumptions in the absence of quantitative data.

The metrics map is shown in Exhibit 1-4. The identified categories incorporate supply chain performance measures, as well as sustainability considerations. The categories build upon what is currently being measured by different agencies, and what the analysis has shown to be salient to supply chain sustainability.

1.6 Report Structure

The remainder of this report is structured as follows:

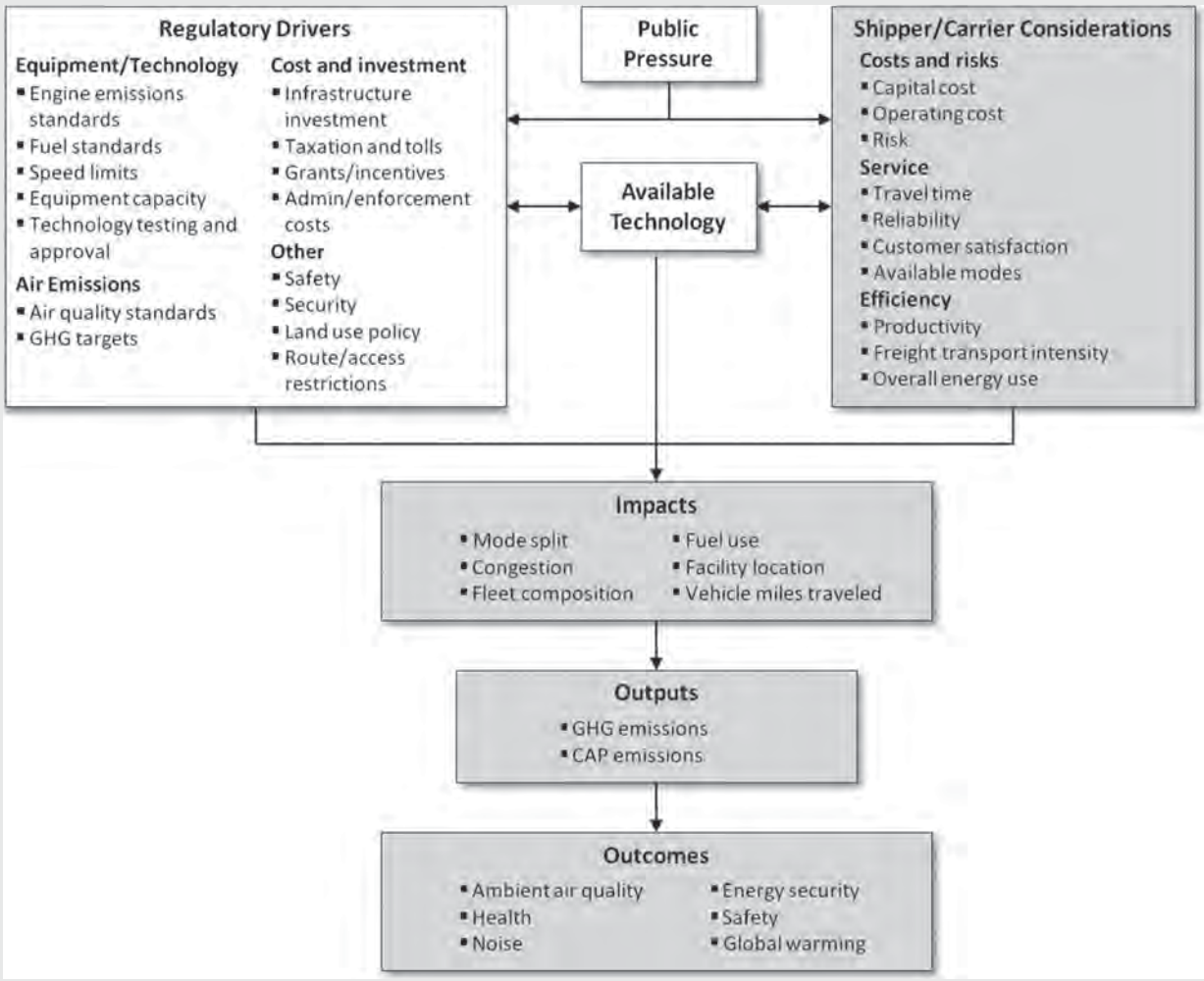
Chapter 2 explores the ways in which regulators and the private sector, together with nonprofit organizations and affected communities, can collaborate so that initiatives to address supply chain air emissions are optimally designed for impact, balance, and practicality. It considers the fundamentals of a sustainable approach and key components of public-private collaboration at the state and local levels, providing examples of good practice from the case studies.

Chapter 3 considers how private-sector operational improvements are benefitting supply chain sustainability. The research explores the main elements of operational optimization, with examples drawn from case studies of shippers and carriers, covering historical results and anticipated future impacts. Key questions addressed are (1) to what extent is operational efficiency (cost savings, especially due to reduced fuel use) synonymous with emissions reduction, and (2) to what extent are these changes purely private-sector driven versus being influenced by public policy?

Chapter 4 outlines key new technologies that shippers and carriers are using to achieve greater fuel efficiency, sustainability, and cost savings. The research touches on the interaction between these private-sector initiatives and public policies that either promote or potentially impede the implementation of more efficient technologies. Additionally, comments on those advances that seem most likely to enter the freight transportation mainstream in coming years are provided.

Chapter 5 looks at the sustainability brand. Many U.S. corporations are actively working to improve the sustainability of their supply chains. The particular focus in this chapter is the efforts made by selected companies to promote their sustainability efforts as a core part of their brand, as well as the motivation for and the components of such initiatives. These examples serve as encouragement for others. Cited are several

Exhibit 1-4. Supply chain sustainability metrics map.



cases of shippers and carriers that can be said to have successfully achieved a sustainability brand based on their green supply chain initiatives.

Chapter 6 focuses on unintended consequences. Demand for freight transport and resulting air emissions are affected by a broad range of public policies and regulations (e.g., economy, industry, regional development, energy, land use, safety, recycling, the environment, and air emissions). These policies and regulations can have a range of unforeseen impacts. This chapter provides cautionary examples of unintended and suboptimal impacts of regulatory initiatives aimed at curbing emissions, as well as some surprising outcomes. It is important that public-sector regulators take heed of such factors when developing future regulations in order to ensure that the sustainability and economic viability of supply chains is supported by regulatory efforts.

Chapter 7 offers suggestions on how best to promote air quality and broader sustainability in the nation's supply chains. These suggestions were developed with the help of interviews of public agencies, shippers, carriers, and others, and from an extensive literature review.

Supplemental information is provided in the appendixes, as follows:

Appendix A: International Case Studies considers the Fair Winds Charter, the New Zealand Emissions Trading Scheme, and the impacts of the extension of the European Union Emissions Trading Scheme to Airline Emissions.

Appendix B: National Initiatives focuses on U.S. EPA's SmartWay Program and Cascade Sierra Solutions—a nonprofit operating across the United States.

Appendix C: Ports and the Coastal Context compares air emissions reduction initiatives at the Port of Charleston

with those at the Port of Houston and contrasts these with approaches taken at the Port of Los Angeles. This case study also explores California air emissions regulations, their unintended impacts, and lessons learned in detail, which is warranted given the amount of regulatory activity in the state (surpassing any other location in terms of quantity and reach), and the possibility for other states to introduce "copycat" regulations under the Clean Air Act.

Appendix D: Inland Perspectives considers the experiences of the Chicago Region Environmental and Transportation Efficiency Program in Chicago and various experiences in Kansas City.

Appendix E: Corporate Programs looks at the range of (largely voluntary) sustainability initiatives adopted by the private sector, including individual shippers and carriers as well as industry associations.

Appendix F: Supply Chain Sustainability Metrics presents a broad range of existing metrics for supply chain performance used by shippers and carriers and required or proposed by public agencies.

CHAPTER 2

Partnerships and Win-Win Opportunities

This chapter explores the ways in which regulators, industry, not-for-profit organizations, and affected communities can collaborate so that initiatives to address supply chain air emissions are optimally designed for impact, balance, and practicality. The intent of such initiatives is to raise the "efficiency frontier" of supply chains, ensuring through enlightened cooperation that the benefits side of the benefit-cost equation is favored. Collaboration can enable the environmental, social, and economic effects of decision making to be weighed, thereby ensuring optimal outcomes in decision making.

Many of the agencies involved in supply chains and their regulation tend to be single-purpose, focusing on a particular aspect only (e.g., emissions, air quality, cost, or transit time). As a result, actions and decision making by these individual entities do not always take into account the full range of supply chain sustainability impacts or the priorities of other agencies. In such circumstances, win-win solutions occur more by accident than by intent. Due in part to their narrowly prescribed mandates, but also because of the complexity of supply chains, few agencies are able to fully appreciate the wider impacts of their actions on the supply chain as a whole. This chapter considers the benefits of an approach based on partnership and how this approach can enable win-win outcomes for all affected parties. The research examines different partnering approaches, the impacts each has had on outcomes, and some of the prerequisites for success.

Voluntary approaches to reduce freight transportation emissions based on partnering between agencies may be more effective than regulations, which

- May involve a lengthy regulatory process and can take time to affect emissions (e.g., emissions standards generally pertain to new vehicles and engines rather than those in use);
- Can result in significant costs to the private sector, whereas win-win solutions focus on balancing costs and benefits;
- Only relate to certain aspects of the supply chain, with others being "off limits" or outside the jurisdiction of the regulatory authority (e.g., regulation of railroad activities and of emissions standards in states outside of California); and
- May not always be possible to reach agreement upon, particularly where multiple jurisdictions are involved (e.g., greenhouse gas [GHG] emissions from marine shipping).

Nevertheless, regulation has a key role to play in the sustainable management of supply chain emissions. For example, regulations are appropriate to ensure protection of human health and the environment in situations where win-win outcomes are not attainable or where private-sector players are simply unable to reach agreement in their emissions reductions efforts. Where voluntary agreements to reduce emissions cannot be achieved, regulation can compel necessary changes in behavior. Regulation also can provide a level playing field whereby all private-sector participants in the supply chain are required to adhere to the same standard, ensuring that individual companies are not placed at a competitive disadvantage by acting sustainably. Further, as explored in this chapter, there is some scope for win-win opportunities to be realized directly through the planning and regulatory processes, by actively engaging industry, environmental lobby groups, and communities in early and ongoing dialog to ensure more balanced and favorable outcomes.

2.1 Elements of the Win-Win and Partnership Approach

Win-Win Opportunities

Win-win solutions are those that address environmental, social, and economic imperatives, while enabling the realization of the objectives of the full range of stakeholders. In the context of supply chain air emissions, the reduction of GHGs presents the greatest opportunity for the achievement of such win-win outcomes. Because GHG emissions correlate directly with fuel consumption, which is a significant cost for carriers,

measures that focus on fuel efficiency can have beneficial outcomes for carriers, shippers, and regulators, as well as for society at large.

In the case of GHG reduction, the benefits arising through win-win efforts are often broader than fuel cost savings alone. For example, the U.S. Environmental Protection Agency's (EPA's) SmartWay Program benefits private participants through the verification of cleaner and greener cost-saving technologies, providing them with the financial support to access these technologies. The program also supplies tools by which emissions can be measured and a marketable accreditation, which is attractive to customers. These benefits are particularly beneficial to small carriers who may lack the expertise and resources to adopt greener technologies or monitor their emissions on their own.

Win-win outcomes tend to be harder to realize in respect to criteria air pollutant (CAP) emissions. This is largely because CAP emissions reductions tend to carry costs for the private sector (e.g., through the replacement or upgrade of vehicles and equipment) while conveying fewer direct and tangible benefits. In such cases, regulation is usually required in order to compel emissions reductions and to ensure the protection of human and environmental health.

Consensus-Based Approach

A critical aspect of win-win approaches is that they are consensus-based and developed through cooperation. The broader array of supply chain issues addressed by a consensus-based approach potentially leads to a wider distribution of benefits, reflective of the perspectives and needs of the range of interested and contributing parties. Further, when solutions are forged through mutual agreement and consensus, effective implementation is more likely. The Port of Los Angeles (POLA) PierPASS Program, developed in consultation with the marine terminal operators (MTOs), succeeded because it allowed MTOs to control implementation, set a level playing field for participants, and enabled increased terminal operating costs to be offset through traffic mitigation fees payable on eligible cargo, while enabling air emissions benefits to be realized through switching truck movements to the off-peak period. In contrast, its predecessor, the Port Gate Appointment System (introduced via Assembly Bill 2650) was less well matched to operations, and ensuring compliance proved challenging (Giuliano and O'Brien, 2008).

Increasingly, government, business, and communities understand the importance of working together to achieve improved sustainability outcomes. The experience of the Port of Los Angeles in the period leading up to the development of the Clean Air Action Plan in 2006 is a stark reminder of the pitfalls of not treating the community as a partner: the ensuing community action and litigation stalled the port's plans for major cargo terminal projects for 5 years.

For business, the capacity for innovation itself often depends on factors outside of the individual enterprise. Private companies are recognizing that working with stakeholders improves their innovation capacity. In fact, the ability to innovate typically depends on a complex network of interactions with various external agencies. Government also has a role to play in facilitating this innovation by providing access to infrastructure, technology, and financing. Research indicates that nations that facilitate these industry-government linkages are more likely to have economies that flourish than those that do not (Hargroves, 2005).

2.2 Challenges and Trade-Offs

Although we refer to win-win, there are, inevitably, some trade-offs in the distribution of where benefits accrue: across environmental, social, and economic impacts; among various stakeholders (public-sector agencies, affected communities, and private companies); and between localized and global GHG impacts.

Balancing Environmental, Social, and Economic Costs and Benefits

Emissions reduction efforts (particularly in relation to CAP emissions) may convey increased economic costs that typically manifest in higher private-sector costs of doing business and/or increased call for public-sector infrastructure investment (e.g., to alleviate congestion).

In air quality nonattainment areas where air pollution levels persistently exceed National Ambient Air Quality Standards (NAAQS), air emissions and public health are critical considerations in public-sector decision making and can override other considerations. The costs of nonattainment are high for both the public sector (e.g., development of complex models and monitoring, development of state implementation plans, or loss of access to federal transportation funding as a result of the nonattainment designation), and the private sector (e.g., alteration of business operation and installation of pollution control equipment). Although efforts to reduce CAP emissions add to business costs, often with limited or no financial return, the risks and disadvantages of inaction also may be significant. Where the need for significant emissions reduction is urgent in order to meet NAAQS or GHG reduction targets, when collective action on the part of the private sector is required, and if the financial returns of independent action for the private sector are not evident, then regulatory measures are likely to be warranted.

A challenge for public policymakers and decisionmakers is the achievement of the optimum balance between benefits and costs across the spectrum of economic, societal, and environmental impacts of their air emissions reduction efforts and, where possible, to assist in offsetting costs to industry where they occur. When developing regulations, public agencies should carefully evaluate the impacts so that the environmental and societal benefits generated outweigh the economic costs, such that no one sector or geography is disproportionately affected. Although regulatory impact assessment [RIA] is a requirement of the federal process, with a similar approach required in California, it is not always undertaken elsewhere.

Balancing Costs and Benefits Between the Public and Private Sectors

Who bears the costs for reducing air emissions from freight-related sources is a critical consideration. A recent U.S. Government Accountability Office (GAO) report recognizes that the U.S. transportation industry generally is not paying the true full costs of goods movement, and contends that external costs (including accidents and pollution) are not fully captured in freight costs (GAO, 2011). These costs are substantial and are often carried by the communities living adjacent to transportation corridors and facilities, as well as by the taxpaying public.

For example, EPA estimates pollution from diesel engines is responsible for 20,000 premature deaths annually as well as for asthma, lung cancer, low birth weight, and cardiovascular illness. Further, the California Air Resources Board (CARB) estimates that the health costs from freight-related air pollution in 2005 in California alone amounted to more than $19.5 billion (Denning, 2010). The GAO report concludes that these unpriced costs are borne by general taxpayers rather than by the consumers of goods (GAO, 2011).

Many private companies have indicated a willingness to assume responsibility for reducing their air emissions (this is explored further in Chapter 5). The challenge for the public sector is to provide a framework that facilitates the private sector in its efforts to reduce supply chain air emissions that, at the same time, enables economic prosperity and avoids creating imbalances in the marketplace. This typically means rebalancing the distribution of any costs associated with emissions reductions so that the costs are passed on to the consumers of goods, rather than being borne by taxpayers, individual companies choosing to "do the right thing," or communities living beside freight transportation corridors or intermodal facilities. Regulation to level the playing field (thereby requiring that all carriers incur such costs) allows carriers to pass the costs of emissions reduction on to shippers and end-point consumers. This is in contrast to a voluntary system, in which businesses that incur costs for pollution reduction may be placed at a competitive disadvantage for doing so.

Balancing Global and Local Benefits

A further challenge for both the public and private sectors is to achieve a balance between the accrual of local versus global benefits of emissions reductions. CAP emissions have the greatest impacts on the local area around the emissions source, with the significance of their impact determined by emissions volumes, meteorological and geo-physical conditions, as well as their proximity to sensitive receptors. Thus, not all jurisdictions are equal when considering the management of air pollutants, and the approaches adopted will necessarily differ between local contexts.

CAP emissions from freight are of particular concern to state, regional, and local agencies in nonattainment areas that consistently fall short of NAAQS, as these agencies are obliged to develop plans, policies, strategies, and regulations to facilitate compliance with air quality standards and state implementation plans. In contrast, the impacts of GHG emissions are both cumulative and global. Thus, no matter where they are emitted, GHG emissions will affect climate change.

For both the public and private sectors, assessing the trade-off between GHG and CAP emissions is a complex process. Although GHG emissions are directly linked to the amount of fossil fuel consumed, CAP emissions can vary greatly depending, for example, on vehicle age and type, fuel quality, and end-of-pipe emission controls. Reducing freight ton-miles can reduce GHG emissions, although this ultimately depends on mode of freight transportation (and the energy intensity of production, which affects lifecycle carbon emissions), empty miles, and other factors. In some cases, CAP-reduction efforts that reduce diesel or marine oil fuel use can reduce GHG emissions. For example, California's shore power regulation, intended to reduce population exposure to nitrogen oxide (NO_x) and PM (from diesel-fueled ocean-going vessels at dock), is an example of where GHG emission benefits also accrued. However, in many cases, efforts focused on either GHGs or CAP can come at the expense of the other. The GHG reduction benefits of a shorter transportation route may be counterbalanced by local CAP emissions impacts, particularly if this route passes through an air quality nonattainment area. Conversely, the achievement of significant CAP emissions reductions from heavy-duty diesel engines in recent years has reportedly decreased fuel economy by as much as 12%, resulting in a GHG emissions penalty (McKinnon, 2008; Tunnel, 2010). Further, according

to interviews with industry stakeholders, the new Tier 4 locomotive emissions standards currently can be achieved only at the expense of fuel efficiency and GHG emissions.

2.3 Fundamentals of a Sustainable Approach

Combination of Enabling and Restrictive Mechanisms

It is generally recognized that the free market, on its own, is unlikely to deliver an environmentally sustainable logistics system, particularly given the short timeframe required to arrest global warming and climate change, and because there are limited direct benefits to the private sector in reducing CAP emissions. Thus, the public sector has a critical role to play in the sustainable management of supply chain air emissions, both by supporting voluntary private-sector initiatives and by leveling the playing field through regulation that establishes a consistent and predictable set of minimum standards to which industry is required to adhere.

Restrictive mechanisms (e.g., regulation, taxation, and emissions standards) are necessary both to protect public health and the environment and to ensure that no one sector, geography, or private company is unduly disadvantaged and that all participants do their part. The Fair Winds Charter illustrates the importance of regulation in supporting voluntary industry-led air emissions reductions initiatives. International carriers who are signatories to the charter commit to switching to low-sulfur fuel while berthed at Hong Kong ports. For these industry participants, there is a financial consequence for using low-sulfur fuel, which is more expensive than the fuel used by competitors. Regulating the use of low-sulfur fuel would create a level playing field across the industry: if all shipping lines incurred the same cost, there is more potential for this to be passed on to shippers and end-point consumers. Industry signatories to the Fair Winds Charter are thus pressing the Hong Kong and Guangdong governments to regulate shipping emissions, consistent with standards applied in other locations. In response to the Hong Kong government's recent pledge to mandate fuel switching at berth, Fair Winds Charter members agreed to extend their voluntary agreement to use cleaner fuel for another year to January 2014, while the legislation to make fuel switch mandatory in Hong Kong is developed. This is intended to keep up the momentum within the industry and is an example of cooperation between the public and private sectors—in this case, led by the private sector.

Where restrictive mechanisms are deployed, they are frequently best applied in combination with enabling mechanisms to ensure that private-sector players have ample opportunity to comply with regulations, taxation, and emissions standards to offset costs. Enabling mechanisms can bring a range of options and technologies within the reach of private companies who, on their own, may not be in a position to make the necessary changes. Such enabling mechanisms may include the identification and verification of cleaner and greener technologies, provision of funding and technical expertise to support the adoption of new technologies, providing data and reporting methods for ongoing monitoring of fuel efficiency and emissions by the private sector, and offering endorsements and "green certification" for companies that take steps to reduce their emissions.

Coordination Across Agencies

Responsibility for policy, funding, and regulation in relation to freight emissions is distributed across multiple public-sector agencies with varying geographic or political reaches. For example, EPA and CARB both develop air quality standards, while agencies such as FHWA and state DOTs provide funding and financing for infrastructure improvement projects. State and regional governments are responsible for developing transport plans, programs, and policies, and for developing strategies to comply with air quality standards. Local governments fund and oversee projects in their respective jurisdictions. However, in many cases, state DOTs and metropolitan planning organizations (MPOs) are organized modally with different divisions responsible for highways, rail, ports, and waterways. This can undermine an integrated approach to freight planning. Cooperation and joint efforts among these divisions and layers of government is essential. In particular, intermodal freight planning requires a commitment to joint working and communication between several agencies at different levels of government. Further, each of these sectors of government requires a firm understanding of the interrelationships between freight transport, logistics activities, and air emissions if they are to develop effective policies, strategies, and regulations, or influence private-sector behaviors.

The California Goods Movement Action Plan (GMAP), released in 2007, is widely recognized for the cross-agency collaborative effort that underpins it. Prepared by the Business, Transportation and Housing Agency (which incorporates Caltrans) and the California Environmental Protection Agency (Cal/EPA) which incorporates the Air Resources Board (CARB), the planning process brought together a range of public- and private-sector stakeholders. The GMAP sets out multimodal policies and programs to reduce congestion and address freight-related environmental impacts. GMAP also identifies potential projects for Proposition 1B funding. Proposition 1B is a competitive grant program targeting diesel-powered equipment owners to co-fund equipment updates. Access to Proposition 1B funding was itself key in bringing participating parties to the table, with Cal/EPA and local agencies (e.g., the ports and air quality management

districts) cooperating closely in the allocation and distribution of funds. Cal/EPA oversees and allocates funds at the state level, but local agencies administer the funds and are accountable for awarding and monitoring project grants.

Inland locations also are undertaking collaborative freight planning efforts. The Kansas City Regional Freight Outlook (2009) study and strategic plan is a regional, bi-state example of cross-agency collaboration, involving the Mid-America Regional Council, Kansas City SmartPort, Federal Transit Administration, FHWA, and the Missouri and Kansas DOTs. The study findings are intended to guide and manage freight growth in the Kansas City region, identifying freight infrastructure needs and outlining a comprehensive freight plan that balances the needs of the community with freight interests. The study fed into the regional transportation plan, "Transportation Outlook 2040" (Mid America Regional Council, 2010). The plan includes a comprehensive framework to review conditions, assess needs, and provide direction for prioritizing freight infrastructure investments based on the designation of corridors of freight significance (COFSs) in which future freight investments will be concentrated.

Engaging the Private Sector

A prerequisite for the achievement of win-win outcomes is the ongoing engagement of the private sector in public policy and decision making regarding the freight sector.

Industry consultation is essential if public policymakers and regulators are to develop and maintain an understanding of the supply chain and its impacts. Nevertheless, bringing the private sector to the table can be challenging for public agencies, especially given differences in expectations and operating styles. Business leaders may be reluctant to engage in the planning process. Public-sector officials are used to dealing with long lead times and high degrees of uncertainty. In contrast, the business community tends to operate on a much shorter timeframe, responding to changes as they arise, in some cases on a daily basis (NCHRP, 2007).

Effective consultation requires that stakeholders have the capacity (time and resources) to engage, as well as the expertise to formulate, a position on particular issues. For small shippers and carriers, time and resources may be in short supply. The manner in which the public sector conducts its outreach and engagement activities thus impacts the effectiveness of its approach to managing supply chain air emissions.

Several public-sector agencies are taking a proactive approach to industry engagement in freight planning and emissions mitigation. In developing the "Kansas City Regional Freight Outlook" (2009), the Mid-America Regional Council collaborated closely with Kansas City SmartPort (a nonprofit investor-based economic development organization supported by both the public and private sectors). The initiative included a survey of more than 400 businesses, as well as focus groups attended by 50 participants.

CARB, together with local agencies (including ports and air resource boards), undertakes extensive outreach using multiple methods as part of the solicitations for Proposition 1B (Goods Movement Emission Reduction Program) funding. One-Stop Truck events, conducted in multiple languages, provide funding, education, and one-on-one assistance to truck owners. Interest in the program has surged, with districts receiving more than 8,800 applications for truck upgrade or replacement grants (CARB, 2011a). CARB also has established a sustainable freight section charged with building a coalition of key CARB staff, beneficial cargo owners, domestic carriers, ocean carriers, business, the community, environmental organizations, and energy providers to foster transformational change in developing a long-term vision that moves toward near-zero emissions (CARB staff, 2012, pers. comm.).

Increasingly, ports are engaging the private sector in partnerships to reduce emissions. For example, the Environmental Shipping Index (ESI), developed by the International Association of Ports and Harbors and the World Climate Initiative (WCI), identifies ocean-going vessels that have lower air emissions than required by the current emission standards of the International Maritime Organization (IMO). The index is intended to be used by ports to reward participating ocean carriers and can be used by shippers in the selection of carriers. The Port of Los Angeles has implemented an ESI with input from the Pacific Merchant Shipping Association and other stakeholders, providing financial rewards and a marketable green credential to ocean carriers that voluntarily reduce ship emissions beyond regulatory requirements. In January 2013, the Port Authority of New York and New Jersey also implemented an ESI-based program. The South Carolina Ports Authority collaborated with the private sector to obtain grants for emissions reductions projects. Support letters from the local environmental and health agency, Chambers of Commerce, and the trucking association, were instrumental in the success of the grant application. Similarly, the Port of Houston (PHA) developed its Clean Air Strategic Plan as a joint initiative with stakeholders including tenants, terminal operators, the trucking community, ocean carriers, public agencies, nongovernmental organizations (NGOs), local communities, and citizens' groups. Consultation was undertaken with more than 150 private industries, and PHA formed partnerships with port tenants and users to apply for state and federal grant programs. Access to funding is a key driver behind these partnerships.

Proactive private-sector industry collaboration and lobbying is also fostering supply chain sustainability. The Coalition for Responsible Transportation (CRT) is an industry group that actively lobbies for the inclusion of industry perspectives in legislative and regulatory activities (in this case, specifically in relation to port trucks), engages in emissions compliance

efforts, and is partnering with ports in switching to clean trucks through shared cost arrangements to make upgrades more affordable (CRT, 2012). This customer-led approach also reduces the risks of competition for discretionary traffic between ports by ensuring that port customers are committed to clean trucks nationwide.

Communicating Best Practices

The sharing of best practices is essential to ensuring a sustainable approach. Both public- and private-sector channels, as well as nonprofit organizations such as the Environmental Defense Fund, contribute to information dissemination. Programs can include advice, benchmarking, and promotional programs to encourage sustainable practices and technologies in an effort to accelerate their uptake by shippers and carriers. Examples include the EPA SmartWay Program, which, in parallel with technology verification, offers best-practice advice regarding operational behaviors for the reduction of emissions. The Web-based BestLog Project financed by the European Union (EU) provided a platform for public and private sectors to collect and share practical experience in tackling logistics challenges in a sustainable way, addressing both business and policy objectives. The project ran from February 2006 to May 2010, when it was handed over to the European Logistics Association (http://www.elabestlog.org/). In California, the South Coast Air Quality Management District (SCAQMD) Technology Advancement Office engages in cooperative partnerships with industry, academic and research institutions, technology developers, and government agencies to co-sponsor projects intended to demonstrate best practices in the use of clean fuels and technologies that lower or eliminate emissions. For example, in conjunction with the Ports of Long Beach and Los Angeles, Caltrans, Southern California Association of Government (SCAG), Gateway Cities Council of Governments, LA Metro, and Siemens, SCAQMD submitted an application for a $19.2 million federal grant to co-fund a demonstration project for zero-emission container transport between the San Pedro ports and the Intermodal Container Transfer Facility that is 5 miles away (SCAQMD staff, 2012, pers. comm.). Other examples include the low-sulfur fuel switching and locomotive powertrain technology demonstration projects at the Port of Houston.

Mitigating Impacts on the Economy and Business

The inclusion of specific mechanisms for reducing adverse impacts on businesses and the economy is another common factor in successful regulatory approaches. For example, the EU Aviation Emissions Trading Scheme (Aviation ETS) includes measures designed to protect economic growth and the commercial viability of new aviation businesses through the reservation and allocation of a portion of the emissions allowances to new and rapidly expanding aircraft operators at no cost. The California At-Berth Ocean-Going Vessels Regulation applies to particular vessel types and fleets that meet or exceed a minimum port visit threshold. Although both of these regulatory measures sparked controversy (discussed further in Chapter 6) by specifying financial measures to protect new businesses, or a threshold below which measures will not apply, the regulations focus on those fleets or vessels where the greatest opportunities exist to effect emissions reductions and relieve small fleets of the administrative and capital expenditure associated with the regulatory compliance.

2.4 Components of Public-Private Collaboration at the State and Local Levels

Robust, Transparent, and Ongoing Consultation

Robust, transparent, and ongoing consultation is a hallmark of effective public-private collaboration and is necessary for enabling sustainable outcomes. It begins at the freight planning stage and continues with investment decision making and environmental regulation.

Both the Transportation Equity Act for the 21st Century (1998) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) include requirements for obtaining input from freight shippers and providers of freight transportation services when developing transportation plans and improvement programs. Although the requirements do not establish procedures for industry involvement, FHWA has developed *A Guidebook for Engaging the Private Sector in Freight Transportation Planning* (FHWA, 2010a).

The July 2012 reauthorization of the federal transportation programs, Moving Ahead for Progress in the 21st Century Act (MAP-21), encourages states to develop comprehensive freight plans, and in so doing, to form freight advisory committees to provide ongoing input on freight planning. These committees are to be composed of a "cross-section of public- and private-sector freight stakeholders, including representatives of ports, shippers, carriers, freight-related associations, the freight industry workforce, the transportation department of the state, and local governments." Their purpose is to "advise the state on freight-related priorities, issues, projects, and funding needs; serve as a forum for discussion for state transportation decisions affecting freight mobility; communicate and coordinate regional priorities with other organizations; promote the sharing of information between the private and public sectors on freight issues; and participate in

the development of the state freight plan" (U.S. Government, Section 1117, 2012).

Several agencies at both the state and regional levels have already set up working groups with the private sector. Examples include the following:

- The Integrating Work Group (IWG), composed of regulators and industry, community, and environmental leaders, established to develop California's GMAP. Subject-specific working groups supported the IWG and addressed the technical and public policy issues while the IWG resolved conflicts among the supporting groups and provided critical input to GMAP development.
- Colorado DOT (CDOT) coordinates private-sector surveys with MPOs and transportation planning regions, regularly attends meetings of the freight interest groups (e.g., the statewide motor carrier associations), and created the Colorado Freight Advisory Council (FAC), a forum for discussion on freight movement and freight infrastructure in the state.
- Washington DOT (WSDOT) engages with industry on an ongoing basis, conducting surveys and interviews at shippers' and carriers' places of business to track trends and freight performance according to metrics relevant to shippers and carriers (WSDOT, 2012). WSDOT's Freight Mobility Strategic Investment Board (with representation from the public sector, ports, railroads, trucking, and steamship industry) is a forum for private-sector participation in freight investment decision making.
- Portland Metro has appointed 33 representatives from the public and private sectors to serve on a goods movement taskforce whose function is to provide advice on the region's multimodal freight transportation system.
- The Chicago Area Transportation Study recruited a team of private-sector experts to share their knowledge and experience to benefit policy and decision making and to act as a "board of directors." A specific Intermodal Advisory Task Force advised on issues affecting intermodal movement of goods while working relationships with local universities enabled teaming on specialized studies (e.g., in relation to advanced technologies and cargo-handling methods) (Rawling, 2005).
- In California, the Maritime Air Quality Technical Working Group (or Maritime Working Group) provides a forum for discussion of air quality issues relating to maritime activities in California. Participation is open to all interested parties and includes representatives from Californian ports, commercial shipping lines, maritime industry associations, EPA, local air districts, as well as community and environmental groups. Maritime Working Group members participate in the development of emission reduction strategies for both commercial marine vessels and dockside equipment. (Note that the Working Group is not intended to replace the public process in the development of regulations, but to provide a forum for discussions and information sharing at the early stage of strategy development, thereby enhancing the regulatory process.)

Industry engagement is equally important to the regulatory process. State-prescribed processes for the involvement of stakeholders at various stages of rulemaking tend to be fairly similar, typically specifying opportunities for comments at key stages and requiring the agency to report on its outreach process, issues raised, and modifications introduced as a result of consultation. For example, CARB rulemaking regarding mobile-source air emissions typically begins with a direction or inputs from government, the public, or industry. Staff members conduct surveys and further research at this early stage, and public workshops are held. The private-sector interests to be regulated are usually notified, invited to specially convened consultation meetings, and kept updated and invited to engage throughout an iterative rulemaking process as draft versions are evaluated. A formal public engagement process is followed in the drafting of regulations, including issuance of an Initial Statement of Reasons, a public hearing and comment process, and issuance of a revised Final Statement of Reasons. Other states, such as Washington and New York, follow similar rulemaking procedures.

CARB staff report that a benefit of the regulatory process is getting to know stakeholders and the emergence of beneficial working relationships with them (CARB staff, 2012, pers. comm.). This ongoing communication can enable a more balanced regulatory approach, affording the private sector the opportunity to provide inputs prior to the formal consultation process and public hearing. In the formulation of tractor-trailer regulations in California, early input based on operational experiences from a private-sector working group ultimately succeeded in changing EPA SmartWay practices to allow for re-tread of low-rolling resistance tires (the use of which is a requirement of the regulation). This change has reduced costs to responsible carriers across the country, cutting emissions and reducing the numbers of tires sent to landfills (CARB staff, 2012, pers. comm.).

Conducting the Necessary Data Gathering, Analysis, and Communication of Results

Access to data is an essential starting point for the sustainable management of supply chain emissions. For example, data linking shipping air emissions to health impacts (provided by the Hong Kong Environmental Protection Department and disseminated by the Civic Exchange, a non-government agency), provided an important component of the education of the public and industry, and drove calls for change at Hong Kong ports. Public-sector agencies have a critical role to play in the

development and maintenance of air emissions inventories, as well as in the collection and monitoring of data regarding origins and destinations of truck traffic, volumes, congestion, journey time, reliability, and safety.

Public- and private-sector stakeholders collect and monitor different metrics relating specifically to their particular mandate. Public-sector stakeholders are typically interested in less-frequently updated measures to assist with policy, planning, and infrastructure investment decisions, while private-sector stakeholders are interested in more continually available measures to make daily operational decisions including reliability and travel-time measures (NCFRP, 2011).

Federal agencies, along with state air resource agencies and ports (particularly in nonattainment areas), are most concerned with collecting data on the quantity and concentration of air emissions and the health risks these pose to communities. Therefore, they undertake analyses concerned with metrics such as risk of death, cancers, and chronic health effects attributed to respiratory illness as a result of freight emissions, and health costs associated with respiratory illness. For private-sector carriers, the use of performance measures to make business practices more efficient was found to be, by far, the strongest motivator. Specific measures included on-time pick-up and delivery, revenue yield by shipment or mile, fuel economy, and equipment use (NCFRP, 2011). However, for many private-sector carriers, these data are proprietary and companies may be unwilling to share them. Nevertheless, close working relationships established over time can be instrumental in enabling information sharing, as exemplified in the memoranda of understanding between CARB and the Class 1 railroads.

Option and Alternatives Development and Assessment

Various approaches and technologies may be employed to manage freight emissions. The methods adopted should be appropriate to local conditions, the extent of the problem, and the stakeholder concerns in a particular geography. This requires clear definition of air emissions issues and an objective assessment of alternatives in terms of their economic, social, and environmental impacts.

The 2012 SCAG Regional Transport Strategy (RTS) has a goods movement component that encompasses initiatives including clean freight corridors, congestion relief, rail, and capacity expansion. Each initiative in the plan is evaluated in terms of impacts on mobility, safety, environment, community, and the economy. Because goods movement and air emissions are inextricably linked in Southern California (which is classified as an extreme nonattainment area), SCAG developed a parallel Goods Movement Environmental Strategy that forms part of the RTS. The environmental strategy defines a path for the achievement of federal air quality standards. A phased implementation process is identified that involves substantial research; close working with public- and private-sector partners; testing and evaluation of technologies, feasibility, and funding availability; and ongoing assessment of impacts on emissions objectives, efficiency, safety, and reliability of the goods movement system.

MAP-21 also mandates the improvement of existing tools and the development of new tools to support an outcome-oriented, performance-based approach to evaluating proposed freight transportation projects. This includes requirements for the systematic analysis of benefits and costs; and tools for ensuring that safety, economic competitiveness, environmental sustainability, and system condition in the project selection process are considered in the evaluation of freight transportation projects.

At the federal level, EPA is required to undertake a regulatory impact assessment (RIA) for all major regulations considering the economic, social, and environmental impacts of the regulation and proposed alternatives (U.S. EPA, 1983). The RIA process employs benefit-cost analysis and considers benefits in terms of the efficient functioning of the economy and private markets, enhancement of health and safety, and protection of the natural environment. Costs include the direct costs of compliance to government, businesses, and others, and adverse effects on the efficient functioning of the economy and private markets (including productivity, employment, and competitiveness). In selecting regulatory approaches, agencies are required to select those approaches that maximize net benefits including economic, environmental, public health, and safety, as well as distributive impacts and equity. Consultation with main stakeholders also is required under an RIA (Bartolomeo et al., 2004).

Similarly, the California Environmental Quality Act (CEQA) and CARB regulations require that analysis is undertaken to identify potentially significant adverse environmental impacts of any proposed projects and alternatives. CEQA requires all state and local agencies to give consideration to environmental protection (including air quality and GHG emissions) in regulating public and private activities, and prevents them from approving projects where feasible and environmentally superior mitigation measures or alternatives exist. This requirement was applied to CARB's agreement with the railroads, for example, requiring CARB to demonstrate that the proposed approach produces better emissions reductions than would the alternatives.

Use of Performance-Based Standards

The 1990 amendments to the Clean Air Act enable the use of innovative approaches to managing emissions, such as performance-based standards. Generally, a performance-

based standard is technology-neutral and sets an upper limit for emissions originating from a source, whereas a technology-based standard dictates the specific control technology. It is considered that a performance-based approach can reduce regulatory rigidity and ease private-sector compliance while also supporting innovation (e.g., through technology forcing) and lowering compliance costs. Nevertheless, an effective and sustainable regulatory regime is one that achieves the right balance between consistency, accountability, and enforceability versus flexibility and innovation. The prescriptive approach emphasizes control and accountability. The performance-based approach aims to promote flexibility with accountability for results.

There are, however, drawbacks to performance-based standards. As identified by May (2003), these can include potential inconsistencies in the application of rules, decreased predictability in regulatory expectations, increased costs to governmental regulators, and uncertainty with respect to equity and distributive impacts. May suggests that performance-based regulations are less costly to develop because they do not require detailed understanding of relevant technology. However, it may be more costly to ensure compliance because of the vagueness of performance standards and lack of expertise on the part of enforcement agencies.

The U.S. GHG emission and fuel consumption standards for heavy- and medium-duty vehicles are an example of performance-based standards. Adopted on August 9, 2011, the rule was jointly developed by EPA, the National Highway Traffic Safety Administration (NHTSA), and DOT, and has the support of industry. The standards, which are technology-neutral, cover not only engines but also the complete vehicle, enabling achievement of the greatest possible reductions in fuel consumption and GHG emissions while avoiding unintended consequences.

CARB has employed a performance-based approach to mobile-source emissions standards. In California, these have typically been "technology forcing" standards and have tended to require greater emissions reductions than required by EPA emissions standards. (*Technology forcing* refers to a regulatory agency's requirement for the achievement of an emissions level, within a specified timeframe, using unspecified technologies, that have been shown to be feasible on an experimental or pilot-demonstration basis, but are not yet widely available commercially.) Such standards have required advances in technology development, resulting in California becoming a "laboratory" for emissions-control innovations. CARB's regulatory process is supportive of this laboratory role, allowing California's standards to be amended rapidly in the face of changing market and technological conditions relative to the EPA regulatory process, which tends to take a long time. An example is the California At-Berth Ocean-Going Vessels Regulation, which includes an equivalent emissions reduction option as an alternative to shore power. Under this option, fleets are required to achieve emissions reductions equivalent to what they might achieve using shore power, by means of another (unspecified) technology.

An essential task for regulatory agencies, particularly in air quality nonattainment areas, is to assess various technologies to ensure that the desired emissions reductions are possible, and then to establish performance-based outcomes rather than prescribing technologies or operating procedures. This approach allows private-sector innovation to flourish.

Considering Funding Needs and Incentives to Drive Implementation

A core component of public-private collaboration is the provision of public funding and financial support to enable industry achievement of the necessary emissions reductions, frequently ahead of, or in addition to, regulatory requirements. Several examples of successful initiatives are described in this section.

The Diesel Emissions Reduction Act (DERA), a federally funded program established under the Energy Policy Act of 2005, gives the EPA new grant and loan authority for promoting diesel emission reductions (U.S. EPA, 2012c). The EPA estimates that since 2008, nearly 60,000 pieces of clean diesel technology (including emissions and idle control devices, aerodynamic equipment, engine and vehicle replacements, and alternative-fuel options) have been implemented through the National Clean Diesel Campaign, which is funded through DERA. The projects meet critical local air quality needs by deploying both proven and emerging technologies much earlier than would otherwise occur. Projects funded have included truck stop electrification, cleaner locomotives, repowering of gantry cranes, retrofit of auxiliary engines of ocean-going vessels with advanced maritime emission-control systems (U.S. EPA, 2012). However, staff at the EPA report that federal budget cuts in recent years have necessitated a shift of effort from these incentive and education programs, with limited resources being focused on air emissions regulation, which is the EPA's "core business."

Through California's $1 billion Proposition 1B Goods Movement Emission Reduction Program, CARB has made grants available to local agencies such as seaports and air districts, for specific types of projects (e.g., truck programs, ships at berth, cargo-handling equipment, locomotives, and harbor craft), that in turn competitively award them to equipment owners. The program leverages substantial matching funds from private, local, and federal sources (more than $1 for every program dollar invested), thereby optimizing investment efficiencies. CARB estimates that the $475 million program will save 2,500 tons of PM and 62,000 tons of NO_x over the life of the grant terms (CARB, 2011).

Funding and financial incentives can reach where state regulation cannot. For example, the Texas Emissions Reduction Plan committed almost $20 million to the reduction of locomotive emissions in the Houston-Galveston area, which suffers from the most severe locomotive emissions and the highest ozone levels in the state, and expects to reduce NO_x emissions by more than 3,300 tons at an average cost of $5,900 per ton (Scott, 2006).

Ports have played a critical role in providing a conduit for public funding for air emissions improvements. For example, the Port of Houston Authority, along with six private partners, was awarded $3.4 million of American Recovery and Reinvestment Act (stimulus) funding to replace, repower, and retrofit more than 128 pieces of old diesel equipment owned by the port and its partners (Port of Houston Authority, 2011). The Ports of Charleston and New York and New Jersey are among other port authorities funding clean truck or green port programs.

At the level of the metropolitan region, funding of infrastructure projects can have significant positive benefits. For example, the Chicago Region Environmental and Transportation Efficiency Program (CREATE) provides $1.5 billion in funding for some 71 projects. Once completed, the program is expected to save more than 7.4 million tons of NO_x emissions and more than 50 tons of PM emissions per year, along with congestion relief, reduced delay for freight and passengers, and safety benefits (CREATE, 2012).

Benefits of Partnerships: Case of the California Railroads

Railroad operations are governed by federal statute, with railroad air emissions generally deemed to be outside state regulatory powers. Thus, to address air quality issues associated with railyards, public agencies may need to enter into voluntary agreements with railroad operators. For example, CARB is working with the railroads, encouraging them to curb emissions in California. Although CARB has a unique position under the Federal Clean Air Act to regulate emissions, a collaborative approach building on the railroads' growing recognition of the importance of sustainability enabled binding agreements to be forged between CARB and the Class I railroads in 1998 and 2005. Under the terms of these agreements, the railroads committed to a range of measures to reduce air emissions, including fleet turnover, use of ultra-low-sulfur fuel, and anti-idling technology (CARB staff, 2012, pers. comm.).

A critical benefit of these agreements is that there is no delay to the introduction of the specified measures, which can make immediate air quality improvements possible in and around railyards. These partnerships have enabled an accelerated reduction of air emissions in the South Coast Air Basin beyond what is possible through the application of EPA standards, and have enabled air emissions benefits to be achieved in Southern California earlier than in the rest of the country.

Importantly, CARB's decision to approve voluntary binding agreements with the railroads included specific steps to avoid unintended consequences through provisions to ensure that older locomotives are not relocated to other yards in California. A CARB review of the environmental impacts of the proposed 2010 voluntary agreements with the railroads found that the implementation of the proposed commitments would be more effective in reducing PM emissions than alternatives—such as the regulation of non-pre-empted locomotives, zero-emission cargo-handling equipment, and railroad risk reduction audits—might have been (CARB, 2011b).

Open discussion, dialog, and data sharing regarding technology, operating characteristics, and inventory are a hallmark of CARB's relationship with the railroads and underpin the levels of trust that have been forged. As a consequence of this relationship, CARB is in a position to substantiate the levels of compliance and validate the railroads' efforts at emission reductions, using a data-based approach. This validation is also important to the railroads in obtaining community buy-in (CARB staff, 2012, pers. comm.).

2.5 Unique Role of Ports

Ports are in a unique position, located at the nexus of trade flows, caught between the need to maintain and grow port business and to mitigate impacts on surrounding communities. Port authorities often find themselves at the intersection of environmental, economic, and social considerations and are regularly at the forefront of the interface between different stakeholders (private business, regulatory agencies, and communities). Perhaps more so than other public-sector agencies, they have a deep understanding of supply chain economics as well as operations and available technologies (across several modes), and tend to enjoy ready access to data not usually available to other public-sector agencies or industry. They also tend to have greater capacity to undertake extensive analysis and market assessment and significant opportunities to enter into win-win partnerships through leveraging their relationships.

The San Pedro Ports Clean Air Action Plan sought to balance cargo growth with community benefits and to address adverse impacts. Given the significant capital they had invested in San Pedro Bay operations, port tenants had an interest in improving their own environmental performance in exchange for the ability to expand their terminals and operations. The port also was able to leverage landlord-tenant leases and tariffs to ensure environmental requirements were met.

Positioned at the intersection of freight transportation modes, including ocean shipping, rail, and road, ports are able to exert influence over different emissions sources, including vessels, on-dock port equipment, and drayage trucks. Through partnerships, ports also may extend their reach beyond that of public-sector regulators (as evidenced through the PierPASS Program, for example) and even beyond the port gates (through affecting drayage truck emissions such as the Clean Truck Program at the Ports of Los Angeles and Long Beach). Through their buying power they are also able to influence the local economy. For example, POLA was able to secure discounts from manufacturers from clean drayage truck purchases and require electric truck manufacturers to establish an assembly plant near the port (POLA staff, 2012, pers. comm.). Ports are also achieving air emissions reductions more quickly than might have been possible through regulation alone (as evidenced through the South Carolina State Ports Authority's voluntary truck fleet replacement program, for example).

2.6 Public-Private Collaboration at the National Level: EPA SmartWay Partnerships

Perhaps the best example of a win-win approach to emissions reduction is the EPA SmartWay Program. This landmark public-private initiative aims to improve fuel efficiency and reduce GHGs from freight vehicles, with the reduction in CAP being an additional benefit.

The program was forged in close collaboration with industry to address industry fuel efficiency and emissions issues. Continued stakeholder engagement helped EPA to understand industry challenges and needs as these evolve. The SmartWay program consists of several components as follows:

- Identifying and endorsing fuel-saving technologies;
- Accelerating the adoption of fuel-saving technologies and operational practices (e.g., through reduced interest and flexible repayment loan programs);
- Making accessible the tools and methods that enable businesses to assess, track, and reduce fuel use, GHGs, and other emissions;
- Establishing incentives and recognition for top performers, thereby assisting private companies in marketing their services; and
- Providing greater transparency of carbon accounting, benchmarking, and reporting.

Joining SmartWay is voluntary. As a SmartWay partner, shippers and carriers agree to assess freight operations, calculate fuel consumption and carbon footprint, and track fuel efficiency and emission reductions annually. In return, partners are entitled to use the SmartWay brand and logo, which provide them with recognition as sustainable service providers. EPA ranks and publicizes the partners' performance on the SmartWay Partner List, which reportedly provides a strong incentive for joining, because shippers are increasingly committing to SmartWay-certified carriers.

The program is significant in that it enables emissions from the legacy fleet to be addressed, whereas federal emissions standards typically apply to new vehicles only. SmartWay has demonstrated that business-supportive public-sector initiatives can be instrumental in promoting the sustainability of the supply chain. The success of the program lies in its ability to address gaps within the trucking industry such as the lack of information about energy efficiency options and technologies, high capital costs, lack of reliable technical assistance, and absence of a consistent approach to measuring sustainability impacts. SmartWay has helped to build strong market confidence, awareness, and calls for sustainable freight practices and reduced difficulties faced by freight companies in their adoption of clean technologies.

The impacts generated by the SmartWay Program, which has a staff of just 10 people and a budget of $1.5 million, have been significant. As of December 2011, a total of more than 2,900 companies and associations were part of the SmartWay Program. In early 2011, SmartWay reported that its partners had saved an estimated $6.1 billion in fuel costs as a result of the program. Efficiency measures have resulted in savings equivalent to 50 million barrels of oil or taking more than 3 million cars off the road for an entire year (SmartWay, 2011b). Emissions savings as a result of the program amounted to 16.5 million metric tons of carbon dioxide (CO_2), 235,000 tons of NO_x, and 9,000 tons of PM at the end of 2010. Air pollution reductions have had economic and environmental impacts, as well as providing social and health benefits, particularly in low-income communities near ports, intermodal yards, truck stops, and border crossings (SmartWay, 2011b).

EPA SmartWay has a strong track record of reducing emissions while saving companies money, and advancing air emissions objectives in a cost-effective manner. The clear view of the stakeholders the research team interviewed for this research is that it should remain a strong program and should be expanded. However, with federal budget cuts, the program may potentially be at risk.

2.7 Other Federal Initiatives

There are two other federal initiatives worth mentioning here. FMCSA has launched an initiative to explore the concept of a state-based commercial driver's certification for safe and fuel-efficient driving. FMCSA proposes to base certification on a combination of standardized knowledge and skills tests. The goal is to achieve improved safety as well as

air pollution and GHG emissions reductions. The proposal is based on the eco-driving concept in Europe, focused on improving vehicle energy efficiency through driver behavior. Research by the National Academy of Sciences supports this, with recommendations for the establishment of a curriculum and process for certifying fuel-saving driving techniques as part of a Commercial Drivers License (National Research Council of the National Academies, 2010).

The U.S. Department of Energy (DOE) SuperTruck Program has provided $187 million in grants to truck manufacturers to improve fuel efficiency of long-haul Class-8 vehicles by 50% (with associated emissions savings). The efficiencies are to be achieved through advanced engine systems and vehicle technologies that also meet safety requirements. Partnering with private-sector manufacturers, the project aims to get 40% of efficiency gains from engine improvements, with the remaining 60% to be derived from other vehicle systems, including aerodynamics, lightweighting, drivetrain friction reduction, and options such as waste heat recovery, and fuel cell auxiliary power units to reduce engine idling. The manufacturers have until 2014 to meet the goal set by the program.

2.8 Non-U.S. and International Public-Private Collaboration

A review of international precedent indicated several examples of partnerships between the public and private sectors aimed at creating win-win outcomes. Three notable examples are as follows:

- European Union (EU) Super Green Corridors Project is financed by the European Commission and the private sector and aims to encourage private-sector users of key freight transportation corridors to rely on co-modality and advanced technology in order to accommodate rising traffic volumes while promoting environmental sustainability and energy efficiency. The project is benchmarking nine corridors (e.g., in terms of costs, transport time, reliability, and emissions) and examining options for the use of green technologies and "smarter" use of information and communication technology flows (Psaraftis, 2012).
- U.K. freight facilities grant scheme provides capital support for rail freight investment where it can be demonstrated that environmental benefits will result from rail use. This program effectively "buys" the transfer of freight to rail. Funding is capped at a maximum of 50% of the eligible capital cost of implementing transport by non-road modes. Between 1997 and 2008, a total of GBP 58 million was awarded in grants, which are estimated to have removed 32.4 million truck miles from Scottish roads each year (McKinnon, 2010a).
- New Zealand's Emissions Trading Scheme (ETS) was introduced in 2008 as a low-cost approach to creating market incentives that encourage consumers and businesses to change their behavior and reduce emissions. Intensive consultation was undertaken and the ETS was supported by stakeholders over other emissions reduction strategies because it provides businesses with greater flexibility in managing GHG emissions, gives government greater certainty about the quantity of emissions to be reduced, and allows for adjustments to the international price of emissions. Following the introduction of the New Zealand ETS, a 21% reduction in overall GHG emissions was achieved in that country between 2007 and 2009, with the transport sector surrendering over 18% more emission units than originally projected during the first reporting period in 2010 (New Zealand Ministry for the Environment, 2011a).

These examples highlight the role that the public sector can play in enabling emissions reduction that the private-sector companies could not easily achieve on their own. This includes funding joint initiatives, providing a forum that brings together partners from across a range of jurisdictions, financing infrastructure improvements, and devising regulatory structures that are responsive to business interests.

2.9 Cross-Private-Sector Collaboration

Various collaborative private-sector initiatives have been forged in recent years to address supply chain sustainability. Although their purposes vary, in general these groups seek to share best practices, standardize metrics, and take a private-sector lead in areas where public policies have not yet been established. This type of collaboration also arises when leading firms in an industry or a region find it valuable to develop a jointly agreed-upon measurement framework that can be uniformly applied and reported by all players. As such, these initiatives represent an interesting alternative to publicly led programs and are worthy of examination.

There are four kinds of private-sector collaborations, focused on the following:

- General sustainability;
- Supply chain, logistics, or transportation sustainability;
- Industry-sector-based supply chain sustainability; and
- Local and regional supply chain or transportation sustainability.

General Sustainability

In the absence of inter-governmental agreement on the regulation of GHG emissions, several private-sector groups

have been established to help companies address sustainability and report on their progress. Some notable examples follow.

The Carbon Disclosure Project (CDP), based in London, was one of the first, involving stakeholders and corporations worldwide to create environmental strategies for, and disclose the GHG emissions of, major corporations. By providing a forum for collaboration among shippers and carriers alike, the CDP allows companies to share challenges and successes, which helps develop best practices and measure progress.

The Global Reporting Initiative (GRI) has developed one of the world's most established standards for sustainability reporting. GRIs are used by more than 1,500 organizations worldwide, and provide a framework for how a company should structure its sustainability reporting. The GRI's environmental reporting protocol set includes a reporting parameter for the "significant environmental impacts of transporting products and other goods and materials used for the organization's operations" (Global Reporting Initiative, 2012: EN29). These impacts include energy use, emissions (e.g., GHG emissions, ozone-depleting substances, NO_x, SO_x, and other air emissions), and noise. One interviewee noted the difficulties in comparing one company's sustainability performance with another's, due to the flexible and incremental nature of the GRI reporting protocol.

Founded in 1992 and headquartered in San Francisco, California, Business for Social Responsibility (BSR) is a global network of more than 250 companies that work together to develop sustainable business strategies and solutions through consulting, research, and cross-sector collaboration.

The World Business Council for Sustainable Development (WBCSD) is an organization led by chief executive officers of progressive companies committed to creating a sustainable future for business, society, and the environment. Headquartered in Geneva, Switzerland, WBCSD has close to 200 members, spanning a wide range of sectors and locations. The WBCSD has created a "Vision 2050" report that calls for, among other goals, a halving of carbon emissions worldwide by 2050 (from 2005 levels). WBCSD is working on a set of metrics and measurement methods for comparing green performance across companies.

Supply Chain Sustainability

Some general sustainability forums have launched subgroups that focus specifically on supply chain and transportation sustainability. Notable among these are BSR's Clean Cargo Working Group (CCWG) and the Carbon Disclosure Project Supply Chain.

The CCWG is specifically committed to integrating sustainable business principles into the freight transportation sector and advocating for standardized, credible information. The forum not only provides access to best practice and the sharing of information, but also has developed a CO_2 calculator that enables the calculation and comparison of carbon footprints across multiple modes of transportation. Interviews with both shippers and carriers suggest that they view the CCWG as a useful mechanism to discuss sustainability initiatives and to define a method for estimating a firm's carbon footprint.

The CDP Supply Chain Program also enables companies to estimate their carbon footprints, identify areas for sustainability improvements, and benchmark against their peer groups, as well as to disclose and showcase their results (Carbon Disclosure Project, 2011). Nevertheless, obtaining reliable supply chain emissions data remains a challenge, especially where multiple suppliers are involved. Supplier data tends not to be externally verified (due to the cost of such verification), and member corporations have difficulties with the comparability of data they get from suppliers. Further, suppliers with multiple customers may have difficulties in allocating emissions. CDP has found that some members are willing to deselect suppliers based on sustainability criteria. However, this number is still relatively low (Carbon Disclosure Project, 2011a).

The Coalition for Responsible Transportation (CRT) includes leading importers, exporters, trucking companies, clean truck manufacturers, and ocean carriers that are committed to driving significant and permanent improvements in air quality at, and around, U.S. ports. They are investing in the deployment of new clean equipment in partnership with federal and state governments, as well as local ports. CRT's core goals include developing a proactive compliance attitude to environmental emission regulations, partnering with ports to allow air quality goals to be achieved in a cost-effective manner, and facilitating the inclusion of an industry perspective in legislative and regulatory activities by engaging in a collaborative dialog with policymakers.

2.10 Industry-Based Supply Chain Sustainability Initiatives

There are several good examples of private-sector industry-specific initiatives that help companies address supply chain sustainability, including the Outdoor Industry Association (OIA) and the Sustainable Apparel Coalition (SAC). Apparel manufacturers, in particular (perhaps because of consumer sensitivity to green issues) seem to be oriented toward the need to understand, quantify, and reduce carbon emissions. The sharing of information and expertise among companies and sustainability forums has been central to their successes. The OIA's Sustainability Working Group now has more than 250 member companies and has developed one of the most collaborative, innovative programs yet, the Eco Index. Based

on members' own internal research and tool development efforts, the Eco Index was developed to address the environmental impacts of the apparel supply chain and provide a common reference point for the industry. By 2011, OIA members had adopted the first version of the Eco Index and, in conjunction with SAC, began to develop a second version (scheduled to launch in October 2013), which is to be applicable to all apparel and footwear products, not just those in the outdoor industry. The index spans the entire apparel lifecycle (materials, manufacturing, packaging, transportation, use, and end of life) and considers environmental impact categories such as GHGs, air pollutant emissions, and social and labor indicators. The goal is to enable designers to make informed decisions based on sustainability considerations. Each finished product receives a score that reflects its environmental footprint (Outdoor Industry Association, 2012, pers. comm.; SAC, 2012).

Globally, companies are organizing on a regional or local basis to address environmental issues facing the freight transportation sector and provide leadership in issues where government regulation or solutions may be lagging. Inspired by the U.S. EPA SmartWay Program, several European companies in various sectors joined to develop Green Freight Europe (GFE). GFE aims to be the leading independent voluntary program for road freight. A key difference between GFE and the SmartWay Program is the level of government involvement. Currently, GFE is a purely private-private collaborative group, although it hopes to have government support and participation in the future.

In Asia, the Fair Winds Charter is an industry-led, voluntary, at-berth fuel switching program for ocean-going vessels calling at Hong Kong and Pearl River Delta ports. The 17 shipping lines that are members commit to burning low-sulfur fuel while docked. This program, conceived by Hong Kong's Civic Exchange think tank and promoted to the Hong Kong Liner Shipping Association by Maersk Line, is an excellent example of how global shipping companies are taking the lead in shaping the regulatory agenda by promoting, on a voluntary basis, best practices for emissions reduction. This unsubsidized voluntary fuel switching program is the first initiative of its kind in Asia (Civic Exchange, 2013). The Fair Winds Charter allows the region to realize benefits while giving the governments of Hong Kong and Guangdong (each of which was reluctant to introduce regulations independently of the other due to the risk of losing business) time to work together to achieve common legislative requirements by the charter's expiration. In early 2013, the Hong Kong government pledged to mandate at-berth fuel switching. In response, shipping lines have agreed to extend their voluntary pact to use cleaner fuel for another year to January 2014, while the legislation to make fuel switch mandatory in Hong Kong is developed.

2.11 Conclusions

GHG emission reductions present an opportunity for win-win outcomes because these emissions are directly correlated with fuel consumed. Win-win outcomes tend to be more difficult to realize for CAP emission reductions because reduction mechanisms often increase private-sector costs not offset by tangible business benefits.

There are several examples of successful private-sector initiatives that are helping companies address supply chain sustainability. These industry-led initiatives engage in collaborative dialog with policymakers to promote the adoption of practical, effective legislation and regulations. Such initiatives are engaging industry in developing a pro-compliance attitude to emissions regulation. The role of public-sector agencies lies in reinforcing these initiatives and focusing their efforts on those aspects of supply chain emissions where the private sector, on its own, is either unlikely or unable to effect change. Public-sector agencies have a particular role to play in assisting the private sector in reducing their CAP emissions through regulation and incentives, as demonstrated by the Fair Winds Charter, for example.

Win-win outcomes are developed through cooperation and consensus rather than being imposed. However, in developing consensus-based approaches, various challenges need to be overcome. The trade-offs occur in the distribution of benefits between the public and private sectors; across environmental, social, and economic impacts; and between global GHGs and local CAP emissions. In many cases, regulation or strong incentives are necessary to foster collective action on the part of the private sector, level the playing field, provide certainty, and achieve the necessary emission reductions.

Because responsibility for policy, funding, and regulation in relation to freight emissions tends to be distributed across multiple public-sector agencies, cooperation and joint efforts among these divisions and layers of government is essential in freight planning, infrastructure provision, and emissions regulation.

Public-sector agencies involved in the planning and regulation of supply chains require a firm understanding of the interrelationships among freight transport, logistics activities, and air emissions. This not only necessitates the recruitment of knowledgeable staff, but also ongoing engagement of the private sector. The challenges presented by growing demands for goods movement in the face of physical, economic, and environmental constraints are beyond the capabilities of any one private entity, level of government, or community of interest. Collaboration among diverse public and private parties is required to meet these challenges effectively.

Access to data is an essential starting point for the sustainable management of supply chain emissions. The fact that public and private sector collect and monitor different datasets, all

of which are pertinent to sustainability outcomes, adds further urgency to the need for consultation, cooperation, and partnerships between the public and private sectors.

Proactive outreach and engagement of the private sector is required, beginning at the freight planning stage, continuing with decision making relating to infrastructure funding, and through the development of regulations. Proactive outreach encompasses a range of engagement methods and forums to encourage active involvement of the full range of private-sector stakeholders in decision making. Evidence from case studies indicates significant benefits to sustainability outcomes when industry is involved in planning and regulatory processes.

A defining feature of a sustainable approach to regulation is the provision of supportive or enabling measures to ensure that private-sector players have ample opportunity to comply with regulations, taxation, and emissions standards. Such measures also can assist in offsetting costs to industry. Where regulation is necessary to attain emissions reductions and air quality improvements, specific mechanisms for minimizing adverse impacts on business and economic growth should be considered. Such mechanisms include transition phases and the phased introduction of regulations (as employed in the implementation of the New Zealand Emissions Trading Scheme, for example), concessions for new and small businesses, and the use of minimum thresholds above which the regulations are applied (as included in the EU Aviation Emissions Trading Scheme and California's Shore Power Rule, for example).

Sustainable emissions regulations are those appropriate to local conditions and the extent of the problem, and that address stakeholder concerns in a particular geography. This requires an objective assessment of alternatives in terms of their economic, social, and environmental impacts, using rigorous performance evaluation frameworks as part of the regulatory process. In order to maintain transparency, such analyses should be publicly available for comment and discussion.

The use of performance-based standards, rather than prescribing technologies or operating procedures, has better potential for the realization of benefits from private-sector innovation. Performance-based standards also can reduce the costs of private-sector compliance and minimize the need for updates to regulations (e.g., when new technologies are made available).

CHAPTER 3

Operational Optimization

3.1 Significance of Transport and Supply Chain Operations

One of the major ways in which supply chains are becoming more sustainable is through operational improvements. Faced with a given set of product sources and required destinations, and given the technological characteristics of different transport modes, how can changes in the overall network design, the routing of freight, and other operational optimization techniques lead to reduced emissions? This operational optimization is generally undertaken directly by shippers and carriers aiming to reduce costs across the supply chain. This chapter explores the main elements of operational optimization, with examples drawn from interviews with shippers and carriers on historical results and possible future impacts. These trends are necessary for public policymakers to understand, as they often drive major reductions in fossil fuel use with attendant atmospheric benefits. Transport-related air environmental regulations should be designed in ways that do not contradict or undermine these major and positive changes occurring in the private-sector supply chain world. Therefore, the research team addresses the following two key questions, in covering each of the major areas of operational optimization:

- To what extent is operational efficiency (or cost savings, especially due to reduced fuel use) aligned with air emissions reduction?
- To what extent are these changes purely driven by the private sector versus being influenced by public policy?

The operational aspects of the vast number of supply chains that exist in the United States clearly have a substantial impact on the environment and society, whether via greenhouse gas GHG) and criteria air pollutant (CAP) emissions, roadway congestion, noise impacts, or other effects. The transportation of goods accounts for 8% of total U.S. GHG emissions from all sources. Further, the activities associated with moving and storing products tend to result in the concentration of pollutant emissions at key nodes (e.g., ports, intermodal facilities, and distribution centers) and along the main transportation corridors, thereby affecting air quality and the health of adjacent communities. Changes in the design and operation of supply chains have a significant impact on emissions as well as on environmental and human health outcomes. Regulators should be familiar with the nature and impacts of these network, modal, and operating changes.

3.2 Main Elements of Optimization

Shippers and carriers can achieve both efficiencies and air emissions reductions via various means. These can be classified as planning (or strategy) measures and execution measures. Most of these efforts are driven purely by economic efficiency and return on investment considerations, with environmental impacts achieved as a co-benefit. The focus on fuel efficiency by fleet operators, for example, aligns directly with carriers' overall operating efficiency imperatives. Under this win-win situation, carbon emission reductions are achieved via the same measures that create cost reductions. Public-sector policies and regulations also contribute to the impetus for change, particularly in the case of CAP emissions reductions (which are not always directly correlated with cost efficiency improvements).

Some of the main levers of distribution and transportation optimization follow:

Planning measures include

- Distribution network design and
- Transport mode selection.

Execution measures include

- Freight routing,
- Empty miles,

- Equipment use,
- Speed reduction,
- Driving style and vehicle idling, and
- Packaging.

Each of these levers is examined in the following paragraphs, with examples drawn from primary and secondary research.

3.3 Planning Optimization

Distribution Network Design

The design of distribution networks involves the determination of how best to connect production (or import) sources with points of consumption (stores, offices, or homes). Typically this means designing a network of nodes such as warehouses, cross-docks, or transload facilities that serve as intermediate points for the consolidation, storage, and final shipment of goods to destinations. Network design is undertaken by shippers for their product flows, and by carriers to most efficiently deploy their equipment and operators. The shippers interviewed cited the use of plant and distribution center network optimization initiatives.

Shippers have worked assiduously to optimize their logistics networks across the United States for at least the past two decades in response to shifting sources of supply (particularly increasing imports as a result of the globalization of the world's economy), expansion from regional markets to nationwide distribution, and rising fuel prices. Sophisticated software is readily available for corporations to facilitate these network decisions, balancing cost and service aspects. Typically, transport costs are reduced largely by reducing fuel consumption, which in turn reduces GHG emissions. In interviews, the research team found that all shippers the research team spoke with undertake network optimization studies, sometimes quite frequently. However, causing a major shift such as opening a new distribution center (DC) or closing an existing one, is often a time- and capital-intensive decision that is not taken lightly. Yet these decisions, taken by the operators of individual supply chains, have a significant cumulative impact on the spatial distribution of traffic and warehouses across the nation.

A few examples follow.

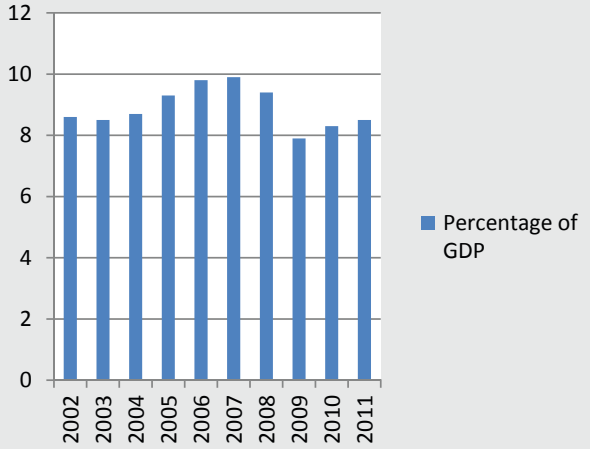
- Software makes "what-if" analyses of network design alternatives readily available to shippers. For example, JDA Software's Supply Chain Strategist solution allows companies to model and analyze their supply chain networks. The software includes capabilities that show sustainability choices and impacts, such as carbon dioxide (CO_2) emissions. Likewise, International Business Machines Corporation's (IBM's) ILOG LogicNet Plus XE software can evaluate a network and determine where/when new facilities (storage, production, etc.) are needed. This software has been used to reduce overall supply chain costs by 5% to 15%, to optimize the balance between shipping, warehousing costs, and service levels, consolidate distribution and manufacturing networks following mergers and acquisitions, and drive CO_2 emissions reduction.
- Large food manufacturers (e.g., Kraft and ConAgra) revised and streamlined their distribution networks in the 1990s to improve service to retailers and reduce costs. Such efforts were sometimes dramatic in terms of the reduction in number of warehousing facilities used and their enhanced ability to fulfill orders rapidly. Many small food suppliers (e.g., King's Hawaiian Bakery) have followed suit in optimizing their networks as well. Giant retailers such as Wal-Mart have also contributed momentum to the move to optimize joint supplier-retailer networks, using the most appropriate warehousing and transportation capabilities available to both parties.
- The goal of these network design studies is typically cost minimization for a given level of service. Given that transport costs dominate physical distribution costs, and are typically several times the cost of warehouse operation, these projects generally aim to reduce transport costs. This is done either by reducing miles traveled or by mode shifting. In either case, there is a direct link to reduced GHG emissions.
- Progressive corporations maintain internal staffs dedicated to conducting network analyses and related supply chain optimization. Examples include TJX Companies, Inc. (a large, off-price retailer) and The Limited (a major apparel producer) (https://www.limited-logistics.com/, 2012).

Although the effect varies from company to company, the optimization of distribution networks combined with the other operational measures discussed in the rest of this section have been responsible for significant gains in logistics efficiency in the United States. The Council of Supply Chain Management Professionals (CSCMP) publishes annual figures showing logistics costs as a percent of U.S. gross domestic product (GDP). This percentage has declined from 9.9% in 2007 to 8.5% in 2011, as shown in Exhibit 3-1.

Freight Mode Selection

Mode decisions are made by shippers at a planning level, based on trade-offs of cost and service. Hence, to meet a particularly tight delivery requirement, it may be necessary to expedite a shipment via air freight or parcel truck, rather than by a more sustainable mode. Shippers need to remain vigilant, however, given that diverting even a small percentage of freight from, for example, ocean to air modes, can cause a major increase in transport cost, fuel usage, and carbon emissions.

Exhibit 3-1. Logistics costs as share of U.S. GDP.



Source: CSCMP, 2012

Nevertheless, if sufficient time is available, it may be possible to ship via a slower but more economical and less-polluting mode, such as rail or barge. These decisions are influenced by the length of the particular route involved, the competitiveness of transport services offered, the expected transit time and reliability. The economics are driven, in part, by evolving technology (discussed in Chapter 4) and by the costs of meeting regulatory requirements for equipment and operations.

Choice of transport mode has a stark impact on fuel consumption per mile (Exhibit 3-2), which can vary by a factor of 3.7:1 (considering just surface modes). For over-water moves, the difference in fuel intensity and GHG emissions is even more dramatic, with air freight fuel use per ton-mile many times higher than sea freight. Modal decisions can have a profound impact on GHG emissions, due to their close link to fuel consumption. However, in the planning and daily running of supply chains, there also are other ways that efficiencies can be gained and air emissions reduced.

Exhibit 3-2. Comparative fuel use by mode.

Mode	MPG for One Ton of Cargo
Truck freight	155
Railroad	413
Inland Towing	576

Source: Kruse et al., 2009

As a general rule, transport costs (and carbon emissions) decrease as speed is reduced and freight capacity is increased. In other words, large ocean vessels can typically move freight far more cost-effectively and with significantly lower carbon emissions per ton-mile than trucks or aircraft. Shippers are thus motivated, particularly in the current era of relatively high fuel costs, to shift freight from a fuel-intensive mode to a more economical mode, wherever possible. Carriers, where they have a choice of how to move the freight using different modes of transport, face the same incentives to "downshift" to slower, greener modes when they can, while still meeting customer on-time delivery requirements.

Through primary research, the research team found numerous examples of shippers shifting to greener modes with resultant carbon emissions benefits. CAP emissions benefits may also occur, although there is less of a direct correlation between mode shift and CAP emissions, and carriers are less likely to track air pollutant emissions. Impediments to shifting more volume to increasingly fuel-efficient and less-polluting modes include transit time and delivery reliability, as well as capacity availability and lot size considerations. Studies also consider that because the overlap of the markets for the different rail and truck freight modes is fairly small, mode shift has only limited potential to affect emissions (Annema, 2008). Nevertheless, many shippers are reportedly finding that rail intermodal, in particular, is now viable on an increasing number of routes and on shorter haul distances than previously was the case.

Public policymakers influence private-sector transport mode decisions via the constraints and incentives applied to each mode. These include federal regulations pertaining to heavy-duty trucks, state restrictions on truck weights and lengths, local restrictions on railyard development, and cabotage laws such as the Jones Act (requiring that domestic marine transport be conducted only by U.S.-flag vessels). Fuel taxes and highway use taxes can play an influencing role, as well. Both within and extra to the existing policy and regulatory environment, private-sector players are actively optimizing their use of fuel-efficient and less-polluting modes. Examples from shippers include the following:

- TJX has expanded the use of rail intermodal in the United States for inbound flows to distribution centers. This increased from 30% of miles traveled in fiscal year (FY) 2008 to 61% of miles traveled in FY2011. The company anticipates further use of rail intermodal in future (TJX, 2012).
- Stonyfield Farm, the yogurt maker, is one of the few in its industry to use rail as a primary transport mode. The fuel cost is low compared with truck, though transit times are about a day longer to the West than via truck. The company makes up for the transport speed difference by process improvements in the warehouse, so the customer does

not experience a difference. Shipments move to retailer DCs on a weekly schedule, from New Hampshire to the Pacific Northwest and California, and from Pennsylvania to California and Florida. Stonyfield's experience is that rail is more reliable than truck transportation (Stonyfield Farm, 2012, pers. comm.).
- Nike plans to focus on optimization over the next few years, concentrating on mode, vehicle, and port optimization, as well as filling containers and decreasing number of shipments.
- Two food manufacturing companies cited the use of rail as a significant transport mode, having shifted away from trucking.
- One consumer goods maker is analyzing emissions per mode, seeking lower costs and environmental benefits.

Carriers are also shifting modes, examples are as follows:

- For United Parcel Service (UPS), mode shift is one of the first things considered when trying to reduce supply chain carbon emissions, as it is highly cost-effective. In 2010, UPS reduced its CO_2 emissions by 2.5 million metric tons as a result of this shift. Typically, for UPS this involves shifting from air to ground transport. The challenge is to help consumers and corporate customers plan ahead for longer lead times (UPS, 2012, pers. comm.).
- At UPS Freight, an effort is being made to switch to intermodal (from truck) whenever possible for long-haul situations. The company has strong relationships with all major railroads and is currently exploring a possible intermodal solution for 2-day service. Railroad reliability is viewed as being at an all-time high and the railroads are increasingly focused on their intermodal product. These carriers are now coming to UPS Freight with ideas and solutions (UPS Freight, 2012, pers. comm.).

Freight Routing

Once the structural decisions are taken with regard to a specific network, the operators (either shippers or carriers) optimally route the freight across the network. Questions arise as to which facilities should be used, and the trade-offs of consolidating versus fragmenting freight flows to provide the most efficient overall solution. Both shippers and carriers actively work to optimize the routing of cargo loads across their networks. Great improvements have been made in this area, largely thanks to better and widely available software solutions. The ability of more efficient routing to reduce miles traveled—and influence fuel, GHG, and potentially CAP emissions—is significant. Essentially, this is a purely private-sector initiative that has not been promoted or incentivized by public policy, but its impact is widely felt across the country.

Shippers have seized the opportunity to route their product flows via the most efficient paths as follows:

- Stonyfield Farm actively examines all elements of its supply chain to raise sustainability. The company found that 9% of its overall CO_2 emissions originate from inbound transport of ingredients and packaging, 13% from manufacturing, and 8% from distribution (with the remainder linked to milk production). Multiple efforts have been pursued, with routing a key factor. Stonyfield has
  - Eliminated 95% of its less-than-truckload (LTL) shipments by re-routing deliveries. This was enabled by electronic invoicing, which yielded detailed data on product delivery points and shipping schedules. Through analysis of these data, the company identified opportunities to add stops to existing truck routes so that trucks could deliver straight to customers with no intermediate terminal (Stonyfield, 2011).
  - Cut more than 4 million miles and 2,500 truck trips through improved routing (between 2006 and 2007), reducing its CO_2 per ton delivered by about 40%. The combination of fewer miles and fewer loads helped reduce fuel consumption, which was directly linked to reduced CO_2 release (Cooke, 2009).
  - Optimized transportation on incoming materials by purchasing full truckloads when possible; using backhauls when possible; and tracking the "food miles" (distance food travels to reach their plant), mode of transport, and associated GHG emissions for all major ingredients.

Carriers engaged in parcel delivery and trucking also have been focused on routing optimization, primarily to save fuel. Examples include the following:

- Federal Express (FedEx) uses dynamic routing software (Route Optimization and Decision Support [ROADS]) for route optimization. The goal is to match "the right vehicle with the right missions with the right route." This dynamic routing system shows how best to move volume through the delivery system by creating and assessing what-if scenarios (FedEx, 2012, pers. comm.). Due to this software and other efforts, FedEx has achieved year-over-year increases in miles per gallon, ranging from 5.4% in FY2006 to 22.0% in FY2012 (FedEx, 1995-2012).
- UPS has worked to decrease its average fuel consumption per ground package delivered in the United States. This indicator improved by 3.3% in 2010 relative to 2009 (and 7.9% relative to 2007), even though package size rose by 1.8%. The company's proprietary routing technology (as well as telematics and other innovations) enabled UPS to avoid driving more than 63.5 million miles in 2010, with an associated air emissions avoidance of 68,000 metric tons.

UPS focuses on opportunities to reduce miles driven and idle time before evaluating the use of alternative vehicles or fuels. Between 2006 and 2011, UPS achieved a 28% reduction in fuel per ton-mile in its parcel business by reducing miles driven and idle time (UPS Freight, 2012, pers. comm.). The routing technology works by optimizing the following key processes:
  - Allocating pick-ups and deliveries to the most efficient number of vehicles each day at each facility, thus keeping vehicles off the road wherever possible.
  - Loading vehicles most efficiently for the order of delivery so that routes and miles driven can be kept to a minimum.
  - Selecting vehicles for routes on which they will deliver the best fuel efficiency (UPS, 2010).
- Con-way has introduced dynamic routing algorithms for its line-haul LTL operations. This software provides optimal routing for each of 60,000 daily shipments. This reduces fuel consumption and operating cost by eliminating schedules, increasing loaded backhauls and improving trailer cube use. It is an active, not static, system. In the past, loads from locations like Maryland to California all moved via the same route. Now, with dynamic modeling, the routing can change from day to day. Overall, this software is expected to generate significant operational efficiencies.
- Weber Logistics, operating throughout the western United States, changed from an environment where drivers routed freight to a computer-driven solution. The software takes circuitous miles out of the route and reduces empty miles. Weber expects the use of this routing software to increase transportation efficiency by 12% to 18%, once fully implemented (Weber Logistics, 2012, pers. comm.).

Empty Miles

Closely related to the routing of cargo loads is the issue of minimizing the distance that transport equipment is moved with no load. Reducing empty miles is a major concern of carriers, particularly within the trucking segment, which creates the most total air emissions of any mode in the United States. This is again largely a private-sector initiative, motivated by seeking lower fuel costs—generally the largest single component of operating cost for transport operators—and having positive impacts on GHGs and CAP as well.

Examples of programs targeting empty miles reduction from carriers interviewed, include the following:

- Con-way achieved major reductions in empty miles through major network changes in 2009 and the continued use of optimization and simulation software. Empty miles in the LTL division have dropped from 11.1% in Q1 2007 to 6.4% in Q2 2012. Con-way's truckload division also has used software to drive down empty miles, from 10.2% of total miles in 2008 to 9.3% as of mid-2012, resulting in the lowest level of empty miles in the company's history (Con-way, 2012, pers. comm.).
- Pacer indicated that reducing empty miles is a major focus. The carrier measures empty miles by terminal location and then develops a targeted marketing and sales campaign to try to balance each lane (Pacer International, 2012, pers. comm.).

Equipment Use

Maximizing the capacity of containers, trailers, or railcars is an important lever in moving freight efficiently, leading to fuel economy per cargo ton moved and air pollution reduction. This is because fuel use for a given truck, ship, or plane is often less than proportional to increases in weight or simply because the cargo is more volumetric or low density. Examples of such initiatives are as follows:

- ConAgra Foods, in addition to focusing on how to take trucks off the road (modal shift) and take miles out of the system (routing optimization), is working to make full use of trailer capacity for miles that they do use (ConAgra Foods, 2011, pers. comm.; ConAgra Foods, 2012a).
- TJX has changed the frequency of store deliveries from its U.S. DCs to so that full truckloads are sent to each store. The retailer employs various co-loading schemes to ensure full truckloads. TJX also looks at alternative methods to load and unload trucks, using various delivery techniques (including live "traditional" deliveries, floor-loaded trailers, pallet drops, and trailer drops) (TJX, 2012).
- FedEx Technology Solutions developed a process for FedEx Ground to help maximize the shipments in line-haul trucks. The system scans every package to measure dimensions. From this, FedEx knows the actual capacity used for each trailer. This information helps FedEx train team members who load the trailers, which leads to better trailer use.

Speed Reduction

Operating transportation equipment at reduced speeds is a fuel efficiency technique frequently used in recent years of high fuel costs. This reduces overall cost for a carrier, given that the lower fuel consumption per ton-mile at lower speeds generally more than offsets any need for additional capital investment to make up for the lost carrying capacity per day. Major speed reduction applications are in trucking and container shipping. Although state authorities set speed limits, currently many motor carriers use regulators on tractors to limit their speed to rates below the speed limit, for fuel savings. In ocean shipping, the practice of slow steaming is analogous (though typically without the regulatory aspect); with

fuel consumption varying roughly as the cube of speed, a reduction of a few knots is sufficient to sharply reduce fuel usage, the largest component of vessel operating cost. Examples include the following:

- Stonyfield's trucks delivering to New England customers are equipped with onboard computers that regulate top speeds to optimize fuel efficiency (Stonyfield Farm, 2011).
- Several trucking executives interviewed indicated that they routinely limit truck speed. One said the company reduces speed by 2 miles per hour (mph) if the truck is fully loaded. Another stated that fuel cost is so significant that it is worthwhile limiting speeds to below the speed limit, even though travel time is increased.
- Container line APL has broadly applied slow steaming, reducing speeds from about 24 to around 18 knots. This slow steaming requires adding one more vessel to a typical service loop, but is still less costly overall. APL is combining slow steaming with the planned introduction of new, larger vessels, which together will drive efficiency gains of 75%. Other operational measures include voyage optimization and routing and vessel trim (burning fuel from specific tanks in a sequence that causes the least-resistant trim condition) (APL, 2012).
- Through the introduction of slow steaming, Maersk Line cut overall CO_2 emissions by 4.6% in 2010 and reduced fuel consumption and carbon emissions on major routes by about 30% (Maersk Line, 2010). Other shipping lines such as Hapag-Lloyd, Nippon Yusen Kaisha (NYK) Line, and Kawasaki Kisen Kaisha have also adopted slow steaming.

The American Trucking Association agrees that speed reductions are an effective means of reducing vehicle emissions, with the benefits felt immediately. The association supports the use of speed governors (already installed on large trucks) set at 65 mph. Reducing truck speeds to 65 mph would save an estimated 2.8 billion gallons of diesel fuel in a decade and reduce CO_2 emissions by 31.5 million tons, equal to the carbon emissions generated by 9 million Americans in a single year. Further, nearly 3,000 lives could be saved annually with a nationwide speed limit of 65 mph or less (American Trucking Association, 2011a). Nevertheless, studies have shown that emissions of most pollutants do not rise or fall dramatically as a result of speed reductions (Panis, 2011).

Ships can improve their operational efficiency significantly by sailing at slower speeds. Reductions in operational speeds stand out from other measures to reduce GHG emissions from ocean-going vessels, as they do not require vessel modifications and can, in theory, be introduced immediately. Generally, a 10% reduction in speed corresponds to a drop in emissions of approximately 27% per unit of time or more than 19% per unit of distance. It is estimated that bulker, tanker, and container emissions can be reduced by about 30% in the coming years. Further, the current oversupply of ships creates a unique opportunity to reduce speed in order to match the supply with demand (Seas at Risk, 2010).

Cost efficiencies play a key role in slow-steaming decisions. Marine bunker costs reportedly make up 21% of vessel operating costs. Slow steaming partially offsets these costs by reducing bunker fuel consumption and has the added benefit of reduced CO_2 emissions. Additional benefits include improved on-time reliability (since buffer time is added to slow-steaming routes). However, marine shipping lines such as Hanjin Shipping note that added transit time can result in a competitive disadvantage, depending on the shippers affected and commodities being moved. In addition, the added charterage (as a result of additional vessel deployment) and additional equipment requirements incurred as a result of slow steaming, as well as additional costs associated with engine maintenance, can offset fuel savings benefits (Hanjin, 2011). Note that where slow-steaming decisions are voluntary, they appear less likely to have unintended consequences. One ocean carrier interviewed cautioned that ships required to slow in one geographic area may need to pick up speed in another area to make the required schedule, which can result in an increase in overall GHG emissions.

Driving Style and Vehicle Idling

Trucking and parcel delivery companies have embraced more fuel-efficient driving styles and the reduction of vehicle idling. This leads directly to fuel and operating cost savings, as well as CO_2 and CAP emissions reductions. Training and telematics are used to encourage fuel-efficient driving practices.

Many trucking and parcel companies have put in place strict limits on how long a vehicle can idle, for instance, as it waits to unload. The trend has been supported through idling regulations by state and local jurisdictions (State of Florida, State of Connecticut, City of Sacramento, City of Denver, and City of Atlanta). Examples of shipper and carrier initiatives are as follows:

- Staples has focused on idling reduction by installing anti-idling equipment in its trucks to keep idling at less than 5 minutes.
- One large motor carrier uses special onboard equipment (monitoring revolutions per minute, transmission wear, and tire condition) and a control module that provides alerts of incorrect shifting behavior by drivers.
- UPS' package planning and routing system includes the identification of idling reduction opportunities. These are related to selecting routes that minimize time spent waiting for lights and left-hand turns, and identifying unloading locations that enable multiple deliveries (UPS, 2010). Over

the 2006 to 2011 period, UPS Freight has been able to reduce idle time by 50 minutes per driver, for a fuel reduction of 400,000 gallons per year (UPS Freight, 2012, pers. comm.).
- As noted in Chapter 2, FMCSA is advancing the concept of a state-based commercial driver's certification for safe and fuel-efficient driving. Some carriers, such as FedEx, already have an eco-driving program designed to lower vehicles' effect on the environment by helping drivers change their daily driving habits (FedEx, 1995–2012).
- Cascade Sierra Solutions (CSS), a nonprofit organization, is supporting the electrification of truck stops along major freight corridors in the United States as an alternative to burning diesel fuel during rest periods. CSS is providing pedestals that allow trucks to plug in to the grid during mandatory rest stops, and enabling truckers to access $10 million in finance from the U.S. DOE to subsidize the retrofit of 5,000 trucks to enable them to plug in to the grid. This can result in considerable savings to truckers, as the cost of electrified power is just $1 per hour, whereas trucks consume upwards of 1.2 gallons of fuel while idling (more for reefers), as well as CAP and GHG emissions reductions (Stifel, Nicolaus and Company, 2012).
- Railroads in California, under the terms of a voluntary agreement with CARB, have installed anti-idling devices on 99% of the California-based locomotives (CARB, 2006).
- Marine carriers have begun to use shore power (also referred to as cold ironing or Alternative Marine Power), for example, at the Ports of Los Angeles and Long Beach as well as at European ports (e.g., Goteborg), to reduce emissions from auxiliary engines while in port. Shore power refers to the use of power from shore-based sources by vessels while they are docked, rather than from onboard fossil-fuel burning engines. However, this is an expensive option for emissions reduction. The recently adopted Californian At-Berth Ocean-Going Vessels Regulation requires container, reefer, and cruise ships making regular calls to California ports to reduce their at-berth emissions by 80% in 2020. They are required to do so either through connecting to shore power or through the use of alternative control technologies to reduce nitrogen oxide (NO_x), PM, and CO_2 emissions. To date, there are no proven alternative technologies available for on-vessel use and CARB has agreed to accept only a very few alternatives. There have been only limited incentive programs to speed adoption.

Packaging

Reduction of unnecessary packaging, both in terms of weight and volume, is a major thrust of shippers and carriers today. These efforts serve to increase the effective use of transport equipment, thus reducing air pollution and solid waste, while driving down costs as well. This is akin to equipment use initiatives, in that the goal is to eliminate unnecessary weight and volume surrounding products as they move through the supply chain. Examples include the following:

- A leading mass retailer has implemented sustainability criteria in purchasing decisions, requiring product suppliers to comply with sustainable packaging requirements.
- One office supplies company is working to raise carton use by eliminating excess air in each carton.
- In order to lower logistics costs and increase efficiency in its transportation and warehousing operations, IKEA initiated an internal competition to reduce unnecessary air in its product packaging, thereby increasing true product volume during transportation and storage. A case study of the introduction of volume-efficient packaging method for tealight candles, for example, shows how a decrease in the amount of air enclosed in the packaging process resulted in a 30% increase in products per load unit. However, this also increased the weight of the load unit to such a level that the weight exceeded the load capacity of vehicles if loaded to reach full volume use. The solution to this overload was to balance the load on the trucks by using lightweight products to fill up the left over space (European Community BestLog Platform for Logistics, 2011).

3.4 Impact of Evolving Trends: Online Ordering and Delivery

Studies have found that alternative retail channels such as e-commerce have distinct GHG emissions benefits when compared to conventional retail models. The major differences between the traditional retail model and the e-commerce model are associated with transportation from the warehouse to the retail store or distribution center, data center energy usage, individual vs. bulk packaging, and transportation from the store or distribution center to the consumer (the "last mile" of delivery). These differences vary in energy usage and intensity. Study results indicate that e-commerce delivery typically uses less primary energy and produces fewer CO_2 emissions than traditional retailing. GHG reduction benefits are primarily derived from customer transport and last mile delivery, as well as packaging reductions (Barrington-Leigh, 2008; Weber et al., 2011). However, there is variability uncertainty in the conclusions associated with customer transport to the retail store with benefits of online ordering and delivery, largely dependent on the nature of the trip being replaced (mode, length, and whether it is single- or multi-purpose).

Study results also found that shippers can have a significant impact on GHG emissions from their online ordering operations through a careful choice of packaging materials and low-impact operations. Nevertheless, the overall GHG emissions reductions potential from online ordering and

delivery is relatively modest compared with the potential for emissions reductions elsewhere in the supply chain (Barrington-Leigh, 2008).

A study of the use of information and communication technology for the online purchase and digital delivery of music found that, despite the increased energy and emissions associated with Internet data flows, purchasing and downloading music digitally reduces the energy and CO_2 emissions associated with delivering music to customers by between 40% and 80% compared to traditional retail delivery of a music compact disc (CD). This reduction is due to the elimination of CDs, CD packaging, and transport emissions associated with traditional CD distribution. Nevertheless, this study found that the traditional retail delivery scenario can be nearly equivalent to downloading and burning a CD at home if the customer walks rather than drives to the retail store. However, as the Internet becomes more energy efficient, the emissions reductions benefits of online purchasing and downloading will increase (Weber et al., 2009).

3.5 Conclusions

The Private Sector Is Optimizing Its Operations with Air Emissions Benefits

The private sector is already engaging in operational optimization, mainly for business reasons that improve economic efficiency and elevate the quality of service provided to customers. In several cases, these optimization initiatives can have emissions benefits. For example, network optimization software capabilities include CO_2 emissions assessment capabilities. Routing optimization is similarly employed as a means to save fuel by reducing miles traveled and can have emissions benefits. Both network and operational optimization are internal company business process decisions.

The Need for Public-Sector Support

Nevertheless, there is potential for public-sector support for optimization initiatives. For example, in the Kansas City region, the movement of containers between railroads moving goods north-south and east-west typically requires multiple truck moves. These "rubber tire" movements are required when the intermodal facilities of the various railroads are not in proximity or equipped for a direct rail-to-rail transfer. Multiple truck moves frequently result in empty moves where there is no backhaul associated with the original move. This adversely affects the overall efficiency of the transportation network, transportation safety, and adds to congestion, fuel use, and air emissions, as well as undermines the quality of life of people in surrounding communities. In response, the Kansas City Cross-Town Improvement Project (C-TIP) initiative was set up to coordinate information among multiple intermodal terminals to improve efficiencies, save carriers time, and eliminate empty moves. Wider benefits include reducing both the overall number of moves and transport air emissions.

C-TIP is a collaborative project between government and industry supported by the FHWA Office of Freight Management and Operations as well as the Intermodal Freight Technology Working Group (IFTWG), a partnership of public- and private-sector interests focused on the identification and evaluation of technology-based options for improving the efficiency, safety, and security of intermodal freight movement. C-TIP has involved the Kansas DOT, Missouri DOT, Mid-America Regional Council (MARC) as well as the railroads and trucking companies. Together these agencies are developing an intermodal moves database that enables the coordination of cross-town traffic, tracking of intermodal assets, and distribution of information to truckers wirelessly. Railroads, facility operators, and truckers can thus share information about available loads, deliveries, traffic, and scheduling. The results of the initial testing proved the concept to be viable.

Mode Shift

Carriers' and shippers' mode choice also can influence freight emissions, and in an era of relatively high fuel costs, many are downshifting to slower, cheaper modes such as rail and short sea shipping which typically have lower GHG emissions. From interviews with carriers and shippers, it appears that many are taking advantage of the cheaper costs of non-truck modes. However, transit time and delivery reliability tend to be the main impediments to a mode shift from trucking. Because the overlap between markets for truck and rail freight is relatively small, mode shift potential is fairly limited.

Further public efforts to support mode shift appear to have had uncertain impacts. Efforts to induce mode shift to rail and short sea routes in Europe have been less successful than expected. For example, distance-based truck tolls in Germany resulted in an only a 7% increase in the number of containers carried by rail (Denning, 2010). Similarly, heavy goods vehicle fees in Switzerland did not achieve significant rail mode shift. Rather, changes to truck configuration and delivery logistics have resulted in more efficient use of trucks in both cases. This highlights the inherent speed, reliability, and logistical advantages of trucks for many shipment types (Minnesota DOT, 2010).

Although mode shift efforts (including pricing policies, targeted grants, and infrastructure investments) by European decisionmakers have had some impacts, the full extent of benefits generated is ultimately uncertain and it is unclear whether the benefits attained were achieved in the most efficient manner, or whether similar benefits could have been attained through other policies at a lower cost (U.S. GAO, 2011a). One of the ways in which public agencies can assist in facilitating

mode shift is by focusing their efforts, to the extent that they are able, on helping to overcome the private sector's perceived challenges in shifting to cleaner and greener modes, most notably those associated with transit time and reliability.

Routing, Vehicle Speeds, and Equipment Use

Shippers and carriers alike are realizing reduced fuel costs from efficient routing decisions with associated air emissions benefits as a result of reduced vehicle miles traveled. In many cases, this involves the use of routing technologies and software that allows pick ups and deliveries to be allocated efficiently, matches vehicles to routes, and ensures efficient vehicle loading. Technology also can enable reductions in empty miles through increasing loaded backhauls, as well as improved trailer cube use.

Businesses are driving down operating costs through improved use of trailers and containers, and through reduced and rationalized packaging.

Private-sector truckers and ocean carriers are reducing emissions by reducing speeds. The trucking industry is advocating a nationwide reduction in speed limits to 65 mph or less. This could have significant benefits in terms of reduced fuel use, carbon emissions reductions, and safety. This requires further investigation.

Several ocean carriers are engaging in voluntary slow-steaming initiatives that can create cost savings as a result of reduced fuel consumed on intercontinental voyages, along with GHG emissions benefits and improved on-time reliability. Ports such as the Port of Long Beach (POLB) are offering incentives for vessel speed reductions within 40 nautical miles of harbor. For example, POLB's voluntary "Green Incentive Flag Program" rewards vessel operators for slowing down to 12 knots or less by providing dockage rate reductions. The program has NO_x, O_x, and PM emissions reductions benefits, with improved health outcomes for port communities. More than 1,000 tons of air pollutants are reportedly prevented each year from this voluntary program. Benefits include reduced CO_2 emissions and the protection of marine mammals from vessel strike (Port of Long Beach, 2012). Environmental groups are, in fact, currently pressing for mandatory 10-knot speed limits off portions of the California coast to protect marine mammals. (Seasonal 10-knot speed limits for ships 65 feet or longer have been in effect in locations along the East Coast for several years with the aim of protecting the North Atlantic right whale.) Options for the regulation of speed limits require further investigation and exploration with industry prior to implementation to ensure that speed reductions in one location do not necessitate speed increases in other geographies for carriers to meet scheduling requirements, and thereby increase overall GHG emissions.

Idling and Driver Behavior

Carriers are engaging in various initiatives to reduce vehicle idling and improve driver behavior. In the trucking sector, this includes the installation of anti-idling equipment on trucks, eco-driving programs, and onboard monitoring. Truckers are also retrofitting their vehicles (in some cases with the assistance of financing from the public sector) to enable them to plug in to the grid. Railroads, too, have committed to reducing idling. In California, they have entered into voluntary agreements with CARB to install anti-idling devices on 99% of California-based locomotives.

Marine carriers are reducing at-berth emissions through the use of shore power. In 2008, at-berth vessel emissions reduction regulations were introduced in California, where docked vessels are responsible for a significant proportion of port emissions that affect the health of local communities. The regulations require reefers, cruise ships, and container vessels to shut down their auxiliary engines and plug in to the electrical grid while at berth, or to use alternative control technique(s) that achieve equivalent emission reductions. Notwithstanding the potential for the use of alternative control technologies, this regulation has evoked strong reactions from shipping lines due to high onboard technology costs, reported lack of available alternative technologies, and limited applicability of shore power in other non-California locations. Shore power is a particularly expensive emissions reduction option for terminal operators, as well as for marine carriers (both in terms of technology and the high costs of electricity when compared with bunker fuel). Air emissions benefits are dependent on the source and availability of grid power, as well as the extent of quality issues in the port area. Thus, where shore power is contemplated, the alternatives, as well as the costs and benefits of the options should be weighed carefully. In particular, the perspectives of the terminal operators, energy providers, and vessel owners should be taken into account, as well as the availability of equivalent emissions reductions approaches and technologies. Successful approaches in Europe have included voluntary partnerships between ports, terminal operators, and steamship lines, rather than mandatory requirements. This approach might be considered at other ports outside of California.

CHAPTER 4

Equipment and Technology

4.1 Main Elements

Transport technology, in terms of energy-efficient equipment (aircraft, trucks, trains, and ships), engines, and alternative fuels, has driven and will continue to deliver substantial benefits for air emissions reduction (primarily GHGs) as well as operating costs. The EPA marine diesel and locomotive engine standards, which set levels of PM and NO_x, as well as GHG emissions standards for heavy-duty trucks, will advance change. It will likely take some years for the full effectiveness of these standards to be realized due to the slow rates of fleet turnover. However, there are situations in which the regulators have been slow to promote new technology or have avoided allowing certain types of equipment due to concerns about effects other than fuel efficiency.

In the primary research, the research team found that most shippers and all carriers are highly focused on testing and then adopting fuel-efficient technologies. These efforts are due, in part, to sustainability objectives that have become ubiquitous within American corporations. But primarily, they are aimed at achieving operational cost savings while also meeting federal, state, and local requirements.

This chapter outlines key new technologies that shippers and carriers are using to achieve greater fuel efficiency, sustainability, and cost savings. It will touch, along the way, on the interaction among these private-sector initiatives and public policies that either promote or potentially retard the implementation of more efficient technologies. Comments also will be provided on those advances that seem most likely to enter the freight transportation mainstream in coming years.

4.2 Equipment Upgrades and Improvements

Improvements in transportation equipment efficiency have been extensive in recent years. The following discussion is organized by mode.

Trucks

Truck size and weight limits are a major element from the trucking industry's perspective. A recent review of policies and technologies for improving truck fuel efficiency and reducing CO_2 emissions concluded that longer combination trucks offer the single biggest potential efficiency gain via lower vehicle miles traveled (VMT). Fuel savings through longer combinations are estimated to be between 17% and 28% (Greszler, 2009). These conclusions are supported by other research that asserts that improving the payload efficiencies through the use of longer trucks is estimated to have the potential to reduce GHG emissions by 11% to 30%, depending on gross vehicle weight, payload size and type, and engine size, compared with standard five-axle tractor-semitrailer combinations. However, longer trucks introduce concerns about safety and pavement wear and tear (Mintz, 2010). The American Trucking Association has voiced strong support for "more productive truck combinations," including single tractor-trailer maximum gross vehicle weights of 97,000 pounds and the use of heavier double 33-foot trailers. The association estimates that a reduction of 294.7 million tons of CO_2 could be achieved over 10 years with the introduction of these changes (American Trucking Association, 2011a).

The potential impact of changes to truck size and weight limitations is significant, particularly in respect to long-haul trucking (Solomon, May 15, 2012), as follows:

- If weight restrictions were increased from 80,000 to 97,000 pounds, an estimated $32 to $37 billion a year in cost savings and productivity improvement could be made.
- MillerCoors estimates it could cut the number of trucks deployed each week to its DCs by 25%, which would translate into 1.15 million fewer miles traveled each week. This would also mean cutting the weekly fuel bill by $180,000 and reducing carbon emissions by more than 4.5 million pounds per week.

- Kraft says that it could cut 66,000 loads a year, which would result in a 33-million-mile drop in weekly vehicle miles driven, saving the company 6.6 million gallons of diesel fuel and 73,000 tons of CO_2 emissions each week.
- Campbell Soup said it could cut its annual loads by 41,000, reducing vehicle miles driven by 23 million, saving almost 4 million gallons of fuel and eliminating almost 40,000 tons of CO_2.

The Moving Ahead for Progress in the 21st Century Act (MAP-21), signed into law on July 6, 2012, includes a call for the U.S.DOT to conduct a comprehensive study of truck size and weight regulations. Thus, fresh policy research on this topic is currently in the offing.

Almost all previous truck size and weight (TS&W) studies have shown significant reductions in costs associated with increases in TS&W limits. However, large trucks would have to be consistently operated at high levels of capacity use for costs and emissions benefits to be realized. Studies also noted various potential adverse impacts of increasing federal TS&W limits, greater noise impacts, added infrastructure costs, disruption of traffic flow, and potential adverse impacts on safety. Greater truck payload opportunities would affect the competitive situation with rail, short sea shipping/inland waterway transport, and intermodal transport, likely resulting in some shift from these modes to road as a result of reduced road haulage costs. This could have an adverse impact on congestion (March, 2001; Döpke, 2007).

Trailer design also affects fuel use, and hence, air emissions. An example of innovative trailer design is FedEx's drop-frame trailers. These carry 12% more shipments than a typical straight-rail trailer. Drop-frame trailers take advantage of the space between the front and rear wheels. Over the course of a year, the additional packages carried per trailer translate into 2,500 fewer line-haul trailers on the road, saving 70 million road miles and 10 million gallons of fuel per year (FedEx Corporation, 2010).

Aerodynamics of tractors, trailers, and the combined unit is another area of design innovation. EPA's SmartWay Technology Program, a testing, verification, and designation program to help freight companies identify equipment and technologies that save fuel and lower emissions, has verified a range of aerodynamic technologies. California now mandates the use of trailer skirts (undertray system) for trucks operating within the state. However, operators suggest these are not effective below about 50 mph (whereas the speed limit in California is 55 mph), so their impact may be limited in this state. One large trucking company, though, cited its new undertray system aerodynamic enhancement on trailers can save about 11% to 12% of fuel consumption for long-haul trailers.

NHTSA and EPA are beginning work on developing regulations for trailer aerodynamics for heavy and medium equipment, with regulations expected in 2014 (Con-way, 2012, pers. comm., 24 May). Investment in aerodynamics of trailers faces a more challenging payback than that in trucks, however, given that the "drop and hook" system means that trailers are only on the road one-third of the time, thus making the payback period three times longer than that for power units.

Ocean Carriers

For ocean shipping, technology change is driven by commercial considerations and by international, national, and local regulations. Large, new containerships being introduced by lines such as Maersk and APL provide considerable sustainability benefits. Maersk, for example, claims that its new 18,000 20-foot-equivalent-unit (TEU) container vessels will produce 20% less CO_2 per container moved, compared to its previous largest class (*Emma Maersk* and sister ships) and 50% less than the industry average on the Asia-Europe trade lane. This new vessel class is called the *Triple-E class* for the three main objectives behind the design—economy of scale, energy efficiency, and environmental improvement. The capacity is 16% greater than the largest containership previously in service, according to Maersk.

APL introduced its latest, largest, and most environmentally friendly, fuel-efficient ship in May 2012. This vessel class is fitted with a ballast water treatment system (in line with International Maritime Organization's (IMO's) ballast water management framework) and electronically controlled main engine. APL will deploy 30 more new vessels in the next 3 years. The new ships will significantly curb CO_2 emissions, with an energy efficiency design index (EEDI) nearly 30% greater than that required by the IMO (APL, 2012). APL also has introduced waste heat recovery on its vessels, leading to a 10% improvement in fuel efficiency, and seawater scrubbers to decrease vessel engine emissions (APL, 2011, pers. comm.).

IMO studies estimate that improved ship design and operational arrangements could reduce CO_2 emissions by as much as 75%, with a cut of around 20% possible without additional costs. The IMO has developed the EEDI for new ships, which sets a minimum energy efficiency level per ton-mile for different vessel types and sizes. The requirement will be tightened incrementally over time. The IMO has developed a management tool to promote energy-efficient operations in the form of the Ship Energy Efficient Management Plan (SEEMP). The SEEMP is to be implemented in parallel with the Energy Efficiency Operational Indicator, the purpose of which is to both monitor and benchmark performance. The EEDI and SEEMP were adopted as mandatory measures by the Marine Environment Protection Committee of the IMO, when it met for its sixty-second session in July 2011. This represents the first-ever mandatory global GHG reduction regime for an international industry sector. Nevertheless, the EEDI and SEEMP will require time to take effect, given the average lifetime of marine vessels. In recognition

that these technical and operational measures will, on their own, be unlikely to reduce global shipping emissions given the projected increase in global trade, the IMO also identified market-based instruments as being both cost effective and environmentally effective, as well as providing strong incentive for change (IMO, 2009). However, agreement on these measures has yet to be reached.

Rail

Railroads have introduced new technology aimed at fuel efficiency and air pollution reduction. One Class 1 railroad, for example, is adopting generator set switchers that use less fuel, piloting alternative-fuel locomotives, and introducing lower emissions intermodal terminal equipment in Southern California. Overall, however, railroads have not been subjected to the same fuel efficiency pressures as trucking, in part because the overall fuel efficiency of the mode is inherently greater than that of trucking.

Major enhancements on the rail side stem from a decade or more ago, when intermodal traffic began to become significant. This traffic continues to grow today. The advent of double-stacked railcars has greatly increased the economic and fuel efficiency of intermodal moves, and routes capable of carrying double-stack cars now crisscross the nation. Growing usage is being driven by high fuel prices and service improvements, with railroads overcoming earlier shipper concerns about delivery reliability.

Rail-based flatbeds are just the latest example of new intermodal technology that may shift long-haul freight from truck to rail. A joint effort by equipment manufacturer Raildecks, Fontaine Trailer, motor carrier Boyd Brothers, and the Burlington Northern Santa Fe (BNSF) Railway aims to develop a more sustainable, cost-effective, and efficient product for flatbed cargoes such as steel coils, drilling pipe, building materials, and forest products. These new flatbed cars can be double-stacked as well, and can be moved over short distances (at origin or destination) via highway on a chassis. Prototypes were tested by several railroads, and 240 loads were shipped successfully before the companies announced their launch in February 2012. Moving freight by rail rather than truck reduces GHG emissions by 75%, according to the Association of American Railroads (Association of American Railroads, 2012).

4.3 Engine Improvements and Alternative Fuels

Engine Emission Standards and Efficiency

Emissions from diesel engines are typically regulated at the federal level by EPA as follows:

- EPA, under the Clean Air Act, sets standards for emissions from diesel engines to combat health risks from diesel emissions. Since 1984, EPA has implemented standards that have progressively lowered the amount of key pollutants from diesel engines by more than 75%, by imposing strict standards on vehicle emissions and fuel content (U.S. General Accounting Office, 2004).
- Emission standards for on-road heavy-duty vehicles were tightened in 2007. Under these new standards, both NO_x and PM emissions are required to be 10 times lower than 2004 levels, and sulfur is reduced by 97% over 1999 levels. To meet these standards, truck engine manufacturers need to use exhaust after-treatment devices (similar to catalytic converters on automobiles) (Burks et al., 2010). Note that the emission standards apply only to new vehicles in the year of their manufacture. No federal emission standards apply to in-use vehicles. Most diesel trucks last 20 years or longer, and older models have little or no emission controls.
- The emission-control devices required to enable engine manufacturers to meet EPA's 2007 standards for NO_x and PM emissions are incompatible for high sulfur levels in fuel. EPA therefore adopted parallel standards for diesel fuel sulfur levels. Since June 2006, on-road diesel fuel has been required to have 0.15 parts per million sulfur or less (also referred to as ultra-low sulfur). This ultra-low-sulfur diesel also was required for off-road applications (e.g., locomotives and port cargo-handling equipment) before 2010.
- In October 2010, EPA and NHTSA proposed the first-ever Fuel Economy Standards for Heavy Vehicles, intended to improve fuel efficiency and reduce GHG emissions. The proposed standards cover not only engines but also the complete vehicle, enabling the greatest possible reductions in fuel consumption and GHG emissions. The NHTSA standards (expressed in gallons per 1,000 ton-mile) are proposed for vocational vehicles and combination tractors, accounting for the fact that the work to move heavier loads burns more fuel and emits more CO_2 than that required to move lighter loads. EPA standards are expressed in grams CO_2 per ton-mile. The agency's analysis indicates that the standards have the potential to reduce GHG emissions by nearly 250 million metric tons and save approximately 500 million barrels of oil over the life of vehicles sold from 2014 to 2018. The majority of vehicles would see a payback period of 1 to 2 years (U.S. EPA, 2010).

As a result of acute air quality issues in California, in December 2008, CARB took a decisive step to address emissions from "in-use" diesel trucks with the passage of the California On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation. It is intended to reduce PM and NO_x emissions from existing diesel vehicles operating in California, to meet federally imposed clean air standards. Amendments to the regulation were considered in December 2010 to provide more time for fleets to comply. The amended regulation requires installation of PM retrofits beginning January 1, 2012, and replacement

of older trucks starting January 1, 2015. By January 1, 2023, nearly all vehicles will need to have 2010 model year engines or equivalent. The regulation applies to nearly all privately and federally owned diesel-fueled trucks. The regulation provides extra credit for PM filters installed prior to July 2011 and has delayed requirements for fleets with three or fewer vehicles.

The trucking companies interviewed by the research team, admittedly large players, emphasized the upgrading of their fleets to adopt the newest engine technology as quickly as possible. Although this is clearly driven by EPA requirements, it also seems to be a point of pride for progressive operators who have the resources to make the investment. For example, one motor carrier the research team spoke with claimed the company has one of the cleanest tractor fleets, half being built in 2008 or later. The carrier is also working with its contractor fleet to promote the purchase of newer and cleaner technology.

The FedEx BlueTEC Clean Diesel Vans are a good example of continuing fuel efficiency within the traditional diesel fuel realm. FedEx has over 10,000 sprinter vans in service, which equates to more than 35% of their U.S. pickup and delivery fleet. The new vans are used for suburban and extended driving range markets (FedEx, 2012, pers. comm.). FedEx states that each sprinter is 70% to 100% more fuel-efficient than the alternatives they replace. FedEx Express' Vehicle Refresh Plan, of which the sprinter vans form part, has saved over 86 million gallons of fuel since its inception (Basich, 2011; FedEx, 2012, pers. comm.).

Matching the vehicle to the mission and the route, FedEx Express is adding all-electric and hybrid-electric vehicles to dense urban routes that involve frequent starts and stops. The use of regenerative braking and electric motors significantly improves the efficiency of the vehicles on such urban routes (Basich, 2011).

Alternative Fuels

The major new fuel concepts of potential interest in the ground delivery world are natural gas and electric or hybrid vehicles. Natural gas includes compressed natural gas (CNG), liquefied natural gas (LNG), and biomethane. Electric vehicles are already used extensively for local delivery work by shippers and carriers. UPS, for example, now has 384 hybrid-electric vehicles deployed in its delivery fleet. Electric power is even being extended to a small tricycle format for urban delivery in Europe. The operating cost advantage is the primary reason for adoption by operators, with environmental benefits an added plus. The main challenges to faster adoption are generally immature technology, high capital costs, or lack of widespread fuel availability.

According to Cascade Sierra Solutions (CSS), the difficulties in switching heavy trucks from diesel to natural gas include a lack of fueling infrastructure, limited access to financing (not many lenders want to be the first to finance alternative-fuel vehicles), and difficulties in getting technologies through the EPA and CARB verification processes. CSS has a goal of supporting the implementation of alternative fueling infrastructure and is working to help private-sector companies secure public funding to help facilitate fueling infrastructure projects. They also are lobbying to obtain government support for technologies that have environmental, as well as economic, benefits.

Regulations are a major factor driving the search for viable alternative-fuel options and will directly influence the pace and direction of change. For example, the rules on subsidies for biodiesel and ethanol have now all expired. It is doubtful they will be reinstated. This will change the pricing of diesel fuel and could affect the choice of fuel for trucks in the future. In 2012, EPA will require that 1 billion gallons of biodiesel be blended into diesel fuel.

California introduced a new Low Carbon Fuel Standard in 2009, intended to expand the use of low carbon alternative fuels (including some bio-fuels, hydrogen, and electricity). Refiners, importers, and blenders of fuel are required to track and steadily reduce the "carbon intensity" of fuels. The regulation has been challenged on the grounds that it discriminates against out-of-state fuels, thereby promoting and protecting local economic interests. There are also concerns about the costs of implementing the regulation. Opponents, including the ethanol industry, fuel producers, business interests, and American Trucking Association, estimate that the rule will result in diesel price increases of between $0.12 and $2 per gallon (Howard, 2009; Con-way, 2012, pers. comm.). There is concern that the regulation will effectively ban the import of certain (cheaper) fuels for use in California, thereby increasing freight transportation costs, but will not address global GHG emissions because these fuels will simply be sold elsewhere. The California Trucking Association believes this will drive up the diesel price by $2 per gallon (Howard, 2009).

On the natural gas front, regulations are again a key element in adoption. For LNG, EPA is in the process of rulemaking on natural gas leakage. The leakage of methane (which has 20 times the global warming potential of carbon dioxide) from gas fields could offset any carbon emissions savings gained through shifting from diesel to LNG gas. The pending leakage rule has major implications for the adoption of LNG (and CNG) in the trucking world (Con-way, 2012, pers. comm.).

Natural gas-powered engines for truck fleets seem likely to emerge as a significant trend in the years ahead. The combination of strong economic motivation for fleet operators (with natural gas costing much less than diesel fuel) and the air quality benefits, together with the growing practicality of the technology, fits the pattern of strong fuel efficiency progress by shippers and carriers that the research team have seen

in the research. Despite the need to solve the issue of methane release, the research team expects this combination of factors could presage rapid development. Further, MAP-21 federal policy supports natural gas, given that the act allows money under the Surface Transportation Program and the Congestion Mitigation and Air Quality Program to be used for development of natural gas refueling stations. Local communities need to be aware that they can tap into these federal funds to help support the local NG refueling infrastructure.

Alternative-Fuel Vehicles

This section provides examples of the progress being made with alternative-fuel trucks and delivery vehicles—an exciting development aimed at tapping new sources of non-petroleum-based fuel.

CNG, widely used for delivery vehicles in countries like the Netherlands, is already a viable fuel for local buses and delivery vehicles in the United States. Many of our interviewees reported that their fleets of CNG light freight vehicles are growing. A major shift may be starting in the use of LNG for long-distance heavy trucks. Interviewees state they are testing and rolling out such vehicles. Cummins Westport is slated to begin production of an 11.9-liter natural gas engine in April 2013, providing the power that a standard, heavy-duty truck requires. The overall economics appear potentially favorable. LNG trucks typically cost $40,000 to $80,000 more than an equivalent diesel truck, but the LNG fuel costs (as of March 2013) are about $1.30 less per gallon than diesel. Thus, trucking companies consider the return on their investment, weighing increased capital cost against lower fuel cost and considering elements such as engine longevity, maintenance, and fuel availability. The boom in natural gas production in the United States, which has kept natural gas (NG) prices low relative to diesel prices, coupled with the expanding network of NG fueling stations along major highways, supports the expectation that NG will be increasingly used by U.S. motor carriers. At present, there are only about 70 LNG stations in operation in the United States, mostly in California, Texas, and other western states. In its Annual Energy Outlook 2013 Early Release, however, the U.S. Energy Information Administration (U.S. EIA) predicts that the use of natural gas (CNG plus LNG) for vehicle transport is expected to rise from 0.1% in 2011 to 4% of the highway energy mix by 2040 (U.S. EIA, 2013). Examples of alternative-fuel vehicle use are provided in the rest of this subsection.

- Staples has added 10 new heavy-duty CNG tractors to its dedicated fleet in Southern California, which is operated by Ryder. These tractors will replace 10 diesel tractors currently in use. The vehicles are made available through Ryder's natural gas (NG) vehicle project agreement with the San Bernardino Associated Governments. This $38.7-million project is part of a public-private partnership among the DOE, California Energy Commission, Southern California Association of Governments Clean Cities Coalition, and Ryder. The project includes 202 NG vehicles, upgrades to three maintenance facilities for proper servicing of the vehicles, and construction of two fueling stations. These tractors will be used to transport inventory to Staples stores in Los Angeles, Orange County, San Diego, and the Inland Empire. Ryder claims that CNG vehicles produce 20% to 30% fewer emissions than comparable diesel vehicles (Trucking Info, 2011).
- UPS's "green fleet" is composed of 2,600 alternative-fuel vehicles. These vehicles have traveled more than 200 million miles since implementation. The first UPS alternative vehicle was electric, in the 1930s. The company uses various alternative-fuel types: LNG, CNG, propane, hybrid electric, electric, hydraulic hybrid, and biomethane. The goal is to drive 400 million miles with these vehicles by 2017. In addition, UPS decided in 2012 to buy 150 delivery vehicles incorporating composite plastic body panels, which save weight and generate 40% fuel savings (UPS Freight, 2012, pers. comm.).
- UPS believes that LNG is most promising in the long term, but challenges still exist in terms of infrastructure such as fueling stations. The potential methane leakage issue is being evaluated, but currently is not viewed as a major concern. The investigation of LNG is necessary because UPS wants to ensure that any new type of vehicle will provide the same miles and lifespan as vehicles currently in the fleet (UPS Freight, 2012, pers. comm.).
- UPS announced the deployment of 10 dual-fuel biomethane trucks in the United Kingdom (U.K.) in April 2012. This could be a major advance for alternative fuels, in that the burning of biomethane as fuel can create an absolute reduction in the environmental impact versus not using it. Biomethane is a renewable energy source produced from organic waste, in this case derived from a landfill. Biomethane has potential for reducing carbon—each unit of biomethane cuts emissions from well to wheels by 70% compared to diesel. Also, it reduces dependency on fossil fuels and is one of the few alternative fuels that supports long-haul, heavy trucks used for moving package trailers (UPS, 2012, pers. comm., May 11). There are challenges regarding availability, because biomethane is mostly used for electricity generation. UPS is currently working with commercial partners and governments to address this issue. In the trials, UPS found that two-thirds of the blended fuel could be biomethane. The test vehicles went on the road in early 2012, were at the Olympics, and are expected to operate over a normal 7-year lifecycle. The vehicles are regular Mercedes tractors, modified by Hartstaff to run on

biomethane, with the fuel provided by Gasrec. This trial is not subsidized and no government entity is currently involved, although UPS is actively seeking public-sector interest. The only government role comes in the form of a reduced fuel tax/duty for the biomethane gas. UPS expects to break even on this endeavor by the end of the 7-year period (UPS, 2012, pers. comm.).

- Pacer announced in September 2011 that it was adding about 40 LNG trucks to its Southern California cartage fleet. Pacer is testing the trucks' operational capabilities to determine whether to continue deployment. The LNG truck testing program is a continuation of Pacer's commitment to reducing emissions and improving fuel efficiency. "We believe that the use of clean tractor technologies for our cartage operations is the right decision for our customers, the environment, and our company. We are excited to test the benefits of this new technology in our cartage operation," said Val T. Noel, president, Pacer Cartage (Transport Topics Staff, 2011). As of mid-2012, Pacer was still resolving issues with components and leases, but was hopeful to get the units released shortly (Pacer International, 2012, pers. comm.).
- FedEx, UPS, and Purolator were piloting hybrid hydraulic parcel delivery trucks as of April 2012. The innovative delivery trucks are made by Freightliner Custom Chassis Corporation, Morgan Olson, and Parker Hannifin. Each of the three parcel companies purchased an evaluation vehicle with assistance from Calstart, through a grant from DOE. These are the first-of-their-kind commercially available hybrid hydraulic parcel delivery vehicles. Braking energy is recovered and stored in hydraulic accumulators, where it is then used to power the truck during acceleration. The vehicle also has an onboard controller that turns the engine off at unnecessary run times. Fuel can be reduced by 40% or better. This type of hybrid hydraulic system has been used with Class 8 refuse trucks, but this is the first time it has been used for the lighter vehicles of Class 6. The three parcel companies are part of the Hybrid, Electric, and Advanced Truck Users Forum's parcel delivery working group and are working with Calstart and Framework Convention on Climate Change to collect data on the fuel economy improvements and reduced brake and engine maintenance costs (Environmental Leader, 2012).
- Navistar (builder of commercial trucks and diesel engines) and Clean Energy Fuels Corp (provider of NG fuel for transportation) recently partnered to try to jumpstart and incentivize a widespread conversion among all U.S. fleet types from gasoline and diesel fuels to NG, "with or without the help of government incentives." This is a unique partnership between two large public companies developing infrastructure for, and financially incentivizing, the shift to natural gas for the transportation sector (Clean Energy Fuels, 2012). To support the initiative, Clean Energy is building what it calls "America's Natural Gas Highway," a network of refueling stations along major U.S. highway corridors (Solomon, 2012).
- In 2012, Con-way took delivery of two CNG tractors for a pilot program in Chicago and will be getting several more in 2013 to operate in the Texas Triangle, and therefore achieve a better understanding of operational characteristics in a warm climate. Although others are looking at LNG, Con-way believes that savings can be achieved using CNG, and the company wants to understand more. If it is not possible to obtain fuel savings from CNG, then Con-way believes it will not be possible to make a return on investment with LNG (Con-way, 2012, pers. comm.).
- Shell Oil and TravelCenters of America (TA), the largest full-service truck stop chain in America, have joined together to expand the network of LNG refueling locations in the United States. This will help lower the perceived barriers to entry, making companies more likely to adopt this alternative fuel. Plans include the construction (and supplying) of more than 200 LNG fuel lanes at about 100 TA sites and gas stations through the U.S. Interstate Highway System. The first of the LNG fuel lanes is expected to become operational in 2013 (Trailer Body Builders, 2012).
- Swift Transportation is optimistic about the future of NG-powered trucks, though challenges exist at the moment. According to Swift, two areas require further improvement—engine reliability and cost. Once these two issues are resolved, NG is expected to become an excellent opportunity. Availability of fuel is not a problem—if the trucks are there, the fuel will come, Swift believes. If the price difference between diesel and natural gas continues, truck owners will be motivated to acquire this technology (Swift Transportation, 2012, pers. comm.).
- Stonyfield Farm is currently using biodiesel in limited applications. Although biodiesel is about 25 cents more per gallon, the company does not use much and believes this exemplifies its commitment to the environment, even though there is an incremental cost. Stonyfield is waiting for NG to reach the mainstream and will convert then (Stonyfield Farm, 2012, pers. comm.).

Electric Vehicles

FedEx is testing the Newton Step Van, launched by Smith Electric Vehicles Corporation in March 2012. These vehicles feature an all-electric, zero-emissions engine and carry enough battery power to cover a 100-mile range. The first batch of these vans has been reserved by FedEx, which is focused on improving its fleet efficiency and reducing emissions (Michelsen, 2012; FedEx, 1995-2012).

Electric propulsion solutions for light-vehicle, urban package deliveries (e.g., tricycles) are being tested for use in old center cities facing issues of intense congestion, air pollution, and noise pollution. Cities and carriers have started working together to find innovative solutions for the parcel delivery sector. Both UPS and FedEx recently tested, or are in the process of testing, electric "tricycle" type vehicles in Europe. Traveling at a top speed between 12 and 16 mph, these vehicles use an all-electric motor supplemented by pedaling. Cities, particularly in Europe, are asking parcel carriers to deploy these vehicles, at least at high-traffic times of day. Examples of the use of electric vehicles are provided in the rest of this subsection.

- UPS has been testing its version of a delivery tricycle (known as the Cargo Cruiser) in downtown Dortmund, Germany. The vehicles will help reduce emissions, noise pollution, and traffic congestion. The trial is expected to run from June to October 2012. A standard UPS delivery vehicle will supply the Cargo Cruisers with parcels at approximately 20 loading zones established by the city of Dortmund on the outskirts of the downtown area. A UPS driver will then travel the "last mile" via Cargo Cruiser to deliver to customers. This will facilitate delivery of the parcels in the downtown's narrow streets, which often present few parking or stopping possibilities for large motor vehicles. During the night, the Cargo Cruiser parks at the depot of a Dortmund energy supplier, where the batteries are recharged via a standard 220-volt electric socket. By the next morning, the Cargo Cruiser is capable of traveling a distance of about 35 km for deployment in Dortmund, with a load volume of 2.2 cubic meters and a possible additional load of 300 kg. The vehicle's top speed is 25 km/h. The test is being conducted as part of UPS Germany's participation in the cooperative project Green Logistics, sponsored by EffizienzClusters LogistikRuhr. The project focuses on ecologically efficient logistics planning and is being conducted in cooperation with the Fraunhofer Institute for Material Flow and Logistics IML of Dortmund (UPS, 2012).
- FedEx, in collaboration with the Green Link, has deployed electrically assisted tricycle delivery vehicles in Paris, serving 60% of the city's districts. The tricycles also are being piloted in Brussels, and opportunities are being explored in other parts of the EU. Locations are chosen based on levels of congestion, pollution, and city center access restrictions on gasoline-powered vehicles at certain times of day. These vehicles run on pedal power and are supplemented by a 250-watt electric motor, which can reach a speed of about 25 km/h. The electric tricycles have a useful volume of over 2 cubic meters and can carry up to 350 kg of payload. They are allowed in pedestrian-only areas and many bike lanes. Paris plans to develop more than 400 miles of bike lanes and has some streets devoted to pedestrian-only traffic, which makes the use of this vehicle particularly viable (McKone, 2010; FedEx, 2012, pers. comm.).

4.4 Warehousing Developments

Warehousing activities represent a small portion of overall fuel, energy use, and air emissions within the supply chain, far less than transportation activities. Nevertheless, shippers and third-party warehouse operators are increasingly focused on green design for their distribution facilities. In taking a holistic view of logistics activities, it is relevant to look at progress in these storage and handling facilities closely linked to freight transportation.

Nike is devoting considerable effort on the development of their warehousing strategy. Nike has recently refreshed its strategy and formally rolled it out with third-party partners, making more explicit how Nike needs its warehousing providers to work toward sustainability. The company's sustainable supply chain group has created a network to share ideas and develop a macro-level assessment of success. The team engages external partners as well, to speed up implementation. Nike achieved Leader in Energy and Environmental Design (LEED) certification for its Shanghai distribution center, as well as 3 of its office buildings and 10 Nike stores in North America. Going forward, the company aims to design all new buildings to LEED standards (Nike, Inc., 2011 and 2012).

Similarly, in November 2011, Becton Dickinson (the global medical technology company) opened a new LEED gold-certified DC in Four Oaks, North Carolina (operated by 3PL partner, Genco ATC), that exemplifies many of the new sustainable design features. The incremental cost to make the facility environmentally efficient was about 8% of the total capital invested. The warehouse uses the latest reach trucks, equipped with regenerative masts. (As the pallet is brought down from the rack, it reenergizes the lift truck's battery.) This feature requires fewer battery changes, increases productivity, and adds 12% more run-time for improved energy use. This DC has 4 acres of solar panels on a roof that spans an area equivalent to 15 football fields. An online dashboard monitors the electricity being generated. These solar panels reduce the site's energy consumption by about 20%. Using skylights with global positioning system technology and mirrors that track the sun bring natural light into the offices, greatly reducing the need for conventional lights. In the warehouse, most interior lights are motion-sensor activated. Exterior lights in parking and trailer lots are also on motion sensors. Employees with fuel-efficient vehicles are rewarded with the closest parking spots and alternate transportation to work is encouraged. Becton Dickinson has achieved an estimated 9% improvement in service times to customers and

subsequent reductions in transportation and facility costs (Napolitano, 2012).

ConAgra Foods, the large food producer, is focusing its warehouse sustainability efforts on electricity conservation, upgrading lighting and controls, and switching the entire fleet of lift trucks to electric or automated guided vehicles (ConAgra, 2011, pers. comm.).

4.5 Encouraging Continued Progress

The private sector has made considerable progress in reducing emissions through equipment upgrades and improvements, engine improvements and the use of alternative fuels, and sustainability innovations in warehousing. Regulations (e.g., in respect to engine emissions standards) have set the scene, but business is embracing a range of innovative technologies ahead of regulations, partly because of expected cost benefits.

Key lessons for the public sector are as follows:

- Ensure that regulations are sufficiently flexible to allow for ongoing innovation and to ensure that processes (e.g., pertaining to the approval of new technologies) do not have a stifling effect.
- Provide support for new technologies (e.g., through the promotion of NG refueling infrastructure).
- Provide opportunities for the recognition of innovation (e.g., through programs such as SmartWay).
- Identify opportunities for the development of well-located warehouse and trans-shipment facilities that minimize trip distances, reduce empty moves, and curtail CAP emissions and noise impacts on local communities.

CHAPTER 5

The Sustainability Brand

Most U.S. corporations are actively working to improve the sustainability of their supply chains. The shippers and carriers interviewed were able to cite initiatives and specific results achieved. This chapter addresses the goals, measures, and results being pursued and realized by companies in their sustainability programs.

The particular focus is on the efforts taken by selected companies to promote their sustainability efforts as a core part of their brands. These companies have taken nuts-and-bolts projects and elevated the sum of the parts to convey a sustainable image to consumers and corporate customers. Such examples serve as encouragement for others. Several cases of shippers and carriers who can be said to have achieved a "sustainability brand" based on their supply chain green initiatives are detailed here.

5.1 Setting and Leading the Sustainability Agenda

Many U.S. corporations have staked out a sustainability vision. These include leading consumer products companies such as Nike and Wal-Mart, as well as carriers such as FedEx and UPS. Nike's website makes clear that sustainability has evolved from an issue formerly relegated to experts to a broad priority integrated into all aspects of the business. Nike boldly states, "our vision is to build a sustainable business . . . by decoupling profitable growth from constrained resources." Furthermore, this broad vision translates directly into supply chain terms, "our vision is to create a sustainable supply chain across all of our brands that is lean, green, equitable, and empowered" (Nike, Inc., 2013). Wal-Mart is equally clear, stating that "Wal-Mart is committed to sustainability because it's the right thing for the environment and for our business." Also, Wal-Mart has provided strong leadership in the sustainable supply chain arena, as the world's largest retailer. The company states on its website that "we strive to positively impact global supply chain practices," (Wal-Mart, 2010).

In the transportation industry, leading companies have firmly enmeshed sustainability principles into their overall corporate missions. For example, "sustainability and innovation go hand in hand at FedEx. We call it EarthSmart—FedEx solutions for a more sustainable world," states the FedEx 2012 Annual Report. In its 2011 Corporate Sustainability Report, UPS states that logistics "is the core of our sustainability as a company, and the engine that drives our contributions to a more sustainable society." Numerous other carriers in multiple modes of transportation also espouse sustainability goals and visions.

Leading companies are organizing to consolidate and elevate their activities in support of sustainability. This generally starts at the top, with chief operating officers (CEOs) and boards taking an interest, and continues with the naming of senior executives responsible for sustainability. Within this overall structure, the research team found some supply chain sustainability or green logistics teams operating to lead or coordinate efforts specific to logistics and transportation.

At the senior levels in corporations, the setting of overall corporate sustainability goals and priorities may rest with a sustainability officer. At ConAgra Foods, the Citizenship Steering Committee is led by a member of the company's senior leadership team and vice president of corporate affairs, and is composed of key leaders and subject matter experts in key functional areas (ConAgra Foods, 2011, pers. comm.; ConAgra Foods, 2012a). At the TJX Companies, Inc., an assistant vice president for environmental sustainability coordinates the company's environmental sustainability initiatives on a global basis (TJX, 2012). Staples has a vice president for sustainability, who leads efforts on product and supply chain sustainability.

Nike launched an executive-level Committee for Sustainable Innovation in 2011. Chaired by the CEO, it oversees the innovation pipeline and portfolio, helping to capitalize on opportunities by "accelerating adoption and bringing these activities to scale." In 2001, Nike formed a Corporate Responsibility (CR) Committee at the board level. The CR

Committee has oversight of environmental impact and sustainability issues, labor practices, and corporate responsibility issues in major business decisions. Within the Supply Chain Department, Nike has established an internal unit devoted to improving logistics sustainability (Nike, Inc., 2011). This multilevel structure is fairly typical of the sustainability approach being taken by leading U.S. manufacturers and retailers.

Carriers also are active in addressing sustainability issues within their organizations. In this case, virtually all the sustainability efforts lie within the transportation and logistics arena, given that that is the industry focus of these firms. Con-way, for example, has a Sustainability Steering Committee that includes a sustainability leader from each business unit (e.g., the CEO, chief financial officer, or head of facilities or engineering) (Con-way, 2011, pers. comm.). One carrier mentioned it has a dedicated Clean Air Accountability Division. FedEx Express' Enterprise Sustainability Council includes chief operating officers of each operating company and corporate vice presidents. The goal is to engage and align corporate and business unit leaders so that sustainability initiatives cascade through the operating companies This council meets quarterly to set strategic direction and push initiatives through the operating companies. Sustainability Impact Teams run working groups (on metrics, data, strategic sourcing, etc.) and meet monthly. Finally, FedEx re-launched their EarthSmart initiative in April 2012 to gain broader recognition that sustainability is critical. Since then, various programs have been introduced to ramp up interest in sustainability. Innovations have included carbon-neutral envelope shipping, solar facilities, all-electric delivery vans, and tricycles (FedEx, 2012, pers. comm.).

5.2 GHG Reduction as Major Focus of Corporate Efforts

The globalized economy is characterized by high levels of freight transport intensity and increasingly complex supply chains. Transportation is intimately connected to sourcing, production, inventory management, warehousing, and sales activities. The research team found that these other activities are typically awarded priority over freight transport efficiency or emissions considerations by shippers and third-party logistics providers.

For example, a growing number of companies apply just-in-time delivery practices that require punctual, reliable, fast, and flexible transportation, usually via road or air freight, to reduce the risk of mismatch between supply and demand within the supply chain. This delivery balancing act tends to favor modes that emit more pollutants and greenhouse gases (GHGs). Business concerns about avoiding product stock-outs while also minimizing inventory often trump the additional cost associated with faster transport modes or part-loading of trucks. Stakeholder interviews confirmed that shippers (more so than carriers) consistently face these trade-offs, which present challenges to minimizing air emissions.

GHG emissions, although a more recent consideration than CAP emissions, presently receive the greatest attention in corporate reporting. CAP emissions have been regulated since at least 1970 (with the advent of the Clean Air Act) in the United States, while GHG emissions are not yet regulated in this country. However, efforts to reduce GHG emissions can directly and positively affect shipper and carrier business economics, aside from their environmental benefits. This is particularly true for carriers, given that fuel cost amounts to a high proportion of total costs in transportation and the competitive nature of freight markets drives tight profit margins. Carriers are, therefore, actively focusing their efforts on improving fuel efficiency, usually with rapid payback prospects.

This alignment of GHG public policy efforts with carrier cost-savings objectives offers the potential for a double win, with environmental benefits as a byproduct of cost savings associated with fuel efficiencies. The interviews indicated that many carriers would be unlikely to voluntarily adopt sustainability initiatives, if they did not make business sense. One railroad executive said, "this is all about reducing fuel cost, environmental benefits are ancillary"(Class I Railroad, 2011, pers. comm.). A third-party logistics provider stated that truckload carriers and their shipper customers might be willing to pay something on the order of 2 to 5 cents more per mile for environmental sustainability, but not likely more than 5 cents.

While GHG reduction links directly with carrier fuel cost savings, the same is not true of CAP reduction. This may explain why there was limited evidence of voluntary CAP emissions reductions on the part of carriers and shippers. Efforts mentioned in our interviews were primarily driven by concerns about potential regulation (e.g., lower-emission intermodal terminal equipment in Southern California, in response to public action) motivated in part by incentives (e.g., switching to lower sulfur fuel within a certain distance of ports or cold-ironing by container ship operators). Further, several corporate sustainability initiatives (e.g., the Carbon Disclosure Project (CDP), the Greenhouse Gas Protocol, and the U.S. Climate Registry) are focused on climate change and GHG emissions rather than on CAP emissions. The exceptions to this are the Global Reporting Initiative, which includes protocols for reporting CAP emissions, and EPA's SmartWay Program, which assists partners in determining mass emissions and emission rates for CO_2, NO_x, and PM.

5.3 Supply Chain Sustainability Initiatives

Shippers (broadly, the owners of cargo moved via the transport system, whether manufacturers, distributors, or retailers) consider many factors in their capital and operating decisions.

Supply chain sustainability is only one such factor, and within that, air emissions is a single element. Shippers' supply chain sustainability programs generally reflect overall corporate sustainability policy and typically address activities across the end-to-end supply chain (including product sourcing, manufacturing, packaging, transportation, warehousing, etc.).

Carbon audits of supply chains often reveal that freight transport is responsible for only a small percentage of total emissions. Estimates in the literature range from 5% to 15% (World Economic Forum, 2009). These results are derived from economic input-output lifecycle assessments for individual products, and are supported by a review of CDP member reporting. This is one reason why freight emissions may be relatively low on the list of priorities when shippers are setting their overall emissions reduction strategies. Furthermore, key global and U.S. voluntary reporting initiatives tend to underplay emissions associated with freight transportation as follows:

- Under the current requirements of the Greenhouse Gas Protocol, an accounting tool used to understand, quantify, and manage GHG emissions that is commonly used in corporate reporting of GHG emissions, the reporting of emissions associated with the movement of goods is only mandatory (within Scope 1 emissions) if the pertinent emission sources are owned or controlled by the company (e.g., if emitted by fleet vehicles), which is not necessarily common.
- Reporting of GHG emissions from third parties is similarly not mandatory under the requirements of EPA's Climate Leaders Program or under the Global Reporting Initiative (GRI).
- Only a small proportion of shipper organizations (less than 15%) actually report on emissions associated with transportation and distribution as part of their CDP reports.
- One shipper interviewed estimates that only 7% of its GHG emissions are from the company's own facilities and fleet operations, while the remaining 93% are from the lifecycle impacts of their products sold.

Virtually all major U.S. shippers of goods—manufacturers, distributors, and retailers—have embraced sustainability at some level in recent years. These initiatives typically include both broad corporate sustainability efforts and projects focused on logistics and transportation environmental effects. Shippers generally consider the sustainability gains realized by their carriers and suppliers, and the related costs as well. Two programs that can be considered fairly typical of large company efforts are

- **Staples' sustainability strategy.** Staples' five pillars of sustainability are (1) selling more sustainable products/services, (2) offering easy recycling solutions, (3) eliminating operational waste, (4) maximizing energy efficiency and use of renewable energy, and (5) becoming a sustainability leader in the global community. The company takes a holistic view of sustainability. Its long-term vision is to achieve zero carbon emissions in operations and to help customers pursue the same goal. In the medium term, Staples' goal is to reduce its global carbon emissions by 50% by 2020 (from a 2010 baseline); so far, it has achieved a 30% reduction in U.S. carbon emissions (from a 2001 baseline). The company also aims to improve its U.S. fleet fuel economy by 15% by 2015 (from a 2010 baseline) (Staples, 2012).
- **ConAgra Foods sustainability efforts.** Since 2008, ConAgra Foods has measured GHG emissions, including its transportation footprint, and has redesigned its external website to communicate its efforts to the public. Over the past 3 years, ConAgra Foods developed a GHG management program centered on tracking facility-specific emissions to enable strategic decisions regarding reduction strategies. The company's overall goal is to reduce GHG emissions by 20% per pound of product produced by 2015. The focus is on CO_2 emissions, rather than on CAP.

ConAgra Foods participates in the CDP and in the EPA's Energy Star Program. For both contracted and owned fleets, the company aims to improve efficiency in all modes of transportation. ConAgra Foods is tracking GHG emissions associated with product transport and has requested that its largest suppliers disclose their GHG inventory and emissions reduction strategy to the CDP.

In the supply chain, ConAgra Foods' Perfect Pallet Initiative is the cornerstone effort, optimizing pallet efficiency by adjusting product packaging size, shape, and orientation. Over the past 4 years (FY2009 to FY2012), ConAgra Foods has completed more than 40 perfect pallet projects, which reduced the use of pallets and stretch wrap, decreased the use of forklifts during staging and loading, and improved overall loading and transportation efficiency. In FY2012, the company optimized the package size, thereby allowing more units to fit on each pallet. Combined, these projects have reduced diesel fuel use by more than 380,000 gallons, cutting GHG emissions by more than 3,900 metric tons. ConAgra Foods also aims to reduce the average length of haul for its products. Currently, its average length of haul is 1,100 miles, but ConAgra Foods hopes to drive this down to 700 miles, which is similar to the haul length of its competitors. Although the company has made some progress, it has yet to make the major changes in its supply chain needed to achieve this result, which would be considered as Scope 3 progress (ConAgra Foods, 2011, pers. comm.; ConAgra Foods, 2012; ConAgra Foods 2012a).

The following good examples of environmental programs by carriers emerged from interviews:

- **Swift Transportation**—This large truckload carrier focuses its environmental efforts on reducing fuel use. The

company has made many investments in achieving the predicted results, but lately fuel economy has improved only modestly, perhaps partly because of an increasing content of biodiesel (with a lower British thermal unit content than regular diesel) in the nation's fuel supply.

Swift tracks several fuel efficiency measures. It is able to do so in highly accurate ways, on an hourly or daily basis. Two key metrics are driving miles per gallon (different from miles per gallon) and idle time (as percent of total engine time). These are reviewed at every level of the organization daily. In addition, fuel efficiency is tracked for loaded ton-miles and empty moves. Swift's empty miles trend is improving (although the company notes that, as empty miles decrease, fuel economy for the miles run worsens). Swift also owns a large intermodal operation, which is fuel-efficient (and hence CO_2 reducing) for long-haul freight moves. Overall, the company requires a positive return on investment for investments, including those that help reduce the environmental footprint (Swift Transportation, 2012, pers. comm., 12 June).

- **Con-way sustainability**—This large less-than-truckload and truckload carrier is actively working on sustainability, although it has not yet reached the point of branding itself under the green banner. Con-way's Menlo Logistics (3PL) business is taking the lead in this area and other units will follow. A broad focus is being taken—environmental, enterprise, and corporate social responsibility. Con-way calls this "people, planet and prosperity." In terms of the supply chain, the company looks at carbon measurement in the broader supply chain, including everything from fuel efficiency and empty miles to the placement of its warehouses. Con-way expects to publish its first annual sustainability report internally in 2014 and externally in 2015. Carriers are cautious about shipper commitment to supply chain sustainability. Some claimed that their customers are asking for help to configure supply chains that take account of carbon. But experience to date indicates that few shippers are willing to pay more than 5% to achieve a carbon-neutral or reduced carbon footprint outcome. "At the end of the day, carbon generated by production and transport activity is part of the landed cost of goods. People fall on the side of sustainability if the cost is the same. If it is different, we are just not seeing it. Companies are willing to be altruistic to a point" (Con-way, 2012, pers. comm.).
- **APL carbon emissions reduction**—The company's overall goal is to reduce CO_2 emissions by 30% by 2015 (from a 2009 baseline). By 2015, APL wants its fleet to produce no more than 130 grams of carbon exhaust for every 20-foot equivalent unit container (TEU) of cargo transported 1 nautical mile. The company's new ships, along with slow-steaming efforts, are expected to help APL reach this goal. In addition, operational measures will contribute by optimizing vessel trim, speed and routing; improving maintenance of vessel hulls to reduce drag in the water; and upgrading cargo-handling equipment at terminals (http://www.apl.com, APL, 2012). APL has participated in several pilots in hopes of finding break-through technologies that will help reduce emissions, including, for example, a sea water scrubber (APL, 2012, pers. comm.).

5.4 Metrics and Reporting

Shippers and carriers often base their sustainability goals and metrics on those recommended by the leading industry organizations (e.g., the Carbon Disclosure Project, Global Reporting Initiative, and Business for Social Responsibility). The particular metrics used by companies the research team interviewed range from straightforward and operationally driven items like mpg for over-the-road tractors to quite complex metrics involving numerous dimensions. For example, one intermodal operator interviewed uses just two metrics (mpg and age of fleet) to measure sustainability, while a parcel carrier uses up to 100 different indicators to monitor sustainability.

Metrics

Overall, for shippers, the main metric used is percent reduction of CO_2 emissions per year. Most shippers who measure and report sustainability initiatives use the widely accepted GRI sustainability reporting guidelines. GRI considers GHG emissions to be a key performance indicator, which is one of the reasons why so many shippers interviewed cited the reduction of CO_2 emissions as their main sustainability metric. One large food manufacturer explained that the overall goal is to drive down the average length of haul—a goal that affects several environmental metrics, including fuel use and CO_2 emissions.

For carriers, the main metrics utilized include average fuel savings or fuel use per ton-mile moved and percent reduction in CO_2 emissions per year. Carriers are focused on measuring and reducing fuel use, given that fuel accounts for such a large share of their direct costs.

Overall, corporate, publicly stated environmental initiatives overwhelmingly emphasize GHG reductions. For example, FedEx is working toward its "20 by 20" goal of reducing CO_2 emissions by 20% by 2020. Maersk Line has set a goal of reducing CO_2 emissions by 25% by 2020. On the shipper front, Nike has targeted a 30% reduction of GHG emissions by 2020. Staples aims to reduce absolute GHG emissions by 50% by 2020 (from a 2010 baseline). Air quality measures, such as CAP reductions, were only mentioned by a few interviewees, most of whom operate in California.

Examples of metrics, goals, and results provided by interviewees are noted in Exhibit 5-1.

Exhibit 5-1. Sustainability metrics and goals.

Metric	Goal	Result	Company
Shippers			
Length of haul	• Decrease average length of haul to 700-800 miles	• Some progress; currently at about 1,100 miles	• Food manufacturer (large)
CO_2 emissions, absolute reduction	• 30% absolute reduction in CO_2 by 2020 (vs. 2003 baseline)	• The company has almost doubled in size since 2003 and they are slightly above baseline, proving they have cut a lot of emissions	• Athletic apparel manufacturer (large)
CO_2 emissions, % reduction	• 50% reduction of CO_2 emissions by 2010, 75% reduction by 2015, 5% annual reduction of CO_2 (per ton delivered) each year	• Reached the 2010 goal so far and continually reach annual goal	• Food manufacturer (small)
CO_2 emissions, % reduction per pound of product	• Reduce GHG emissions by 20% per pound of product produced by 2015	• On target	• Food manufacturer (large)
Renewable energy use	• 100% renewable energy • Produce no waste	• Currently unable to achieve this goal, but waiting for technology and legislation to catch up	• Mass retailer (large)
Carriers			
CO_2 emissions, % reduction	• Reduce CO_2 emissions per TEU-km by 25% by 2020	• On track	• Container shipping line
	• Reduce CO_2 aircraft emissions intensity by 20% by 2020	• Achieved 13.5% reduction in CO_2 emissions by 2010	• Parcel carrier
	• Reduce aviation CO_2 emissions by 42% by 2020 (1990 baseline)	• CO_2 emissions reduced by 33%, as of 2008 goal	• Parcel carrier
	• Reduce fleet CO_2 emissions by 37%	• Goal completed and fulfilled	• 3PL
Fuel efficiency	• 20% efficiency increase by 2020 for vehicles	• By end 2010, achieved 15.1% increase in vehicle fuel efficiency	• Parcel carrier
Fuel use	• Reduce aviation fuel use to 6.9 gals/100 available ton-miles (ATM) by 2011	• Met fuel goal already and set a new goal of 6.57 gals/100 ATM	• Parcel carrier
Empty miles	• Reduce empty miles by 20%	• Empty miles now reduced by 32%	• Intermodal operator
Age of fleet	• 100% of fleet at 2008 or newer model	• 50% of fleet is now at 2008 or newer model	• Intermodal operator
Electricity use	• Reduce warehouse electricity use by 30%	• Both goals completed and fulfilled	• 3PL
Idle time	• Reduce idle time as a % of total engine time	• On track	• Trucking company
CAP emissions, total	• Reduce PM emissions and NO_x emissions	• Eliminated 21.63 tons of PM emissions and 805.2 tons of NO_x emissions	• Trucking company
Driving miles per gallon	• Reduction over time	• N/A	• Trucking company

Source: Analysis of shipper and carrier interviewee responses, 2011 and 2012

The active use that carriers, in particular, make of these metrics was emphasized in several interviews. For example, Weber Logistics has developed a dashboard for all energy and efficiency areas, which is reviewed daily and includes driving time, idle time, and average miles per hour (speed perspective) (Weber Logistics, 2012, pers. comm.). A long-haul trucker stated that it reviews two key measurements daily, driving mpg and idle time (as percent of total engine time) at every level of the organization. Yearly goals are broken up into shorter-term objectives (Swift Transportation, 2012, pers. comm.). In its advertising, MOL (a Japanese ocean carrier) shows its progress against environmental goals (CO_2, NO_x, and sulfur dioxide emissions per TEU-mile) as well as its operational service performance (American Shipper, 2012).

Reporting

Reporting of sustainability results also varies considerably across companies. Several companies the research team interviewed (e.g., Wal-Mart, Nike, FedEx, UPS, and Maersk) produce and release annual sustainability reports.

Some companies like Wal-Mart disclose results via collaboration groups such as CDP. Others release their targets and results in a less formal format. Stonyfield Farm and Weber Distribution report selected sustainability results on their websites, although Stonyfield is considering producing a more formal report in the next few years (Stonyfield Farm, 2012, pers. comm.). Other companies—including those with strong sustainability programs but not seeking to build a sustainability brand—measure, but do not release, results.

Nike presents an interesting example of sustainability reporting by a large consumer products manufacturer. Nike releases a corporate responsibility report annually. The purpose of this report is to connect with consumers and communicate plans and progress. Socially responsible labor practices in manufacturing appear to share top billing with environmental issues in this document. Within the environmental considerations, CO_2 is definitely more of a focus than CAP (not included currently, but Nike will have the capability to do so in the near future), and more than 10 pages in the report are devoted to GHG emissions. Nike also actively addresses transport and logistics aspects, although these are only a modest part of the overall sustainability footprint. Nike has adopted a CO_2 measurement tool that calculates emissions for inbound freight flows and is trying to increase visibility of transport legs all the way to the store (Nike, Inc., 2011 and 2012).

Patagonia, an apparel maker, has taken a novel approach to communicating its commitment to "use business to inspire and implement solutions to the environmental crisis." It has developed a project called "The Footprint Chronicles" that documents and shares with customers information about the environmental effects of every part of the supply chain (Patagonia, 2012).

5.5 Branding Supply Chain Sustainability

Certain companies have elevated their sustainability efforts, and their public communication of these initiatives, to a level that sets them apart from others. Although the extent and results of these efforts can be debated, such companies clearly believe that there is value in taking a strong sustainability approach. The motivation ranges from enhancing the attractiveness of products for environmentally conscious consumers to altruism on the part of company founders. In many cases, it is difficult, if not impossible, to quantify an exact return on investment in these programs. Yet several companies have set the bar high enough to serve as inspirations to others, whether large or small, shipper or carrier. A few of these companies and their sustainability programs are described in the following:

- **Stonyfield Farm**—This New Hampshire-based yogurt maker places significant emphasis on sustainability and educating consumers about its environmental efforts. Sustainability was one of the founding principles of the company and is central to its brand, as the consumer understands it. Over time, Stonyfield has concentrated its sustainability efforts on the hot spots of its supply chain—milk (largest and most difficult impact area to fix), transportation, packaging, and facilities.

  Stonyfield seeks to achieve its internal sustainability goals while also addressing consumer needs. The company focuses on educating consumers about why they should choose a sustainable brand. It expects that the level of green consumer awareness will rise in future, based on Stonyfield's own efforts and those of its competitors (Stonyfield, 2012, pers. comm.).

  Stonyfield's main sustainability target is to achieve a 5% annual reduction in CO_2 emissions per ton of product delivered. Reaching this goal implies a 75% decrease by 2015 (from a 2006 baseline); a 50% reduction was already achieved by 2010. All of the company's individual sustainability projects tie into this 5% annual reduction in GHG. The company does not directly address CAP.

  On the transportation side, Stonyfield looks at miles in network, vehicle use, and mode to reduce the CO_2 footprint. The company became a certified EPA SmartWay Transport Shipper and measures its GHG impact using EPA SmartWay's FLEET performance model. Stonyfield also requires that all trucking companies moving its products be SmartWay-certified carriers.

Significant progress has been achieved. Between 2006 and 2008, Stonyfield reduced transportation CO_2 emissions by more than 40% while also growing the business. This is equivalent to taking 1,700 automobiles off the road for a year (Stonyfield, 2012, pers. comm.; Stonyfield, 2012; Cooke, 2009).

In terms of advice to other small companies seeking to make sustainability a core part of both the company's image and its operations, Stonyfield advises that "the biggest thing is getting [sustainability] into the day-to-day. It's not top to bottom, it is at the employee level" (Stonyfield Farm, 2012, pers. comm.).

- **Nike**—Nike's supply chain sustainability program is evolving to encompass a complete, end-to-end supply chain view that is more transparent to consumers. The company has developed a list of supply chain expectations that includes environmental footprint analysis; publishing a corporate responsibility report on a consistent basis; proactively investing in research and development of alternative materials; understanding supplier footprint; ensuring traceability of materials throughout the supply chain; and integrating environmental standards, certifications, and traceability systems to ensure integrity throughout the supply chain (Nike, Inc., 2011).

  Each segment of the supply chain is measured via a common denominator (grams of CO_2 per unit processed). This allows Nike to roll up the impact along each leg of the product's journey. In transportation, Nike has realized many opportunities to conduct existing operations more efficiently and is pursuing new approaches, such as shifted transport modes (Nike, Inc., 2011 and 2012). Nike recently updated its environmental targets to FY2015 (baseline FY2011) as follows:
  - Achieve 20% reduction in CO_2 emissions per unit from FY2011 levels through FY2015.
  - Source all products from factories that have achieved bronze or better on Nike's Sourcing and Manufacturing Sustainability Index by the end of FY2020.
  - Accelerate the adoption of cleaner fuels and vehicle technologies by transport and logistics partners (Nike, 2010/2011).
- **UPS**—UPS focuses on its sustainability programs and has made these efforts a part of its brand. At UPS, "sustainability is more than a practice, it's a value" according to Cindy Miller, managing director of UPS United Kingdom, Ireland and Nordics, in a statement quoted on the UPS website (UPS, 1994-2012). Although specific UPS initiatives have been discussed earlier in this report, the following overall objectives are significant:
  - Increase average in-service miles per gallon for package cars in the U.S. domestic package segment by 20% (from 2000 to 2020). The actual experience achieved was about an 8% improvement from 2000 to 2010.
  - Reduce global CO_2 emissions for UPS Airlines by 20% (from 2005 to 2020). Supporting initiatives include reduced aircraft flight speeds, computer-optimized flight plans, computer-managed aircraft gate departure, arrival and taxi times, biodiesel in ground support equipment, environmentally friendly paint that reduces drag, and cleaner engines (UPS, 2010).

  UPS has extended its sustainability brand by offering customers a carbon-neutral shipping option (using carbon offsets) and eco-friendly packaging. UPS expects interest to grow as consumers become more aware of the sustainability advantages. To encourage demand, UPS initially matched customer cost (up to $1 million, by 2011). The carbon offsets are viewed as a cost-effective way to get carbon out of the supply chain (UPS, 2012, pers. comm.; UPS, 1994-2012).
- **FedEx**—FedEx presents its sustainability efforts in an annual global citizenship report. This emphasizes the "simple goal" of connecting "the world in responsible and resourceful ways." Environmental and efficiency goals are highlighted, such as aircraft emissions intensity, vehicle fuel efficiency, alternative jet fuel, renewable energy generation and procurement, and LEED certification.

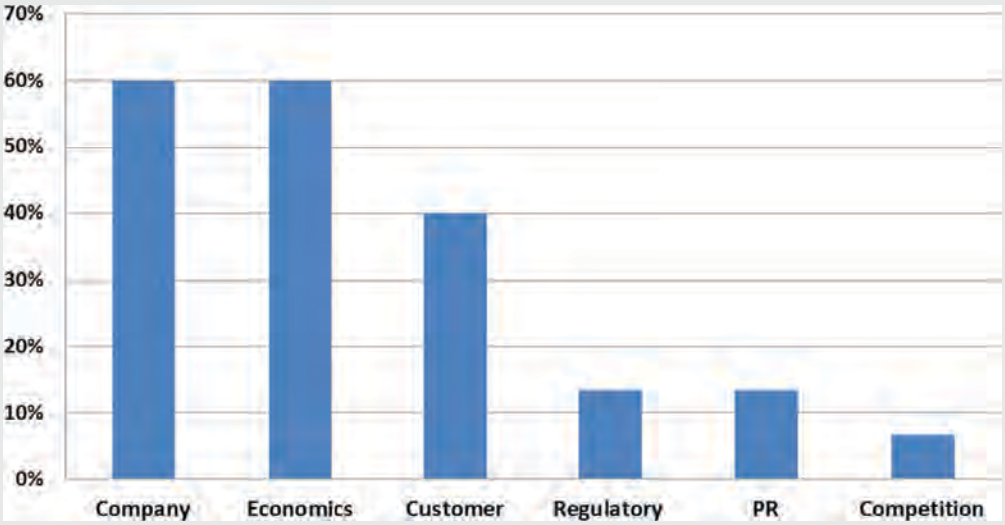
  Specific targets flagged include improving fuel efficiency and CO_2 emissions of the FedEx fleet by 30% by 2020 (from a 2005 baseline). One of the main innovation-focused levers to achieve this goal is to increase the electric and hybrid fleets by 20% (FedEx, 2012).

  FedEx expanded its sustainability brand in April 2012 by launching a worldwide carbon-neutral envelope shipping program. FedEx purchases the equivalent amount of CO_2 offsets from BP Target Neutral for the transportation emissions of all global FedEx envelopes shipped, at no extra charge to customers (a first in the industry, according to FedEx). As of April 10, 2012, every FedEx Express envelope that moves through the system is being offset. Customers like the idea of carbon-neutral shipping and are asking FedEx, "What is our carbon footprint?" With the new program, FedEx can show customers that its carbon emissions are now effectively zero for envelope shipping (FedEx, 1995-2012; FedEx, 2012, pers. comm.).

5.6 Rationale for Shipper and Carrier Sustainability Efforts

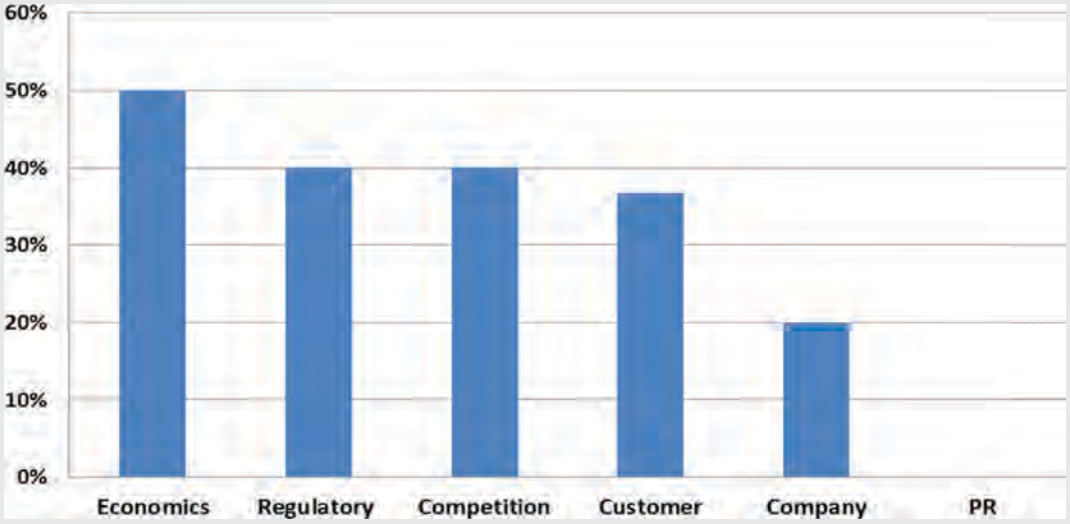
A key question for policymakers and regulators is "what are the drivers of private-sector sustainability initiatives?" The research team encountered various answers to this question. Economics (particularly reduced costs) and company policy rank highly among shippers' and carriers' reasons for efforts to reduce emissions. Other reasons cited range from customer or consumer demand to competitive positioning

Exhibit 5-2. Drivers of shippers' supply chain sustainability programs.



Note: "Company" means company policy and the right thing to do. "Economics" means a company's internal business economics, driven by cost reduction. "Customer" means pressure from business customers or consumers. "Regulatory" means legislative or regulatory requirements. "PR" means public relations reasons. "Competition" refers to competitive pressures.
Source: Analysis of shipper interviewee responses, 2011.

Exhibit 5-3. Drivers of carriers' supply chain sustainability programs, weighted by rank.



Note: "Company" means company policy and the right thing to do. "Economics" means a company's internal business economics, driven by cost reduction. "Customer" means pressure from business customers or consumers. "Regulatory" means legislative or regulatory requirements. "PR" means public relations reasons. "Competition" refers to competitive pressures.
Source: Analysis of shipper interviewee responses, 2011.

and public relations. The driver behind supply chain sustainability programs is clearly not regulatory requirements alone.

Overall, the research team found company policy (including simply "doing the right thing"), business economics (e.g., cost savings or increases), and customers to be the main stated drivers for shippers. Regulatory factors were rated as being much less significant. For instance, one food manufacturer explained that the top driver of their sustainability program is consumer requirements, because this company's particular customers are focused on local and organic products. A leading retailer was largely influenced by consumer perceptions in taking a high-profile stand on sustainability. An apparel maker was stimulated to launch a broad sustainability effort, in part, by negative press on one aspect of its supply chain. An office products wholesaler and retailer noted that its corporate clients now require detailed descriptions of sustainability programs as part of their requests for proposals. Exhibit 5-2 illustrates the main drivers of shippers' supply chain sustainability programs, presented on a weighted basis, by driver rank (first = 3 points, second = 2 points, third = 1 point).

For carriers, economic (business cost), regulatory, and competitive factors are the main drivers (Exhibit 5.3). Carriers, in contrast to shippers, cite regulations as a major driver of sustainability programs. However, carriers also state that customers are driving progress as well, with sustainability now typically being considered by shippers alongside price and service in selecting a transportation partner.

An interview with a state environmental agency supported the main drivers of sustainability found in the researcher's interviews with carriers and shippers. This interviewee stated that intense carrier competition has raised the importance of fuel cost savings and green credentials (e.g., SmartWay certification and carbon footprint calculations) (U.S. EPA, 2011, pers. comm.).

CHAPTER 6

Unforeseen and Unintended Consequences of Air Emissions Regulation

Demand for freight transport and resulting air emissions are affected by a broad range of public policies and regulations that may pertain to the economy, industry, regional development, energy, land use, safety, recycling, and air emissions. These policies and regulations have the potential to result in unforeseen and unintended impacts on air emissions.

Even those policies and regulations that do not specifically relate to air emissions can have air emissions impacts. For example, in the view of one researcher, policies that favor trade liberalization can lead to more trade and greater demand for the international movement of goods and freight air emissions (Hummels, 2009). Monetary policy may inflate the real cost of holding inventory, which could tighten just-in-time deliveries, leading to more road freight deliveries and increased emissions (McKinnon, 2010a). Freight-related policy and regulation also can have unintended air emissions consequences. Carriers interviewed as part of this study expressed concern that regulations limiting hours of service for truck drivers can result in productivity losses, potentially forcing carriers to put more trucks on the road, and thereby increasing total truck miles and air emissions.

Economic policy efforts that promote industrial development in peripheral regions; land-use policies and zoning regulations that move intermodal facilities, warehousing, and distribution centers to the urban edge; and environmental regulations that require product recycling are examples of public policies and regulations that can increase freight transportation movements per ton of product, with potentially adverse implications for GHG emissions from freight transportation. At the same time, policies and zoning regulations supporting the decentralization of intermodal, warehousing, and distribution facilities may, in some cases, have CAP emissions benefits where such facilities are removed from population concentrations. In addition, the way freight air emissions are regulated can have potential collateral consequences for business and society. Supply chains involve the movement of goods across jurisdictional boundaries, where they encounter a range of different regulations. In the United States, a unique mix of international, federal, state, and local environmental regulations apply across transport modes. Although air emissions standards, policies, and regulations can be geographically based, depending on the jurisdiction of the regulating authority, carriers and shippers tend to move goods along corridors that traverse several jurisdictional boundaries, where they encounter a range of regulatory requirements. Differences and discrepancies between regulations in various jurisdictions can create difficulties for supply chain operations. These can result in high costs and additional administrative requirements for carriers. A key question considered in the research is whether these additional costs and reporting requirements have caused shippers and carriers to make decisions about mode, routing, and vehicle deployment that might result in higher overall GHG emissions or the transfer of CAP emissions from one location to another (where the environmental and health impacts to communities may be worse).

This intelligence is important for public-sector decision-makers who can then consider such factors and ensure that the sustainability of supply chains is supported in the development of policies and regulations. Through the literature review and interviews with industry, the research team found only limited evidence of policy and regulation resulting in unintended consequences for supply chain sustainability. In some cases in the literature, the impacts of policies, programs, and regulations aimed at reducing emissions were not clear-cut and outcomes were unexpected or ambiguous. From our interviews with industry, the research team also found that in several cases, emissions regulation has resulted in higher private-sector costs, increased administration, and reduced flexibility. Although not the primary intent of regulation, these impacts are often to some extent "foreseen" in the rulemaking process, and their impacts on industry may not be well understood. It is the outcomes of these impacts on the behavior of shippers and carriers that is a specific focus of this chapter.

6.1 Unintended Consequences—Evidence from Literature

Balancing CAP vs. GHG Emissions

A key issue for regulators, carriers, and shippers is that CAP and GHG emissions do not always respond in tandem to emissions reduction efforts. In fact, regulations aimed at CAP emissions may conflict with, or undermine, GHG emissions reductions efforts and vice versa. For example, diesel truck engine improvements that reduce CAP emissions have tended to compromise fuel efficiency improvements, thus, adversely impacting GHG emissions (Tunnel, 2010). End-of-pipe controls, such as selective catalytic reduction for the control of NO_x can carry a fuel efficiency penalty. Reducing the pollutant content in fuels (e.g., by requiring the use of low-sulfur diesel) can increase fuel consumption and GHG emissions at refineries (Purvin and Gertz, 2004). Therefore, efforts to regulate air emissions should take into account—and balance—the potentially conflicting objectives of air quality improvements and GHG emissions reduction.

As with GHG emissions, CAP emissions can increase with the amount of fuel used or distance traveled. However, these emissions categories behave differently. Although GHG emissions are global and cumulative, CAP emissions have localized impacts. CAP concentrations, and NAAQS exceedances, are determined by local atmospheric concentrations of pollutants that depend on atmospheric chemistry, wind, meteorological and topographical characteristics, all of which vary dramatically across the country. CAP impacts also are affected by the proximity of sensitive receptors.

The concentration of pollutant emissions from greener/less-GHG-intensive modes such as shipping and rail at critical points along the supply chain (e.g., ports and intermodal yards) can result in health impacts to adjacent communities. However, efforts to regulate such pollutant emissions that result in higher costs to carriers and shippers could result in a shift away from greener modes to more GHG-intensive modes, particularly where regulation increases the cost of these greener modes. For example, a potential loss of mode share from short sea and inland shipping to less sustainable modes is forecast by some authors as a result of the future introduction of the North American Emissions Control Area (ECA), effective in 2015 (Research and Traffic Group, 2009). Studies of the impacts of the proposed tightening of sulfur emissions limits in the Baltic and North Sea ECA also predict a 50% mode shift to road and rail, thereby potentially increasing GHG emissions (Entec, 2010). The extent of these impacts needs to be properly understood prior to the adoption of air emissions regulations, with consideration given to mitigation measures, for example, through the potential provision of financial incentives to these greener modes.

Truck Size and Weight Limits

Measures that increase the fuel efficiency of trucking (e.g., by increasing truck size and weight limits) are considered to have potential to reduce GHG emissions. As one example, fuel and GHG savings through longer combination trucks in Europe are estimated to be between 17% and 28% based on ton-km traveled (Greszler, 2009). However, these improved truck efficiencies resulting from the relaxation of truck size and weight restrictions can have the unintended impact of increasing demand for road freight as a result of reduced costs. This can undermine the mode share of rail and short-sea shipping, causing an overall net increase in GHG emissions (March, 2001). This phenomenon is generally referred to as the "rebound effect." A German study found that the rebound effect can increase road congestion and reduce road safety (Döpke, 2007). Further, a study of lifecycle effects of heavy trucks indicates a potential increase in sulfur dioxide (SO_2) and PM emissions as a result of the relaxation of truck size and weight restrictions due to increased emissions from additional pavement maintenance and construction required to accommodate heavier trucks (Sathaye et al., 2010b). Some U.S. states are opposed to longer and heavier trucks. MAP-21 calls for the U.S.DOT to undertake a study to assess the effects of longer and heavier trucks on the nation's infrastructure, highway safety, efficiency, and the economy.

Speed Limits

Measures such as reduced vehicle speed limits can have fuel consumption and GHG emissions benefits for individual truckloads. Nevertheless, reduced speeds have been shown to have little or ambiguous impacts on CAP emissions from trucks. Furthermore, reduced speeds also decrease the distance a driver can cover during a workday; requiring more trucks to move the same amount of freight, and resulting in sub-optimal outcomes including higher shipping costs, increased traffic congestion, and increased opportunity for accidents from more trucks on highways and roads (Committee to Assess Fuel Economy Technologies et al., 2010).

For ocean carriers, slow steaming can reduce bunker fuel consumption and emissions while improving on-time reliability. However, the advantages are dependent on the commodities being moved. In addition, increased charterage, longer transit time, additional equipment requirements and engine maintenance costs can offset fuel savings and affect a carrier's competitive advantage. Further, vessels required to slow in one geography may be compelled to pick up speed in another location to ensure schedules are met, thus increasing GHG emissions on the unregulated leg of the journey. Because of the multitude of issues at play, it is considered that voluntary, as opposed to mandatory, slow steaming is

less likely to have unintended or undesirable consequences (Hanjin, 2011).

Efforts to Promote Mode Shift

It can be difficult for public agencies to influence mode shift. For example, truck tolls in Switzerland were set deliberately to discourage truck traffic and induce a freight mode shift to rail with associated air emissions benefits. However, studies found that significant mode shift to rail did *not* occur. Instead, unforeseen changes to truck configuration and delivery logistics were set in motion, with large trucks chaining more pick-ups and deliveries together. These unintended (although still beneficial) effects occurred partly as a consequence of delays in rail freight improvements, but also demonstrate the inherent logistical advantages of using trucks for many shipment types (Minnesota DOT, 2010).

Another study found that a Pan-European truck tolling program would reduce truck miles by 15%. However, only one-third of this reduction was attributed to freight mode shift from trucks to other modes, with the rest being attributed to improved truck freight efficiencies (De Jong et al., 2010). Although significant public investment in pricing policies, targeted grants, and infrastructure investments aimed at promoting freight mode shift has had some impact in Europe, the full extent of benefits generated remains uncertain, and it is unclear whether similar benefits could have been attained at a lower cost through other means (U.S. GAO, 2011a).

Mode shift over the ocean is usually between air and ocean-going vessels. The per ton-mile emissions of marine vessels are typically 2.5% or less than those associated with airfreight carriers (U.S. EPA, 2008b). Thus, significant emissions reduction gains are possible through mode shift from air to marine modes. However, despite the cost competitiveness and comparative environmental sustainability of marine shipping, the scope of mode shift from air to ocean carrier tends to be limited given the requirements of just-in-time delivery schedules for certain products. Further, the emissions penalties associated with shifts from marine to air cargo are significant. Therefore, regulations that adversely affect the speed, reliability, and cost of marine shipping, resulting either in mode shift from marine vessel to air, or the diversion of marine cargo to ports with poorer or no rail connections, could risk significant overall increases in GHG emissions for that particular journey. Note that the research did uncover specific instances of this occurrence.

Truck Time and Weight Restrictions in Urban Areas

Delivery time and weight restrictions in urban areas intended to reduce congestion and improve urban amenity have been shown to result in the need for additional trips, causing environmental and financial impacts (Allen and Browne, 2010). Vehicle weight restrictions applied during parts of the working day have been found to increase total vehicle operating costs by as much as 30%, depending on the level of restriction. Such restrictions can increase total time traveled due to the need for a greater number of vehicle trips using lighter vehicles. Environmental impacts worsen as a result of increases in total miles traveled (Anderson, 2005). Research has found that social benefits such as reduced noise, vibration, and road accidents that accrue from time and weight restrictions tend to occur at the expense of environmental performance (Quak and de Koster, 2009).

Unilateral Decision Making on Global Emissions—the EU Aviation Emissions Trading Scheme

On a global scale, agencies such as the International Maritime Organization (IMO) serve a key role in ensuring international regulatory consistency. For example, the IMO International Convention on the Prevention of Pollution from Ships (MARPOL) agreements regulate CAP emissions from ocean carriers. However, in some cases, international agencies are slow or unable to reach agreement on emissions. For example, the IMO has, to date, been unable to reach agreement on the regulation of international maritime GHG emissions. As a result, the European Commission (EC) has threatened to develop proposals of its own if the IMO fails to act. A myriad of locally or regionally defined emissions regulations can add significantly to administrative requirements and can result in increased costs for global carriers. The EC's threat of unilateral action is not an idle one. Their frustration with slow progress of the International Civil Aviation Organization (ICAO) on aviation GHG emissions resulted in a unilateral decision in 2009 to extend the European Union Emissions Trading Scheme (EU ETS) to international aviation. This was applied without the prior agreement of the affected countries or airlines, and resulted in significant opposition from ICAO member countries. There are indications that non-European governments, such as China, are developing parallel plans to reduce emissions from their own airlines, and are negotiating EU aviation ETS exemptions for their own carriers based on their own adoption of "equivalent measures." Note that flights arriving at EU airports from countries that have adopted equivalent measures are exempt from the EU ETS. The nature of "equivalency" and the administrative requirements that another, potentially different (Chinese or other) regulatory regime will place on the airlines is unclear.

Despite industry assertions to the contrary, studies estimate that the EU aviation ETS will not constrain growth in the U.S. aviation business, and that the financial impact on

airlines is relatively modest (Malina, 2012; Schröder, 2008). Nevertheless, some analysts consider that the European aviation ETS may create some distortions in the cargo sector, with express freight favored over standard cargo, and could result in increased use of pure freighter aircraft models as opposed to belly cargo within passenger aircraft (Schröder, 2008). This could increase the GHG intensity of passenger air travel, although in the absence of further study, the extent of this impact is unclear. There is also some concern that the EU aviation ETS may undermine the competitiveness of products derived from outside the EU, because the costs of transport will increase and producers will have limited ability to pass on these costs. Producers contend that this may, in some cases, unfairly prejudice products whose carbon footprint may actually be less than that of equivalent European products (New Zealand Productivity Commission, 2012).

Notwithstanding the challenges that locally defined emissions regulations can pose for international carriers that are required to deal with administrative and technology requirements that vary by jurisdiction, there are indications that the application of emissions regulations in one region can result in willingness on the part of carriers to engage in voluntary changes in other locations. For example, regulations requiring a switch to lower sulfur fuels in certain areas (e.g., those currently required in sulfur emission-control areas in the North Sea and Baltic Sea, and off the coast of California) have arguably paved the way for shipping lines to voluntarily commit to using low-sulfur fuel off the coast of Hong Kong as part of the Fair Winds Charter initiative.

6.2 Unintended Consequences and Increased Costs—Evidence from Industry Consultation

Heavy-Duty Vehicle GHG Reduction Regulation

This Californian regulation requires the use of aerodynamic tractors and trailers that also must be equipped with low-rolling resistance tires to improve fuel efficiency and reduce GHG emissions. Tractors and trailers subject to this regulation must either use EPA SmartWay-certified tractors and trailers, or retrofit their existing fleet with SmartWay-verified technologies, including trailer skirts. Consultation with industry revealed concerns that the necessary investments in trailer skirts do not yield commensurate benefits in California where the Motor Vehicle Code prohibits a truck from exceeding 55 mph. Fuel efficiency benefits of trailer skirts are only realized at 50 mph, with optimal benefits gained at speeds of 65 mph. For example, a large national truckload carrier interviewed by the research team considered the California trailer skirts regulation to be the result of good intentions combined with poor understanding of local operating conditions. This carrier cites the following three issues:

1. Carriers generally run three trailers per tractor, using a drop-trailer system. This rule requires installing skirts on all trailers (at a cost of 3 x $1,000). Yet the benefit only accrues to the one trailer being towed. So the cost is $3,000 for 100,000 miles per year. The carrier's view is that the same $3,000 could be spent on the tractor with more beneficial environmental outcomes.
2. The skirt is most effective at high speeds, as noted. At 55 mph (the speed limit for trucks in California), there is little aerodynamic benefit.
3. The carrier also cited the reporting and administrative requirements associated with this regulation as being time consuming for the private sector.

Concerns about the impacts of these requirements on interstate commerce have been voiced, particularly as the regulation places cost and administrative obligations on interstate fleets that often do not know in advance which equipment will be used in a particular region on a given day. Many carriers contend that the regulation potentially curtails flexibility and efficiency as they may be required to shift loads to different vehicles to meet regulatory requirements when traveling between different states. Concerns were expressed that trailer skirts present safety risks, because they can be damaged during situations such as while crossing railroad tracks and driveways, and during loading and unloading. Drivers face a liability risk of damaged devices detaching from the trailer while driving. Others contend that the operation of aerodynamic side-skirts under treacherous weather conditions could compromise device safety and result in failure at high speeds (Tata, 2009). One carrier interviewed stated that this and other regulations cause them to try to avoid California altogether, although the research found no evidence that this is occurring on a widespread basis.

According to staff at CARB, carriers' attitudes are changing as they realize cost savings as a result of improved fuel efficiency, and there has been no evidence of safety issues (CARB, 2012, pers. comm.).

At-Berth Ocean-Going Vessels Regulation

California has mandated that ocean-going vessels plug in to the electric grid or use an equivalent emissions-reduction option while docked at California ports, rather than using onboard auxiliary engines. This "cold ironing" or shore power requirement is intended to reduce port communities' exposure to harmful NO_x and PM emissions from diesel-fueled auxiliary engines. It offers the added benefit of reduced CO_2 emissions. The regulation applies to container fleets making

25 or more annual visits to a California port. By 2014, the State of California requires that for 50% of container ship visits, vessels must either rely on shore power while ships are berthed at California ports, or make use of an equivalent emissions-reduction option. However, given that connect/disconnect times are not included in emissions reduction calculations, this effectively means that over 50% of the vessels are required to use shore power in order to achieve a 50% emissions reduction (APL, 2012, pers. comm.).

A leading container shipping operator expressed concern about the financial impacts of these regulations for ocean carriers—typically the most GHG-efficient of freight modes—required to make significant investments to convert vessels to enable them to plug in to the shoreside electric grid. This onboard infrastructure is only usable when vessels are docked at ports equipped with shore power facilities. According to APL, the equipment is typically used only about 1 month per year (APL, 2012, pers. comm.). The capital outlay, estimated by CARB to be approximately $1.5 million per vessel (California EPA, 2007), reduces capital available for other sustainability innovations, argue ocean carriers. From a shipping line's business perspective, the regulation also limits global vessel deployment options and flexibility to rotate vessels, given that not all vessels are outfitted with cold-ironing capability.

In the future, if the adoption of shore power becomes more widespread with other ports providing at-berth shore power infrastructure, shipping lines will have more opportunities to plug in during port calls, thereby improving their return on investment over time, as well as their flexibility to rotate vessels. However, as is generally the case in global transportation, the adoption of international standards is essential to ensuring full compatibility, and wider adoption and cost-effectiveness of the technology, and it will likely take some time for ports to become shore-power enabled.

The reaction to this regulation on the part of ocean carriers is driven by concerns about the high capital costs, associated with shore power technology combined with the lack of technological alternatives and perceived lack of flexibility in the regulation. For example, APL supports seawater scrubber technology, arguing that this technology is effective in emissions reduction and is cheaper than shore power. The At Berth Ocean-Going Vessels Regulation permits operators the use of alternative emission-control strategies, *provided the requisite emissions reductions can be obtained.* However, seawater scrubber technology, although effective in reducing PM, SO_x, and VOC emissions, is less effective at reducing NO_x emissions (e.g., APL reports that technology is expected to reduce diesel particulate emissions by 80 to 85%, SO_x emissions by 99.9%, VOCs by more than 90%, and NO_x by just 10%) (APL, 2012; APL, 2012 pers. comm.). The regulations also place limitations on carriers changing from cold ironing to an alternative technology. Ocean carriers are required to choose the equivalent emissions reduction (EER) approach early in the program, and may not switch from cold ironing to EER (APL, 2012, pers. comm.).

Nevertheless, ocean carriers are reportedly adopting innovative approaches to the adoption of shore power technology. For example, NYK proposed to deploy 38 container ships with shore power capability at a total cost of $22 million (or a cost of $600,000 per ship, or $900K less than the costs estimated by CARB). This cost is based upon placing the necessary shore power equipment (transformer, switchgear, and associated controls) in a container at the berth. This container can then be placed on each ship equipped to use shore power, and the necessary equipment can be moved from ship to ship on an as-needed basis instead of fully retrofitting each ship. Given that the cost to modify the ships represents about 80% of the capital costs for shore power, reducing the shipside costs can significantly reduce overall costs (California EPA, 2007).

Nevertheless, when combined with the costs of other regulations in California such as low-sulfur marine fuel requirements and the North American ECA, the shore power regulation can add significantly to ocean carriers' costs. It is, at present, too soon to assess whether the shore power regulation in combination with other regulations has had unintended impacts in terms of the diversion of cargo away from Californian ports as a result of higher costs, and whether these costs outweigh the benefits of shipping via California.

Ocean-Going Vessel At-Sea Low-Sulfur Marine Fuel Requirements

Several ocean carriers interviewed expressed concern about overlapping regulation that applies to the use of low-sulfur marine fuel, particularly in California. The MARPOL North American ECA came into effect on August 1, 2012, bringing in stricter controls on emissions of SO_x, NO_x, and PM for ships trading off the U.S. coast. All vessels sailing within 200 nautical miles of much of the North American coast are required to use 1% low-sulfur fuel (falling to 0.1% after January 2015). For a vessel on a 1,700-nautical-mile route, this regulation will increase ship operating costs by an estimated $18 per TEU container (U.S. EPA Office of Transportation and Air Quality, 2009).

Nevertheless, CARB's Low-Sulfur Marine Fuel Regulations, which took effect in July 2009, will still apply since the low-sulfur fuel required by the North American ECA does not presently satisfy California's requirements. CARB regulations require ocean-going vessels within 24 miles of the California Coast to use distillate fuels such as marine gas oil (MGO) with a sulfur content of 1% or less or marine diesel oil with a sulfur content of 0.5% or less. This adds an estimated $30,000 per vessel to the cost of a California port visit (estimated at about $6 per TEU). In their Initial Statement of

Reasons, CARB considers this to be a small proportion of the overall transportation costs (estimated at about 1%) of a voyage from Asia to the U.S. West Coast for a typical container (California EPA, 2008).

Although the initial regulation was subject to legal challenge on the basis that its requirements impose a "non-uniform and costly regulatory regime on the maritime industry," the courts found that notwithstanding the costs of compliance, the State of California has a compelling interest in protecting the health of its citizens. The regulation has helped achieve a 91% reduction in SO_2 levels, a 90% reduction in PM emissions, and an unexpected 41% reduction in black carbon levels (California EPA's Air Resources Board, 2011).

Despite these air quality benefits, international ocean carriers like APL are concerned about having to use three different types of fuel during a single voyage requiring separate fuel storage, crew time, and recordkeeping (APL, 2012, pers. comm., May 23). CARB has acknowledged that uniform national and international regulation is preferable to individual state regulation, and the Low-Sulfur Marine Fuel Regulations include a sunset clause that provides for the termination of this regulation once CARB determines the federal government has adopted, and is enforcing, requirements that will achieve equivalent emission reductions in California.

Efforts to Address Port Operational Practices

State legislation aimed at addressing emissions can be slow to take effect and may not always address issues in the most responsive manner. For example, of the 17 bills aimed at regulating port operating practices put before the California state legislature since 2000, only 3 have passed (Giuliano, 2008). AB2650, introduced in 2003, focused on changing dock operational practices at the Ports of Los Angeles and Long Beach in order to reduce truck emissions in the vicinity of the ports. Marine terminal operators (MTOs) were required to pay fees for trucks idling more than 30 minutes at terminal gates, or could avoid fees by extending operating hours or offering gate appointments for trucks dropping off or picking up containers. No terminals opted to extend gate hours (due to the costs involved), with most implementing an appointment system. However, surveys indicate that drayage operators made few appointments, and that the appointment system was being used to achieve compliance and avoid fines, rather than to promote efficiencies. There was also no evidence that appointments generated time savings for carriers, and the measure proved difficult to enforce (Giuliano, 2008).

By contrast, the more successful OffPeak Program (also known as PierPASS) introduced by the Ports of Los Angeles and Long Beach in 2005, was based on collaboration between the ports, MTOs, and steamship lines. The program is run by PierPASS, a not-for-profit company created by the ports and MTOs to address common issues of congestion and air quality. The PierPASS Program provides financial incentives to move cargo outside of the peak daytime traffic hours. A Traffic Mitigation Fee (TMF) of $61.50 per TEU, as of August 1, 2012, is applied to cargo. Revenues are returned to the MTOs to cover the costs of extended hours of operation. The initiative shifted 22% to 30% of cargo to the off-peak period in its first year of operation. It has resulted in redistribution of heavy truck traffic from the midday (peak) period, shifting it to nighttime (Giuliano, 2008). The shift also enabled growth in container activity to be accommodated without adverse impacts on CAP emissions.

Nevertheless, the program has had some unintended consequences, with those in weaker positions finding themselves somewhat disadvantaged. For example, drayage operators are now required to work nights with no change in pay, and no evident improvement in turn times. Distribution centers, warehouses, and exporters are required to modify their operations (e.g., by adding a night shift), thereby incurring additional costs. Further downsides include increased nighttime truck traffic and noise in local communities (Giuliano, 2008).

Technology Availability Concerns

Regulators often push industry to adopt new technologies by setting emissions standards that speed up the development and deployment of new technologies, frequently referred to as "technology forcing." This presents a delicate trade-off between encouraging innovation and pressing for solutions where the technology is not yet proven or, in the worst case, not feasible. One shipper with which the research team spoke urged regulators to review regulations that in their perception restrict companies in their ability to implement sustainability innovations. On the other hand, several interviewees criticized well-intended regulations for overestimating the available technology.

Rail operators, for example, express frustration about the lack of available technology to meet new EPA Tier 4 locomotive emission standards. Tiers 3 and 4 standards were introduced in the 2008 Locomotive and Marine Diesel Engine Emissions Standards. The Tier 3 standard is already effective. The Tier 4 standard applies to newly built engines and is based on the application of high-efficiency catalytic after-treatment technology (ECOpoint Inc., 2012). According to the railroad industry, Tier 4 technologies are not yet commercially available, even though they are mandated for introduction by 2015. Currently, the only way to meet these pollutant emissions standards is through processes that increase locomotive fuel consumption. Thus, although this federal policy seeks to improve air quality, the practical effect will be to increase GHG emissions, effectively conferring a local benefit but applying a global cost. Rail sources indicate these regulations

are mostly driven by concerns in Southern California where CAP emissions concerns are particularly acute, yet the EPA rules will apply nationwide.

Industry Views of Potential Local Regulatory Impacts on Operations

Industry views on the impacts of regulation on operations vary. It is recognized that in some cases, the private sector has been known to overstate the adverse impacts of regulation on their ability to do business, and that comments should not always be taken at face value. Nevertheless, the research team did come across instances where private-sector interviewees identified specific regulations as being particularly restrictive. At one extreme, a motor carrier and one of the shippers interviewed stated that they would prefer to avoid operating in California if they could, due to the tougher environmental regulations in the state. A manufacturer stated that Californian air (and water) emissions regulations have led them to minimize the number of plants in the state. A motor carrier also told the research team that California's renewable fuel regulations have required them to run different fleets in the state and, in some cases, to avoid it altogether. Were other states to follow the Californian regulatory example, several interviewees claim that doing business would become more difficult. Some carriers claimed that they might have to significantly alter their operations and ultimately become less sustainable in the process (e.g., by increasing journey distances to avoid transiting these high-regulation states entirely). Several interviewees mentioned particular triggers or breakpoints that could result in major changes to their operations, ranging from equipment deployment decisions to port gateway selection. One third-party logistics provider (3PL) stated that if other individual states were to embrace California's aggressive clean air approach, they would have to significantly adjust their operations. In the view of one motor carrier, California's regulations are potentially shifting CO_2 emissions to other states, and a unified federal (rather than state-level) approach to GHG emissions regulation is required. Despite these claims the research team did not uncover any quantitative evidence through the literature or interviews that such shifts in the location of business or cargo routing had actually occurred to the extent that this is having an impact on CO_2 emissions.

An ocean shipping industry association expressed the view that environmental requirements in certain states (e.g., those pertaining to ballast water discharge in California and New York) are examples of "chaos" created by state regulatory agencies that, in the view of the interviewee, lack the necessary depth of expertise. In general, according to this view, states should not be involved in decisions affecting the international shipping arena. Even when states have the technical knowledge, such regulations are viewed as damaging the federal government's credibility in international forums. In this view, as sustainability issues increasingly come to the fore, such conflicts are becoming more common.

A motor carrier claimed that the combination of reduced highway infrastructure investment and curtailed hours of service for drivers (which require more vehicles on the highway to deliver the same level of service) has an adverse impact on economic efficiency and freight emissions. This carrier supports the regulatory change to permit the use of doubles, triples, and other alternative truck configurations to improve efficiency and cut emissions. In the view of this carrier, this solution could make better use of existing infrastructure and potentially removes trucks from the highway. The role of public agencies, in the industry view, should either be to improve the capacity of freight corridors or allow carriers to operate more efficiently on existing highways.

It is not only air quality and GHG regulations that are of concern. For example, a container shipping line cited changes in ballast water regulations would require them to shift their operations and strategies. Additionally, they mentioned that they would need to modify their operations if regulations (already in place for certain port approaches) relating to protecting North Atlantic right whales and decreasing vessels' acoustic output became more widespread. Several carriers and shippers referred to the high cost of fuel as a potential future breakpoint, driving them to switch to alternative fuels, as well as to improve optimization and efficiency. However, other stakeholders told the research team that they do not have a specific regulatory breakpoint in mind because their supply chain networks are fairly balanced and large scale in nature and are unlikely to change significantly.

Lack of Evidence Regarding Shifting Coastal Cargo Shares Due to Local Regulatory Actions

In the United States, one of the major potential unintended consequences of local regulatory action could be the shifting of transportation activity between nodes and corridors. That is, although federal environmental regulations would be expected to affect all regions equally, stricter state or local regulations could impact supply chains passing through multiple regions.

One of the oft-cited examples of the potential for such disruption to established supply chains relates to stricter air and water quality requirements on the West Coast, California in particular, than in other parts of the country. Although there is no doubt that California and other West Coast states have enacted environmental regulations over the past decades, often in advance of federal regulators, there is no clear evidence that this regulation, even in combination with other factors, has driven business away from Pacific Coast ports.

A review of Association of American Port Authority (AAPA) data on container freight by coast over the past 20 years indicates there is little overall change in coastal shares. The U.S.

Pacific Coast ports maintained exactly the same share (53%) of total U.S. container traffic, measured in TEUs, in 2010 as they did in 1990, according to AAPA data. Also, the Southern California ports of Los Angeles and Long Beach substantially increased their share of U.S. container traffic over this period, rising from 24% to 33% of the U.S. total. Although the POLA/POLB share increase was particularly dramatic during the late 1990s, it continued to rise through 2005 and has been stable since then (AAPA, 2012).

There is no overall evidence, in terms of port-specific or coastal shares, to support the argument that environmental regulations in California and on the West Coast have driven freight to other ports. Even if there were some variations in share, it would be difficult to isolate the impact of environmental regulations from the effects of differing rates of transport cost increases, transport technology developments, and differential regional economic growth rates. In short, although the research has described various unintended consequences from environmental regulatory initiatives, the research team does not see a broad pattern of distortion within the nation's overall supply chain system, as regards ocean container flows at U.S. ports.

6.3 Conclusions and Implications

The Need for Integration Between Public Policy and Regulation

Demand for freight transportation and associated increase in freight miles and freight air emissions are affected by a range of policies and regulations, many of which are external to the environmental regulatory context. Although the focus of this section is air emissions regulation, the importance of ensuring that the range of policies and regulations affecting freight transportation are aligned and supportive of supply chain sustainability cannot be overlooked. In particular, there is a need for integration across all public policy initiatives such that they are supportive of freight air emissions reduction and avoid unintended consequences. In locations such as Chicago, Kansas City, Port of Houston, and California where public agencies responsible for planning, infrastructure development, and air emissions regulation are working together in pursuit of mutually beneficial outcomes, air emissions are being managed and even reduced while economic growth and freight traffic continue to grow.

Balancing CAP and GHG Emissions

Concerns about public health and climate change have resulted in the tightening of CAP and GHG emissions regulations. However, in some cases, these regulatory efforts can undermine one another. Regulations, standards, and policies aimed at reducing CAP emissions can have the effect of increasing GHG emissions, and vice versa.

As the evidence presented in this chapter suggests, locally defined regulations that are inconsistent across geographies can create difficulties for carriers that are required to cope with a range of different requirements as they transport freight between jurisdictions. Nevertheless, because CAP emissions have localized health impacts, there is an argument that these emissions are best managed at the local level. The potential alternative involves the universal application of stricter CAP regulations (in response to the needs of those jurisdictions with the poorest air quality) across a wider geography, even where air quality standards are presently being met. However, this would result in unnecessary costs to industry without commensurate public health benefits necessarily being achieved at the local scale. A critical objective for regulatory agencies is to fit the regulation to the need and to mitigate any adverse impacts in supply chain operations, noting, in some cases, these adverse impacts will be unavoidable.

Longer term, the move to a zero- and near-zero-emission freight system, as being contemplated by the Southern California Association of Governments (SCAG) in their Regional Transport Strategy (RTS), is likely to be the only way to accommodate economic growth, protect public health, and reduce GHG emissions, particularly along corridors with high concentrations of population and poor air quality.

Evidence from International Experience

Outside the United States, other countries have attempted to address supply chain emissions issues in various ways, many of which present stark lessons for regulators and policymakers stateside, should they be considering similar paths of action. Evidence from studies undertaken in Europe indicates that allowing longer combination trucks can have significant efficiency gains in the trucking sector, resulting in GHG emissions reductions. However, these studies also indicate that there is a risk of a "rebound effect," where fuel savings result in reduced road freight costs, hence, an increase in road ton-kilometers. Such cost reductions also can result in mode shift from greener modes, such as rail and short sea/inland shipping, with detrimental effects on GHG emissions.

Similarly, reducing speed limits may have fuel consumption and GHG benefits. However, reducing speed limits also may result in more trucks required to move the same amount of freight due to reductions in the distance that can be covered in a single day. Further review of potential impacts on costs and safety are required if reduced speed limits are to be considered. Reduced speeds also can undermine the effectiveness of various SmartWay-approved technologies. Further investigation is required to assess which option offers the greatest potential for supply chain sustainability improvements.

Efforts to promote mode switch to greener modes, such as encouraging switching from truck to rail modes via introduction of truck tolling, have had varying and ambiguous

benefits. Many have not achieved their mode shift targets. Because of the inherent logistical advantages of trucking for certain shipment types, and because the overlaps between the truck and rail freight markets tends to be relatively small, the potential for freight mode shift is relatively limited. Several shippers are already taking advantage of the cheaper costs of non-truck modes without the need for incentives. However, transit time and delivery reliability tend to be the main impediments to mode shift from trucking. Careful consideration of the full extent of potential benefits from mode shift initiatives is required prior to program development, including assessments of whether such benefits may be attained at lower cost through other means.

It is preferable for international agencies to develop protocols and regulations for global carriers (e.g., in respect to aviation and shipping GHG emissions). The EU aviation ETS provides a case study of the impacts of particular jurisdictions "going it alone" where global agreement cannot be reached. Other locations, such as China, appear to be following suit. If China's procedures are vastly different than those in the EU, this could significantly add to airlines' administrative requirements. Nevertheless, despite resounding opposition to the EU aviation ETS from non-EU states, compliance levels have been high, and the EU aviation ETS is not expected to constrain growth in the U.S. aviation or airfreight business. However, there is a risk that by focusing on transport carbon emissions, the EU aviation ETS can, in some cases, result in distortions. For example, this could occur by adding to the costs and reducing the market share of imported products that may actually have a smaller carbon footprint than locally sourced products.

The California Experience

Given the amount of recent regulatory activity in California, it is not surprising that the carriers and shippers consulted as part of this research provided the most examples of what they perceived to be unintended consequences from their experiences in that state. This can be ascribed to the following two factors:

1. California has had to take significant steps in response to its acute air quality issues and has, at the same time, made strides forward in efforts to address GHG emissions.
2. The state has exceptional authority under the federal Clean Air Act, which allows it to adopt emissions standards stricter than federal standards, subject to the submission of a waiver petition to the EPA.

Several states have expressed an interest in using their authority under Section 177 of the Clean Air Act to adopt California standards. Some consider the adoption of California standards to be a safety net in case EPA delays similar federal standards (National Research Council, 2006). Because the Clean Air Act allows other states to adopt California standards without any alteration, it is vital that before adopting these standards, states understand both the context for the California regulations, as well as the unintended consequences that have resulted, to avoid potential replication of these problems elsewhere. Further, the research did not find any indication that California's cargo share has shifted to other locations because of the uniqueness of the Californian economy and context. The size of the local Californian market, its proximity to Asian markets, and its well-established road and rail infrastructure (which reduces the costs of transporting goods to destinations beyond state borders) add to the advantages of doing business there. Other states do not benefit from such advantages and therefore run a greater economic risk with the application of "copycat" standards and regulations.

The research established that some of the underlying reasons behind the unintended consequences of air emissions regulations in California lie in, for example, specifying technologies (e.g., trailer skirts, shore power, ballast water treatment technology) that may be less than optimal given the circumstances, and that can add to carriers' (and ultimately shippers') costs, while the benefits are, in some cases, overestimated or unsubstantiated.

A further issue is the layers of regulation at the international/national level (e.g., the North America ECA) and the state level (e.g., the California low-sulfur marine fuel requirements). In addition, regulation may have been less effective because it was developed without the benefit of deep and wide consultation, and as a consequence did not get to the heart of operational practices and was not enforceable (e.g., the Port Gates Appointment System).

Cost-Effectiveness of Regulation

Cost-effectiveness estimates consider the ratio of the cost of compliance per ton of pollution reduced and allow different regulations to be compared. They are useful to compare alternative options for a given location, but are context-specific and therefore not as useful as a comparative yardstick against other jurisdictions. Public agencies would do well to pursue the most cost-effective solutions first, thereby prioritizing elimination of the lower cost emissions units from the supply chain. The cost-effectiveness of California regulations vary widely. For example, CARB's estimates of the average cost of air emissions regulations recently implemented vary from between $15,400 to $320,000 per ton of PM per year. The Low-Sulfur Marine Diesel Rule is comparatively cost efficient, at $31,000 per ton of PM per year (U.S. EPA Office of Transportation and Air Quality, 2009a). By comparison, full implementation of the Shore Power Rule is expected to cost

between $200,000 and $550,000 per ton of container ship PM removed, making this regulation particularly expensive. Part of the reason for the high costs of emissions reduction under this rule is that the previously adopted regulations for auxiliary diesel engines had already reduced PM emissions from hoteling ships by 70% (California EPA, 2007).

Similarly, the Low-Sulfur Marine Diesel Rule is expected to cost around $3,200 per ton of NO_x and SO_x per year (U.S. EPA Office of Transportation and Air Quality, 2009a). Full implementation of the shore power regulation is estimated to cost between $5,500 and $16,000 per ton of container ship NO_x reduced (California EPA, 2007). The incremental costs of emissions reductions can become progressively expensive with successive regulations.

Cumulative Costs

California generally does a good job of assessing the costs of compliance and cost-effectiveness of individual regulations prior to implementation. However, assessments are undertaken on a regulation-by-regulation basis, while the cumulative impact on carriers and shippers is not assessed. For example, the cost to comply with the North American ECA is estimated at $18 per TEU; the cost of the Low-Sulfur Marine Fuel Regulations is estimated at $6 per TEU; and the Port of Los Angeles/Port of Long Beach Traffic Mitigation Fee is $61.50 per TEU. Though individually each fee is a small proportion of the overall cost of a trans-Pacific voyage, collectively they represent a much more significant portion and are not exhaustive. The cost of equipping a ship with shore power technology—estimated at $1.5 million per vessel, the Alameda Rail Corridor surcharge of $18 per loaded TEU, and the capital costs for regulatory compliance such as the heavy-duty vehicle GHG emission reduction regulation also impact total cumulative costs. Combined, these costs can result in simultaneous financial, technical, and administrative compliance impacts on the private sector. The private sector has felt these impacts more acutely since 2008 with revenues already down due to the global economic recession. A regulatory approach that assesses the cumulative regulatory costs facing the private sector would go some way toward enabling a better understanding of the full costs of regulation.

CHAPTER 7

Suggestions for Policymakers

This chapter offers suggestions to public policymakers as they consider how best to integrate air quality and climate change considerations into the nation's supply chains. The research team developed these suggestions with the help of interviews of public agencies, shippers, carriers, and others, and from an extensive literature review. In summary, nine points are most significant in achieving effective results that balance environmental, societal, and economic needs.

7.1 Consult Closely with Stakeholders to Craft Win-Win Solutions

Public agencies (including ports) can best accomplish intended policy goals by consulting and collaborating closely with stakeholders, including the shippers and carriers who will carry out the desired actions and improvements to reduce air emissions. Generally, these private-sector actors operating U.S. supply chains are sensitive to climate change and air quality concerns. Large companies, in particular, are knowledgeable about what can and cannot be readily achieved and are taking steps to reduce emissions where this makes sense for their businesses. They also are able to provide a business and operational perspective on policy development, investment decisions, and regulatory mechanisms that is essential in ensuring win-win outcomes. Experience shows that consulting these players is an important prerequisite to developing, and implementing, effective solutions. Rather than one-off consultations, the creation of a culture of consultation and cooperation is essential to engendering trust and furthering mutual understanding of supply chain sustainability issues. In the best of cases, win-win opportunities can be developed through joint discussion, sharing of perspectives, and assessing options. Such solutions result in the optimization of benefits for everyone.

The research has shown that policy, regulation, and conformance evolving from private-sector engagement typically results in a more balanced approach to sustainability. Proactive outreach and engagement of the private sector should thus begin early at the freight planning stage, continue with decision making relating to infrastructure funding, and be maintained in developing regulations. This should encompass a range of engagement methods and forums to encourage active involvement of the full range of private-sector stakeholders. Evidence from case studies indicates that significant economic and environmental benefits are derived from concerted efforts to involve industry in the planning and regulatory processes. A compelling example of the value of such an approach is found in the Port of Los Angeles PierPASS Program, which was developed in close collaboration with marine terminal operators (MTOs). This effort, which included paying a traffic mitigation fee to offset terminal operator costs, proved far more successful at reducing trucking emissions than the earlier Port Gate Appointment System, which was conceived with limited inputs from private industry and proved ill-suited to operations. In another example, California's tractor-trailer regulations involving low-rolling resistance tires were significantly improved by allowing SmartWay retreads as a result of inputs received from a working group of private-sector players. This enabled reduced private-sector costs, as well as environmental benefits from emissions reductions and fewer tires sent to landfills. For the private sector, engagement in this statewide initiative has resulted in changes to SmartWay policy at the national level, thereby extending benefits widely.

The federal transportation bill, Moving Ahead for Progress in the 21st Century (MAP-21), sets out a greater role for freight than did previous bills. In addition to requirements for national freight policy and state freight plans, MAP-21 also specifically directs the U.S.DOT to encourage states to establish freight advisory committees. Such committees are to be formed of public- and private-sector freight stakeholders and include representatives of ports, shippers, carriers, freight-related associations, freight industry workforce, state DOTs,

and state and local governments. Their purpose is to advise on freight issues, projects, and funding needs; provide a forum for discussion of decisions affecting freight mobility; promote the sharing of information; and participate in the development of the state freight plan. Similar public-private consultative freight forums have been successfully established in states such as California, Colorado, Washington, and Oregon. Such forums also could provide a platform for a discussion of options for reducing freight emissions and for regulatory decision making in this regard.

At the metropolitan level, regions such as Kansas City and Chicago have set up freight forums that allow for collaboration and sharing of information as part of the freight planning process. In Chicago, this took the form of the Intermodal Advisory Task Force, formed for the purposes of providing inputs into the Chicago Area Transportation Study. In Kansas City, the Mid-America Regional Council set up a Goods Movement Committee as part of the Transportation 2040 process. The committee continues to meet on a regular basis (at least quarterly) to review freight data and corridor analyses. The Goods Movement Committee also provides a forum for MARC to engage the private sector in taking a proactive stance by joining the dialog on regional air quality standards, measurement, and regulation, as well as taking voluntary action to maintain air quality in support of the region's Clean Air Action Plan.

Research has shown that a basic problem for public planners is their ability to attract and sustain private-sector engagement (Rawling, 2005; FHWA, 2010a; supported by pers. comm. with MPOs). This is partly because of the differences in expectations, operating styles, and timelines between public and private sectors, which may lead to reluctance on the part of business leaders to engage in public-sector processes. The private sector has a stronger incentive to participate in such forums where they have the opportunity to contribute their perspectives on policy, infrastructure investment, and regulatory changes. Nevertheless, medium-sized MPOs especially may find that they lack the ability to ensure sustained industry engagement efforts. Strong institutions are required on both sides for effective engagement to occur.

The approach adopted in Chicago is instructional. The public agency worked with business representatives as a team of experts, as opposed to occasional consultees to the freight planning process (Rawling, 2005). This can create a dynamic whereby the private sector may be more interested in sharing its knowledge and experience. Building on this approach, private-sector participation in freight decision making might take the form of a Board of Directors appointment. The option of paying participants (or their companies) for their time could be explored. The offer of payment infers a two-way transaction and may be likely to elicit an obligation on the part of the private sector to engage in freight policy planning, regulation, and decision-making processes. Private-sector inputs may thus be procured in much the same way as are consulting services. In practice, DOT or EPA will likely have to agree, but given the importance of private-sector input to the freight planning and environmental regulation process, this may be considered an acceptable and efficient use of public funds, and may support more engaged commitment to the process on the part of the public sector.

7.2 Analyze Trade-Offs and Options

Policymakers at local, regional, and state levels need to carefully analyze the trade-offs involved in setting air emissions requirements for supply chain operations. In particular, local impacts of air emissions should be weighed against global GHG impacts. Costs for shippers, carriers, and consumers should be weighed against environmental and health benefits.

Both federal and state regulators have developed detailed methods to conduct such analyses. Examples are the regulatory impact assessments (RIAs) required by the federal government in support of proposed regulations. RIAs used by EPA to assess impacts of environmental regulations have generally been found to be both accurate and beneficial (e.g., in terms of reducing cost or enabling the net economic benefits of the Clean Air Act amendments to be realized) (Hahn and Tetlock, 2008; Morgenstern, 2011). At the state level, California will require RIAs as of November 1, 2013, as part of the Initial Statement of Reasons for any regulation that will have an impact of more than $50 million on California businesses or individuals. Assembly Bill 1504, introduced in January 2012, would reduce this threshold to $25 million and introduce several other requirements as well, including an analysis of alternative means to achieve the statutory purpose. Such assessments are required to consider impacts on new businesses; business competitiveness; investment in the state; innovation; and the health, safety, and welfare of residents. Both the federal and California RIA processes include opportunities for public comments and inputs.

One consideration that seems to be missing from the Californian RIA approach to date has been that it considers the impacts of each regulatory measure in isolation and does not consider the cumulative impacts of various layers of regulation on the private sector. Further, CARB typically considers only the costs or impacts of regulations within its own jurisdiction (California) and not in other states.

States considering adopting California air emissions standards as an alternative to EPA standards, or those considering adopting regulations to curb air emissions from freight transportation sources, should consider undertaking a full impact assessment that takes into account costs and benefits of regulation in their own jurisdictions and other states, as

well as considering the combined effects of various regulatory measures on the private sector. Those states considering adopting California standards should pay attention to the economic impacts of regulation. Although the research found no evidence of loss of business as a consequence of recent air emissions regulations in California, this is likely a result of this state's favorable position in respect to freight flows. The risk of freight diversion (with potential economic and air emissions costs) may be higher in other locations.

7.3 Coordinate Across Jurisdictions

Supply chains and freight transportation are activities that, by their nature, are likely to cross multiple jurisdictions. Ocean transport, for instance, typically involves long intercontinental hauls of containerized freight. The operators of ocean-going vessels are required to navigate numerous international, national, and local regulations. In the case of road and rail modes in the United States, freight is often moved across state lines. To the extent possible, state and local agencies seeking to address air pollution or GHG emissions should coordinate with national and international bodies to ensure consistent approaches and regulations that facilitate efficient operation of global or national freight networks. Well-established organizations, such as the International Maritime Organization for international shipping or EPA and DOT at the federal level, can serve as valuable guides for state and local agencies.

Supply chain efficiency issues can arise where there are differences in the air emissions standards and the regulations applied between geographies. Dual standards or regulations can, for example, complicate equipment design, thus increasing manufacturer costs and risks, and may cause difficulties for global and national carriers. Consistent approaches, on the other hand, benefit industry and consumers by streamlining administrative requirements, allowing optimal supply chain operations, keeping costs down, and maintaining certainty.

Nevertheless, regional differences in air quality, as well as impacts on public health and the environment, imply that uniform national emissions standards and regulations may be economically inefficient in low-pollution areas and potentially ineffective for meeting NAAQS in regions that face extreme air quality problems. Under the Clean Air Act, states wishing to adopt standards that are more stringent than the EPA's requirements have the option to adopt California emission standards. In doing so, such states are obliged to adopt standards identical to those in California. Based on the research team's analysis and previous studies (National Research Council, 2006), states with limited specialist air emissions resources may benefit from additional guidance during their regulatory decision-making process. For example, states contemplating adoption of the higher California air emission standards might need assistance in addressing their technological feasibility, costs, and usefulness in attaining air quality goals, as well as potential impacts. One option might be for EPA to provide this guidance. Either by formally issuing guidelines, in the role as a mandatory consultee on rulemaking, EPA might be granted the authority to review, advise on, and, even deny state adoption decisions in respect of emissions standards, if necessary (National Research Council, 2006). These changes could help avoid unintended consequences and contribute to ensuring a balance between the benefits of additional emissions reductions and costs to industry and consumers.

Corridor-based approaches to freight transportation planning and air emissions management can provide an effective way of planning, financing, and regulating freight movement. The cross-jurisdictional cooperation required under a corridor-based approach can contribute to ensuring that the necessary funds are directed to large-scale projects and better distribute economic, community, and environmental benefits and costs. This concept is being advanced by the EU, which promoted the Green (Freight) Corridors concept through their *Freight Transport Logistics Action Plan* (2007) aimed at integrated, efficient, and environmentally friendly freight transportation. Specifically, the focus along these Green Corridors, which are marked by a concentration of freight traffic between major hubs, is on co-modality and advanced technology to accommodate rising traffic volumes, as well as environmental sustainability and energy efficiency. They are characterized by the development of the necessary trans-shipment facilities at strategic locations, advanced Intelligent Transport Systems (ITS) applications, and supply points for alternative fuels and other forms of green propulsion.

The corridor-based approach is broadly supported by MAP-21, which requires the DOT to establish a national freight network to assist states in strategically directing their resources. However, the focus is on highways rather than on co-modality. Nevertheless, MAP-21 also calls for a national freight strategic plan, which will identify major trade gateways and national freight corridors; set out best practices for mitigating the impacts of freight movement on communities; and provide a process for addressing multistate projects and strategies to improve freight intermodal connectivity.

7.4 Develop Supply Chain Sustainability Metrics

Agreed-upon metrics for supply chain sustainability are lacking. This is an area that cries out for an effective public-private resolution. Developing a definition of supply chain sustainability that is shared by both public and private-sector agencies, and agreements as to how this should be measured would go a long way toward enabling concerted and joint

efforts by the public and private sectors to act on shared objectives. The research has made a start by developing a working definition of supply chain sustainability, based on consultation with public and private stakeholders. The research team also developed a supply chain metrics map and a table of potential measures (see Appendix F).

SmartWay is the most widely recognized U.S. supply chain sustainability success story of public- and private-sector collaboration. The program is already extending its international and modal reach. The research team suggests that SmartWay (or an equivalent program) could be an appropriate vehicle to tackle the broader issues of supply chain sustainability and measurement on a public-private collaborative basis. Nevertheless, this would be contingent on an appropriate level of funding to support such an initiative. Further, issues to be addressed include the following:

- The extent of SmartWay's jurisdiction and remit, especially given that international companies are reluctant to submit data to a part of the EPA;
- The need to broaden SmartWay's expertise to include international ocean-going vessel operations; and
- The requirement for data verification and consistency in the units used for measurement.

7.5 Adopt Performance-Based Approach to Regulation

Performance-based approaches are generally technology-neutral and set an upper limit for emissions from a given source. Performance-based standards and regulations reduce rigidity and redundancy as well as offering more scope for innovation, compared with prescriptive requirements that stipulate a single technology or solution (e.g., prescribing the use of cold-ironing technologies or low-rolling resistance tires).

Examples of the use of performance-based approaches include performance-based mobile-source emissions standards developed by EPA and CARB. In California, these standards have typically been "technology forcing" (*technology forcing* refers to a regulatory agency's requirement for achieving an emissions level within a specified timeframe, using unspecified technologies that have been shown to be feasible on an experimental or pilot-demonstration basis, but are not yet widely available commercially). As such, these standards have driven advances in technology development, resulting in California becoming a "laboratory" for emissions-reduction innovations. CARB's regulatory process is supportive of this laboratory role, allowing California's standards to be amended rapidly in the face of changing market and technological conditions.

EPA and the NHTSA's recently introduced fuel economy standards for heavy-duty on-road vehicles provide a further example of performance-based standards. These standards, which are vehicle-based and not just engine-based, are set according to the unit of work performed (gallon or ton-mile, and CO_2 emissions per ton-mile). This leaves manufacturers various options to combine the most appropriate and cost-effective GHG emission reduction methods in product development and to select from among different technologies, components, and strategies. Other flexibilities widely supported by stakeholders include meeting the standards on the basis of fleet averaging, banking or trading of emission credits, providing allowances for making GHG-reducing improvements to vehicles or for innovative technologies to reduce GHG emissions, incentives for advanced technology vehicles, or optional standards for companies selling smaller volumes of vehicles.

An essential task for regulatory agencies using performance standards in air quality nonattainment areas is to test these standards to ensure that the desired emissions reductions are possible. Performance-based outcomes can then be established, rather than prescribing technologies or operating procedures. This approach allows private-sector innovation to flourish and leaves business to meet these standards as it sees fit.

7.6 Provide Incentives to Change

Grants, tax credits, and funding for pilot projects are all effective methods by which the public sector can shift shipper and carrier behavior. Results typically include achieving desired emissions reductions ahead of (or even exceeding) regulatory requirements. There are a number of successful examples of such incentive programs overseen by ports as well as at the state or metropolitan government.

At the state level, California created a billion-dollar Proposition 1B Goods Movement Emission Reduction Program aimed at reducing emissions and health risks from freight operations in priority trade corridors. Under this program, CARB makes grants available to local agencies (e.g., seaports and air districts) for specific types of projects like truck programs, ships at berth, cargo-handling equipment, locomotives, and harbor craft. Local agencies then offer grants via a competitive process to diesel equipment owners to co-fund the upgrade of their equipment to cleaner technologies ahead of regulation. Matching funds are attracted from private, local, and federal sources. It is anticipated that 2,500 tons of PM and 62,000 tons of NO_x will be avoided over the life of the grants (CARB, 2011:2).

At the metropolitan level, similar approaches have been successfully employed as follows:

- The Texas Emissions Reduction Plan (TERP) committed $20 million to reduce locomotive emissions in the Houston-Galveston area, which suffers from the most severe locomotive emissions and the highest ozone levels in the state. TERP

funds projects in nonattainment areas for purchasing new locomotives, replacing old engines, and retro-fitting or adding emission-control technology. New locomotives are required to emit 25% less NO_x than the engine replaced or 25% less than the federal standard (if new). These projects are expected to reduce NO_x emissions by more than 3,300 tons (Scott, 2006).
- The Chicago Region Environmental and Transportation Efficiency Program (CREATE) provides $1.5 billion in funding for some 71 projects, including road and rail overpasses and underpasses; roadway overpasses and underpasses; viaduct improvements; grade crossing safety enhancements; and upgrades to tracks, switches, and signal systems. Once completed, CREATE is expected to save more than 7.4 million tons of NO_x emissions and more than 50 tons of PM emissions per year, as well as to provide congestion relief, reduce delay for freight and passengers, and offer safety benefits (CREATE, 2012).

Incentives can play a significant role in enabling or accelerating regulatory compliance. This is especially true for CAP-reduction initiatives for which public benefits may not align as directly with shipper or carrier benefits as they do in the case of GHGs. Ideally, such incentive programs should yield a benefit-cost ratio of one or higher in order to be an efficient use of resources.

7.7 Push the Boundaries of Technology

Regulatory agencies bear a responsibility to conduct sufficient analysis to assure that proposed criteria can be met with the available technology. If the standards are of a technology forcing type, then it is essential to allow sufficient time for an appropriate technology to be commercialized. Regulations calling for unattainable technical performance are counterproductive and frustrating to responsible industry participants. Here again, local agencies can benefit from consulting with experienced federal, state, and international regulatory bodies and, of course, from the public-private consultative process advocated earlier in this chapter.

Public agencies also can play a central role in pushing the frontiers of new technology. For example, California's South Coast Air Quality Management District (SCAQMD) Technology Advancement Office engages in cooperative partnerships with public and private organizations (industry, academic and research institutions, technology developers, and government agencies) to co-sponsor projects intended to demonstrate best practices in the use of clean fuels and technologies that lower or eliminate emissions. SCAQMD staff recently submitted an application for a $19-million federal grant to co-fund a demonstration project for zero-emission container transport between the San Pedro ports and the Intermodal Container Transfer Facility, 5 miles away. The technology will include hybrid-electric trucks with all-electric range and wayside power to recharge and power such vehicles on the route. The Zero-Emission Truck Initiative is intended to catalyze the development and deployment of zero-emission trucks in Los Angeles County. It is being developed in conjunction with the Ports of Long Beach and Los Angeles (LA), Caltrans, Southern California Association of Governments, Gateway Cities Council of Governments, and LA Metro, and is being undertaken with the cooperation of Siemens (technology provider) (SCAQMD staff, 2012, pers. comm., May 11).

Public agencies in California recognize that the extent of the freight air emissions challenge is such that a zero-emissions approach is required if they are to address pressing air quality challenges, drive down GHG emissions, and accommodate economic growth. Thus, agencies are taking an inspirational step—examining the potential for zero-emissions freight corridors. For example, the Southern California Area Governments Regional Transportation Plan includes a proposal for truck-only lanes from the San Pedro Bay ports to downtown Los Angeles along Interstate (I)-710; and a new east-west freight "truck-only" corridor near State Route 60 (SR 60), connecting I-710 with I-15 in San Bernardino, allowing for use of zero-emission truck technology as these technologies evolve. Note that the terminology used is "zero and near-zero" emissions, with a conscious decision not to specify a particular technology. A clear message from industry is to maintain an open mind with respect to the type of technology to be adopted, while setting a standard for zero emissions. Working toward a zero-emission freight rail system is also a defined regional priority in the plan. Similar approaches are being adopted in Europe (e.g., as part of the EU Super Green Initiative).

Envisioning and enabling a zero-emissions future is critical because it allows for growth in freight transportation without associated air quality, health, and climate change problems. It also allows the "either-or" approach to CAP versus GHG emissions reduction to be overcome. Planning for a zero-emissions future allows for technology assessment and testing to get underway at this early stage. This long-term approach ensures that future opportunities for zero-emissions technologies are built into current infrastructure plans.

7.8 Redefine Operational Optimization in Metropolitan Areas

The research revealed various ways in which the private sector is optimizing operations with air emissions benefits. In urban areas, CAP emissions are of particular concern. Technologies to promote fuel efficiency and reduce GHG

emissions tend to be less effective under urban operating conditions. These operating environments can have a significant impact on freight emissions including factors such as the necessity of serving customers at congested times of day, the quality and congestion of delivery routes, and even the time it takes to park a vehicle or gain access to a shipper's freight dock. Although the research has shown that shippers and carriers do a good job of optimizing their operations, a generally unanswered question is whether a higher level of optimization could be achieved by reducing the constraints of the urban operating environment. This is important because urban areas are where air emissions outcomes (most notably, health impacts) are felt most keenly. Put differently, how much sustainability potential is lost because of less-than-optimal infrastructure and facilities, municipal restrictions, and commercial practices in urban areas?

The research also revealed examples of how successful approaches to supply chain sustainability have been formulated. For example, the sustainability successes of some ports have been made possible in part by the ability of port authorities themselves to realize operationally practical changes, as well as their influence over service providers (MTOs, marine carriers, drayage operators, and railroads) and the port environment itself. The ability of Chicago's CREATE Project to generate sustainability benefits from changes in the rail network and its function echoes these success factors—the Class I railroads, working with the public sector, were able to invest in improving the system with operational and environmental benefits. Is there a way to reproduce these success factors in the far more fragmented world of motor carriage, and to do so in metropolitan regions, which are the operating environments presenting the greatest challenge to logistics sustainability? More specifically, could the operational skills and experience of large companies be brought to bear to address the sustainability constraints of the urban environment, redefine the limits, and give rise to a new class of "optimum"?

Suggested candidates to step into a leadership role are the large private truck fleets of major supply chain companies (e.g., those run by Wal-Mart, Coca-Cola, or Frito-Lay) and leading parcel and motor carriers such as UPS, Federal Express (FedEx), and Con-way. Freight-related air emissions fall within the GHG Protocol Scope 1 emissions for shippers and national carriers, and their sustainability initiatives tend to be already well advanced. They have the capacity, as well as the inclination, to further demonstrate their sustainability credentials. A partnership of such companies, together with leading less-than-truck-load carriers, acting jointly with public agencies in a few major cities, could identify and drive new practices that would raise the operating productivity of the metropolitan environment and yield benefits in terms of environmental sustainability. Working together with public agencies, such partnerships might identify infrastructure and operational improvements specific to the urban operating context. For example, an optimized operating environment could feature responsive parking reservations, modernized building access, truck routes designated for accommodation instead of restriction and managed from traffic operations centers, left-turn bays, information technology to improve driving decisions and dispatch planning, and e-commerce delivery planning for urban neighborhoods. The requirement for public support would be sustainability gains, while the motivation for the fleets would be cost and service efficiency. Much of that efficiency would be within reach of other, smaller fleets and independent operators, thus enlarging the public benefit, while the methods and approaches devised could be promoted and duplicated in other cities in which the partnership companies are active, thus increasing the value to the partners.

The logic in establishing these "urban fleet forums" would be to create an organizing entity to tackle the questions faced by hundreds of motor carriers operating in urban areas. Private fleets and carriers with a national reach are considered ideal candidates because they tend to be at the forefront of sustainable freight practices and have an in-depth knowledge of operational issues. Their publicly stated commitment to sustainability would make them strong candidates to take a leadership role. Such forums might be facilitated by the MPOs or could be industry initiated, but under either approach, experience from our case studies of ports suggests these forums should be led by industry.

7.9 Promote Sustainability Branding

Companies are using green programs to differentiate themselves, both with product consumers and corporate clients. In consumer goods, examples include shippers such as Wal-Mart, Nike, and Stonyfield Farm. Parcel carriers, including FedEx and UPS, have taken major steps to position themselves as green operators. Companies serving corporate customers—such as Staples, Maersk, and Con-way—have also promoted their supply chain sustainability practices to enhance their commercial appeal. Although industry participants report that consumers are not yet necessarily ready to spend more for superior environmental performance across the supply chain, great strides are nonetheless being made.

The SmartWay Program is considered an outstanding success by public- and private-sector observers, including many shippers and carriers the research team interviewed. The question is, "What else can the federal (or state) government do to further promote sustainable brands for shippers and carriers?" SmartWay has been extended to railroads, for instance. What about parcel carriage or other modes of transportation? Could the government (or international agencies) work out an agreed method to track environmentally and socially

responsible behavior across the entire supply chain of a product, in collaboration with shippers and carriers? This is what the outdoor apparel industry is doing for a particular industry segment.

The success of SmartWay suggests there may be other opportunities where a joint public-private approach could be valuable in promoting sustainable supply chains. The attraction of brand recognition for leading-edge supply chain practices forms a strong motivation for operators to embrace environmentally friendly approaches. If not, overly simplistic (e.g., food miles) and potentially misleading efforts may arise that detract from the even playing field and optimal balancing of environmental, social, and economic benefits.

7.10 Conclusions

The alignment between operating cost reduction (via fuel efficiency measures) and GHG emissions reduction is so direct that the private sector (shippers and especially carriers) is strongly motivated by their own financial interests to reduce emissions.

Regulators need to be sure they do not impede the adoption of new technology or practices by issuing directives that "freeze" the solution without allowing flexibility for alternative solutions as they become available.

Regulators can be helpful by coordinating across jurisdictional lines, given that supply chains necessarily cross these boundaries, and GHG emissions have global impacts. Uniform requirements help assure a level playing field and achieve maximum benefits with the fewest potential distortions of economic activity.

While the reality and anticipation of regulations is a factor with shippers and carriers, the research team's interviews show that private players are at least as motivated by consumer and competitive forces, and even by a desire to "do the right thing," as they are by regulation.

The issue is more pronounced with CAP emissions. This is because of the local nature of the impact. Transportation nodes (e.g., seaports, railyards, and intermodal facilities) are the locations where CAP emissions effects are greatest. At these locations, there will be potential conflict of objectives, between private parties (shippers, carriers, facility operators) and the local communities impacted, as represented by state and local air quality agencies and others. It is these situations that are the most challenging to resolve in a balanced fashion.

Close collaboration at all stages of planning, investment, and public rulemaking is the best approach. This entails ongoing consultation with the private sector and effective coordination across public-sector jurisdictions and agencies.

Port authorities across the country provide very effective examples of this type of public-private and cross public-sector collaboration. Local agencies faced with such issues can draw valuable lessons from the case examples cited in this research.

Similarly, the research team suggests that a broad public-private initiative be launched to address urban freight sustainability at a national level. This effort could draw from the success of SmartWay, as well as regional initiatives (e.g., Kansas City SmartPort and CREATE in Chicago). The goal would be to establish a common nationwide approach to dealing with the problem of GHG and CAP emissions, and of congestion, linked to freight transport concentrations in or near urban areas. A coherent and uniform strategy across the country would yield benefits, both in terms of air pollution and congestion reduction, as well as improvements in supply chain efficiency.

Abbreviations

AAPA	Association of American Port Authority
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ARB	Air Resources Board
ATA	American Trucking Association
ATM	available ton-mile
Aviation ETS	Aviation Emissions Trading Scheme
BNSF	Burlington Northern Santa Fe Railway
BSR	Business for Social Responsibility
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CAP	criteria air pollutant (including ozone, nitrogen oxides, sulfur dioxide, and particulate matter)
CARB	California Air Resources Board
CASP	Clean Air Strategy Plan
CATS	Chicago Area Transportation Study
CCWG	Clean Cargo Working Group
CD	compact disc
CDOT	Chicago Department of Transportation
CDP	Carbon Disclosure Project
CE	Categorical Exclusion
CEO	chief operating officer
CEQA	California Environmental Quality Act
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COFS	corridor of freight significance
CR	corporate responsibility
CREATE	Chicago Region Environmental and Transportation Efficiency Program
CRT	Coalition for Responsible Transportation
CSCMP	Council of Supply Chain Management Professionals
CSS	Cascade Sierra Solutions
C-TIP	Cross-Town Improvement Project
DC	distribution center
DERA	Diesel Emissions Reduction Act

DETEC	Department of the Environment, Transport, Energy and Communications
DHEC	South Carolina Department of Health and Environmental Control
DOE	Department of Energy
DOT	Department of Transportation
EC	European Commission
ECA	Emissions Control Area
EDF	Environmental Defense Fund
EEDI	Energy Efficiency Design Index
EER	equivalent emissions reduction
EPA	Environmental Protection Agency
ESI	Environmental Shipping Index
ETS	Emissions Trading Scheme
EU	European Union
FAC	Freight Advisory Council
FedEx	Federal Express
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Association
FY	fiscal year
GAO	Government Accountability Office
GDP	gross domestic product
GFE	Green Freight Europe
GHG	greenhouse gas
GMAP	Goods Movement Action Plan
GRI	Global Reporting Initiative
HGB	Houston-Galveston-Brazoria
HVF	heavy vehicle fee
ICAO	International Civil Aviation Organization
IFTWG	Intermodal Freight Technology Working Group
IMO	International Maritime Organization
IMPACT	Internalisation Measures and Policies for all External Costs of Transport
ITS	intelligent transport systems
IWG	Integrating Work Group
KDOT	Kansas Department of Transportation
KPI	key performance indicator
LA	Los Angeles
LEED	Leader in Energy and Environmental Design
LLC	limited liability corporation
LNG	liquefied natural gas
LTL	less-than-truck-load
MAP-21	Moving Ahead for Progress in the 21st Century Act
MARC	Mid-America Regional Council
MARPOL	International Convention on the Prevention of Pollution from Ships
MGO	marine gas oil
MMT	million metric tons
MODOT	Missouri Department of Transportation
mpg	miles per gallon
mph	miles per hour
MPO	metropolitan planning organizations
MTO	marine terminal operator
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969

NG	natural gas
NGO	non-government organizations
NHTSA	National Highway Traffic Safety Administration
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NYK	Nippon Yusen Kaisha Line
NZU	New Zealand Units
O_3	ozone
OIA	Outdoor Industry Association
PHA	Port of Houston Authority
PHL	Pacific Harbor Line
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in aerodynamic diameter
POLA	Port of Los Angeles
POLB	Port of Long Beach
PRD	Pearl River Delta
RIA	regulatory impact assessment
ROADS	Route Optimization and Decision Support
ROI	return on investment
RTS	Regional Transport Strategy
SAC	Sustainable Apparel Coalition
SAR	Special Administrative Region
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SCSPA	South Carolina State Ports Authority
SEEMP	Ship Energy Efficient Management Plan
SIP	state implementation plan
SKU	stock keeping unit
SLC	California State Lands Commission
SO_2	sulfur dioxide
SO_x	sulfur oxides
SR	state route
Swift	Swift Transportation
TA	TravelCenters of America
TERP	Texas Emissions Reduction Plan
TEU	twenty-foot equivalent unit
TL	truck load
TMF	Traffic Mitigation Fee
TS&W	truck size and weight
U.K.	United Kingdom
U.S.	United States
UPS	United Parcel Service
VMT	vehicle miles traveled
VOC	volatile organic compound
WBCSD	World Business Council for Sustainable Development
WCI	World Climate Initiative
WSDOT	Washington State Department of Transportation
WWF	World Wildlife Fund

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APPENDIX A

International Case Studies

Introduction

This case study cluster explores international experience in managing freight transportation emissions.

A cap-and-trade initiative was previously proposed as a possible way to manage and reduce greenhouse gas (GHG) emissions in the United States. Although a proposed cap-and-trade initiative failed in Congress in 2010, Assembly Bill 32 mandates that the California Air Resources Board (CARB) develop regulations and market mechanisms to reduce California's GHG emissions (although this does not currently apply to transportation). In this appendix, the researchers consider the implementation and impacts of mandatory emissions trading in New Zealand and the extension of the European Union Emissions Trading Scheme (EU ETS) to aviation emissions in Europe. Although neither of these programs is aimed specifically at freight transportation, they both impact this sector and thus hold potential lessons for managing supply-chain GHG emissions.

These mandatory regulatory regimes are compared and contrasted with the voluntary private Fair Winds Charter Initiative aimed at reducing shipping emissions.

Mandatory Emissions Trading

Case Study: New Zealand Emissions Trading Scheme

Inception

Context. New Zealand's geographical isolation makes the country highly reliant on ocean and air freight. Freight transport has increased as the economy has grown. Between 1990 and 2006, total transport emissions increased by 5.6 million metric tons of carbon dioxide (CO_2), or by 64 percent (Ministry for the Environment, 2008a). New Zealand's emissions trading scheme (ETS) was introduced by the government in response to climate change.

Objective. As a signatory of the Kyoto Protocol, New Zealand was obliged to reduce its GHG emissions to 1990 levels in the first commitment period (2008 to 2012) or pay for the difference. The ETS was introduced in 2008 as a low-cost approach to creating market incentives that encourage consumers and businesses to change their behavior and reduce emissions.

Legislation. Legislation and regulations that support the ETS (Ministry for the Environment, 2011a) include the following:

- 2002 Climate Change Response Act: Ratified the Kyoto Protocol;
- 2008 Climate Change Response (Emissions Trading) Amendment Act: Introduced the ETS concept; and
- 2008 Climate Change (Liquid Fossil Fuels) Regulations: Define the liquid fossil fuels covered by the ETS, and the methods for participants to monitor and calculate the emissions that result from the use of those fuels.

Program Components

Participants. The ETS applies to specific sectors, including forestry; industrial processing; transport (which includes liquid fossil fuels used on land, sea, and in the air, as well as fuels used for non-transport purposes); synthetic gases; stationary energy (power generation); waste; and agriculture (Ministry for the Environment, 2007a). Mandatory reporting was phased for each sector between 2008 and 2013. The liquid fossil fuels sector joined in July 2011 (Ministry for the Environment, 2008b).

The ETS applies to liquid fossil fuel suppliers (e.g., fuel wholesalers) rather than emitters (e.g., road users). Consistent with the Kyoto Protocol, emissions from fuel used for international aviation and marine transport purposes are exempted from the ETS (Ministry for the Environment,

2011a). The ETS applies to CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, which are all of the GHGs specified in the Kyoto Protocol (Barrat, 2008).

Program Components. Credits in the form of New Zealand Units (NZUs), representing 1 ton of CO_2 equivalent (CO_2e), are issued by the Crown and can be traded in the market through the New Zealand Emissions Unit Register. Under the program, the aggregate *quantity* of net emissions is set (and is decreased over time), while the price of emission units is determined by the market (Ministry for the Environment, 2011b). The ETS operates within the cap on emissions established by the Kyoto Protocol during its first commitment period (2008–2012). There is no cap on emissions. However, domestic emissions that exceed New Zealand's allocation under the Kyoto Protocol are required to be matched by emission units bought internationally from within the Kyoto cap on emissions (Ministry for the Environment, 2008b).

Participants are required to monitor and report their own emissions. Each business is granted a GHG emissions allowance or permit, and is required to purchase a sufficient quantity of NZUs to cover any emissions in excess of their designated GHG allowance. Participants "pay" for each ton of CO_2 equivalent they emit by surrendering emission units to the government at year end (Ministry for the Environment, 2007a).

Businesses that require large amounts of energy to create their products or have significant emissions associated with industrial processes (e.g., steel producers) receive a free allocation of units (Ministry for the Environment, 2007a). These generous free allocations and the lack of a carbon price signal have led to criticism of the ETS and its effectiveness in reducing emissions. In contrast, the transportation industry/fuel suppliers do not receive a free allocation, so they may pass on any costs incurred to their customers; thereby, limiting the impact of the scheme on their profits (Ministry for the Environment, 2008a).

Transition Arrangements. The ETS was amended in 2009 to help moderate its impact during the worldwide economic downturn by including a transition phase from July 1, 2010, to December 31, 2012. During this phase, participants in the transport (liquid fossil fuels), energy, and industrial sectors were only required to surrender 1 unit for every 2 metric tons of emissions until 2013. Participants also have the option to buy NZUs from the government (instead of the market) for a fixed price of NZ$25 per NZU (Ministry for the Environment, 2011a).

Engagement Process

Engagement has been a key feature of the design and implementation of the New Zealand ETS. From December 2006 through March 2007, the government consulted broadly on design options for price-based measures to reduce GHG emissions in different sectors (Ministry for the Environment, 2007a). This consultation process included approximately 50 public or multi-sector meetings, workshops, and meetings with Aboriginal groups, and approximately 100 focused stakeholder meetings. The consultation events took place throughout the country, with over 4,000 people attending. Over 3,000 written submissions were received (Ministry for the Environment, 2007a).

A key reason for selecting an emissions trading scheme over other strategies (e.g., emissions tax) to manage GHGs was the wide stakeholder support received. Further, an emissions trading scheme was considered favorable for the following reasons (Ministry for the Environment, 2007a):

- Provides businesses with greater flexibility for managing GHG obligations;
- Provides the government with relative certainty about the volume of emissions, and hence the environmental objectives, whereas a tax simply adds a price on each unit of emissions and does not limit emissions per se; and
- Allows for automatic adjustment to the international price of emissions.

Following this initial consultation, the government undertook an extensive engagement process with stakeholders and Aboriginal groups to develop and refine the ETS. The public engagement process consisted of the following four key stages (Ministry for the Environment, 2007b):

- **Stage 1:** In-principle decisions on ETS core design features (2007);
- **Stage 2:** Engagement and final decisions on core design, as well as detailed design features and implementation for forestry and liquid fossil fuels (primarily transport) sectors (2007/2008);
- **Stage 3:** Parliamentary select committee process and passage of core legislation by Parliament (2008); and
- **Stage 4:** Engagement and final decisions on detailed design of the ETS and implementation process (2008–2012), involving ongoing engagement with major stakeholders and Aboriginal groups on program decisions, regulation, and implementation.

Engagement activities varied and included the following (Ministry for the Environment, 2007b):

- Cross-sector emissions trading workshops;
- Several regional Aboriginal *hui* (meetings);
- Workshops with the private sector;
- A nongovernmental organization forum;

- Numerous one-on-one meetings with key stakeholders;
- Written submissions received by the government from various stakeholders; and
- Establishment of a Climate Change Leadership Forum to facilitate communication with the broader community on the proposed design of the ETS, including senior representatives of sectors and firms subject to the ETS, community and nongovernmental organization representatives, academics, and the chief executives of the government departments responsible for advising on the ETS.

In 2011, an independent panel reviewed the ETS to consider how the scheme should evolve past the first Kyoto commitment period. The panel consulted widely and received more than 150 submissions from the public, which provided input into a set of recommendations to the government for amendment of the ETS (Ministry for the Environment, 2012). Key amendments potentially affecting the freight/liquid fossil fuels sector involve extending the one-for-two reporting and fixed price options in the transition phase to 2015. Following the 2011 panel review, the government engaged the public for feedback on the proposed set of amendments to the ETS through a call for submission of comments.

Cross-Jurisdictional Consistency

Although the principal unit of trade under the scheme is the NZU, international carbon emission units also can be traded and surrendered. Allowing international trading means scheme participants can quickly buy or sell emission units without causing a significant movement in their price (Ministry for the Environment, 2008b). It also means the price of units tracks the international price of emissions. This allows New Zealand businesses with limited low-cost ways of reducing their own emissions to fulfill the country's emissions trading scheme obligation by buying emission reductions from overseas (Ministry for the Environment, 2008b).

At present, the only other existing mandatory regional ETS is the EU ETS. Certain differences in the design between the EU and New Zealand schemes are likely to make direct bilateral linking challenging in the short term (Ministry for the Environment, 2008b).

Australia introduced its Carbon Pollution Reduction Scheme in July 2011—an ETS designed to commence with a 1-year period in which the carbon price was set at New Zealand $10/metric ton CO_2e (Ministry for the Environment, 2011b). The New Zealand government is working with Australia on harmonizing New Zealand's ETS with the Australian scheme. One impediment to linking the two schemes, however, is that Australia is not a party to the Kyoto Protocol. This means that trade would not be in Kyoto units, which would have increased New Zealand's Kyoto liability if linking had occurred in the first commitment period (Ministry for the Environment, 2007a).

Impacts on Freight

The Ministry for the Environment estimated that during the transitional phase, the ETS would add $0.031 per liter to the cost of gasoline and $0.033 per liter to the cost of diesel (Ministry for the Environment, 2010). Analysis of liquid fossil fuel prices by Covec (2011) identified a statistically significant impact of the ETS, suggesting an impact of approximately $0.04 per liter to the price of diesel and petrol—$0.01 higher than the Ministry for the Environment's initial estimate. Domestic freight operators do not participate directly in the ETS but will face these additional costs as a consumer of liquid fossil fuels (Ministry of Transport, 2011). Although this cost increase may seem small, the aggregate effects to the supply chain can be significant (Ministry of Transport, 2012).

Analysis by the Ministry of Transport found that the additional operation cost to heavy vehicles due to the ETS is approximately $0.98 per 100 km for road freight transport (Ministry of Transport, 2012). The average net tonnage per vehicle is 7.4 metric tons, thus the ETS adds around $1.32 per 1,000 net metric ton-kilometers to vehicle operating costs (Ministry of Transport, 2012). These estimates are based on fuel consumption information collected during 2006. If the heavy vehicle fleet has gradually been replaced by more fuel-efficient vehicles since then, the effects of the ETS would be lower than those illustrated above.

In 2009, over 16,500 million metric ton-kilometers of road freight was moved in New Zealand. The ETS therefore adds $22 million per annum to road freight costs for a similar level of cargo movements as in 2009 (Ministry of Transport, 2012). The Ministry of Transport estimates that the ETS will add approximately $0.45 per 1000 ton-kilometers to the cost of rail freight (New Zealand Productivity Commission, 2012).

Additionally, many transport operators working in the forestry industry are already feeling a slowdown as a result of the forestry industry adopting the scheme since 2008. The scheme makes it more costly to fell trees and therefore creates a decreased demand for transport services on behalf of the forestry industry (Barrat, 2008).

Outcomes

Following the introduction of the ETS, New Zealand is on its way to meeting its Kyoto obligation, with net emissions dropping significantly from approximately 70 million metric tons CO_2e to below 55 million metric tons CO_2e between 2007 and 2009 (Ministry for the Environment, 2011a).

Within the first reporting period of the ETS (1 July to 31 December 2010), approximately 8 million metric tons of CO_2e

emissions were reported and 4 million NZUs (i.e., 4 million metric tons CO_2e) were surrendered by the transport sector—18 percent more than was initially projected (Ministry for the Environment, 2011a). This constitutes almost half of the emission unit surrenders from all participant sectors within the ETS for the 2010 calendar year (Ministry for the Environment, 2011a). A total of 16.3 million metric tons were reported and a total of 8.1 million metric tons were surrendered (Ministry for the Environment, 2011a).

Summary

1. Following introduction of the New Zealand ETS, a 21 percent reduction in overall GHG emissions was achieved between 2007 and 2009. The transport sector surrendered more than 18 percent more NZUs than was originally projected during the first reporting period in 2010, indicating the program's success in reducing emissions.
2. The regulation affects all domestic freight transportation. However, the scheme applies to fossil fuel suppliers rather than emitters thus reducing potential complex compliance requirements for carriers, many of whom have limited capacity.
3. The main impact on domestic carriers is increased fuel prices (which are estimated to increase by $1.32 per 1,000 metric ton-kilometers). The aggregate effect across the supply chain is considered to be significant. These price increases affect all carriers, and can be passed on to shippers and ultimately to consumers. Such price increases can encourage more efficient truck fleets and driver behavior. Further, because the relative fuel price increases to the rail freight sector are just 34 percent of that of road freight, this may have the effect of promoting a shift to rail.
4. Part of the success of the New Zealand ETS is due to the intense and ongoing consultation process prior to, during, and subsequent to the implementation of the ETS. The ETS was supported by stakeholders above other strategies because it provides businesses with greater flexibility in managing GHG emissions, offers government greater certainty about the quantity of emissions to be reduced, and allows for adjustments to the international price of emissions.
5. In addition to the consistency in the application of the ETS within New Zealand, the scheme also is consistent with international trading platforms, ensuring that NZUs can be internationally traded with other types of emissions units. This means that the price of NZUs tracks the international price, allowing emission units to be traded without causing a significant movement in their local price. This permits businesses that may have limited low-cost ways of reducing their own emissions, to fulfill their obligations by buying emission reductions from outside of the country.
6. The ETS regime has been implemented in a flexible manner that ensures a degree of responsiveness to economic conditions (although this has been criticized by the environmental lobby). For example, amendments introduced in 2009 as a result of the worldwide economic downturn allow for a transition phase between 2010 and 2012. This offers respite to participants in the transport (liquid fossil fuels) sector who are only required to surrender half the required emissions units. Participants also have the option to buy NZUs from the government (instead of the market) for a fixed price, thereby mitigating adverse business impacts during this period.

Case Study: EU Aviation Emissions Trading Scheme

Inception

Introduction. The International Air Transport Association developed joint industry targets for the reduction of carbon emissions, which have been endorsed by Air Transport Action Group. These voluntary targets include an average annual fuel efficiency improvement of 1.5 percent to 2020, with carbon-neutral growth beyond 2020. The International Air Transport Association also has set an ambitious goal for the industry to decrease 2005 net carbon dioxide emission levels by 50 percent before 2050. These targets are supported by the International Air Cargo Association.

However, these voluntary targets and aspirations have been insufficient for the EU, which extended the EU ETS to cover carbon emissions from aviation in 2009.

Objective. The stated goal of the EU ETS is to reduce total carbon emissions by 20 percent by 2020. The scheme works by capping emissions from the aviation sector. If aviation emissions increase beyond this cap, aircraft operators are required to purchase allowances from other sectors participating in the EU ETS scheme. In 2010, aircraft operators began 2 years of mandatory pre-compliance reporting, with emissions trading beginning in January 2012. Aircraft operators are required to account for their CO_2 emissions, surrendering emissions allowances to the regulatory authority each year, equivalent to the amount of carbon-equivalent emitted. All flights arriving and departing from European airports are covered by the scheme with some exceptions (e.g., military aircraft and commercial aircraft operators with very limited operations).

Allocation of Allowances. Affected operators were required to submit an Annual Emissions Monitoring Plan in 2010 providing details of activities and metric ton-kilometers. This provided the benchmark that determined each operator's carbon allowances for future years. Most aviation allowances

(85 percent) are distributed to aircraft operators free of charge. The remaining allowances (15 percent) are auctioned. A proportion of the allowances are reserved for allocation to new and rapidly expanding aircraft operations, thereby protecting economic growth and the commercial viability of new businesses. Proceeds from auctioned allowances are required, by law, to be used to mitigate the effects of climate change.

Involvement and Engagement

Absence of agreement despite several years of proactive engagement by the International Civil Aviation Organization (ICAO) resulted in the EU taking a firm lead by incorporating aviation emissions into their own cap-and-trade system and extending the requirements to cover third-party countries. The EU imposed the aviation ETS on foreign flights without the prior agreement of the affected countries or airlines, resulting in significant opposition. In 2011, 26 ICAO member countries (including the United States, China, India, Russia, and several Latin American countries), signed the "Delhi Declaration." The declaration opposes the EU Aviation ETS, instead declaring support for the ICAO efforts to develop aircraft carbon emissions standards with the intent of adopting such standards at the General Assembly in 2013. ICAO does not, in principle, oppose the use of "market forces" to reduce airline emissions. However, the organization is urging the EU to refrain from including non-EU flights in the EU ETS and to work collaboratively with the international community (Leggett, 2012). The International Air Cargo Association also has lobbied the EU to suspend the ETS until a global agreement can be reached with the ICAO.

Since January 2012, some governments have instructed their airlines not to participate, threatened to sue the EU, or suggested they might impose trade sanctions (e.g., bills before the U.S. House and Senate also seek to exclude U.S. aircraft from participating in the EU ETS). Nevertheless, the European Court of Justice recently ruled that the EU has the right to levy such taxes or fees. Any operator who fails to comply with the ETS will be fined €100 per day per ton of emissions. Early reports are that 99 percent of airlines are in compliance.

There are indications that perhaps as a result of action by the EU, other governments (such as China) are developing their own plans to reduce emissions from their own airlines, and are negotiating to explore exemptions for Chinese airlines based on "equivalent measures."

Cross-Jurisdictional Consistency

Although enacted without the agreement of countries outside the EU, the ETS consistently applies to *all* airlines flying into or out of EU airports. The legislation includes various options to avoid double counting on certain flights and ensure optimum interaction between EU ETS and measures adopted outside the EU. Such options include exemptions for flights arriving at EU airports from countries that have adopted equivalent measures and agreements with other countries to ensure optimum interaction of measures. Further, if an international agreement on global measures to reduce GHG emissions from aviation is reached, the EC has stated it will consider amending the EU Aviation ETS.

EC officials have, in fact, stated their preference for agreeing on global, binding measures via the ICAO, but require three conditions to be met first: it must deliver more emissions reductions than the EU ETS on its own; it must have clear targets and measures; and any action must be nondiscriminatory and apply to all airlines (Legget, 2012).

Impacts on Airlines and Freight

Studies estimate that the EU Aviation ETS will only have a small impact on U.S. airlines and emissions, and that growth of U.S. aviation business will not be constrained by this regulation. Where carriers are able to pass on all additional costs to consumers, profits for U.S. carriers are, in fact, expected to increase. In addition, some studies estimate that airlines may benefit from substantial windfall gains from free allowances from the EU ETS. Nevertheless, a future increase in the proportion of allowances auctioned would reduce windfall gains, and profits may decline (Malina et al., 2012).

Research specific to the air cargo sector found that the EU ETS may create distortions, favoring express freight over standard cargo because of differences in demand elasticity and yields. Further, it seems that EU-based airlines are at a disadvantage under the scheme compared to non-EU carriers because of the high proportion of short-haul operations subject to the EU ETS. Nevertheless, the study finds that the EU ETS creates some incentives for airlines to use pure freighter aircraft models (as opposed to belly-hold capacities of passenger aircraft); to shift their activities toward long-haul missions; to increase load factors; and to introduce emissions abatement measures. However, the magnitude of the financial burden to airlines (in terms of demand and cost effects) remains modest, and potential incentives are therefore small (Schröder, 2008).

Impacts on business will ultimately depend on the ability to pass costs on to customers. For example, the New Zealand Productivity Commission estimates that the ETS will impact around 10–15 percent of New Zealand air freight exports (by value) and that New Zealand exporters may face higher cost increases relative to their international competitors (who, in general, are located closer to European markets). Indications are that the EU ETS will increase air freight rates from New Zealand to the EU by around $60 to $70 per metric ton, an increase of approximately 1.6 percent on the price of air freight

to the United Kingdom, for example. New Zealand exporters will have limited ability to pass on these costs. Further, this may in some cases unfairly prejudice New Zealand products whose carbon footprint may be less than that of European products (New Zealand Productivity Commission, 2012).

Outcomes

It is too early to assess the impacts on GHG emissions. However, modeling indicated that CO_2 emissions from U.S. airlines would continue to grow between 2011 and 2020, but by a reduced amount (3 percent) if the costs of the aviation ETS were passed on to customers (Malina et al., 2012).

Summary

1. The EU's perception that the aviation industry lacked a clear, coherent, and combined commitment to reducing their carbon emissions led to their extending the EU ETS to cover aviation emissions in 2009.
2. The aviation sector was not involved in the design or development of these regulations and has actively opposed their implementation, threatening nonparticipation, to sue the EU, and to impose sanctions. However, a European Court of Justice ruling declared the aviation ETS to be lawful and the EU warned that sanctions in the form of fines will be imposed on noncompliant airlines. Early studies reported 99 percent compliance.
3. Although applied to flights arriving to and departing from the EU only (rather than all global flights), the regulation is complied consistently across all airlines serving EU airports. Although reporting and compliance adds to administrative efforts and costs, large commercial airlines generally have the capacity to meet requirements of the EU ETS.
4. The regulation does allow exemptions for certain flights (e.g., military aircraft and commercial aircraft operators with very limited operations). The reservation of a proportion of the allowances for allocation to new and rapidly expanding aircraft operations protects the economic growth and the commercial viability of new businesses, allowing economic growth at the same time as environmental protection.
5. A system that is implemented in one geographic region and implemented in the absence of broad-based engagement is not generally optimal. Nevertheless, the aviation ETS appears to have provided a catalyst for change beyond the EU: other governments (such as China) are developing plans to reduce emissions from their own airlines, and are negotiating to explore exemptions for their airlines based on "equivalent measures." European Community officials have, in fact, stated their preference for agreeing on global, binding measures via the ICAO, and have stated that if an international agreement on global measures to reduce GHG emissions from aviation is reached, they will consider amending the EU Aviation ETS.
6. Studies estimate that the EU Aviation ETS will have only a small impact on U.S. airlines, and that growth of U.S. aviation business will not be constrained by this regulation, although emissions will grow at a slower rate. Likely impacts for air cargo are considered to be a preference for freighter aircraft (as opposed to belly-hold capacities of passenger aircraft), a shift toward long-haul missions, increases in load factors, and the introduction of GHG emission abatement measures.
7. Impacts on the private sector are ultimately dependent on the ability of shippers and carriers to pass costs on to customers. Studies indicate non-European exporters with longer journeys and greater emissions may face higher cost increases relative to competitors. Where exporters have limited ability to pass these costs on, this may in some cases unfairly prejudice their products whose whole life carbon footprint may be less than that of European products. Thus, the EU ETS may not result in a net reduction in carbon emissions for certain products.

Voluntary Private-Sector Emissions Reductions Initiatives: Hong Kong Fair Winds Charter

Inception

Introduction. The Fair Winds Charter is a voluntary, industry-led, unsubsidized fuel switch program for ocean-going vessels calling at Hong Kong. It is the first initiative of its kind in Asia, as well as the first unsubsidized voluntary fuel switch in the world. The charter was announced in October 2010 and went into effect January 1, 2011. This voluntary initiative is intended to provide a "bridge" between the current situation and a future regulation in respect to low-sulfur fuel use for vessels calling at Hong Kong ports.

Context. Globally, there has been recognition of, and actions to, mitigate the health impacts arising from sulfur emissions in fuel, specifically within the maritime sector. The International Maritime Organization (IMO) regulates international shipping, and the current sulfur limit is 3.5 percent with the limit set to drop to 0.5 percent in 2020 following a review in 2018. Within emission control areas (ECAs), sulfur limits are stricter. At present, the sulfur cap within ECAs is 1 percent, and this is set to drop to 0.1 percent in 2015. Some regional governments have adopted policies and operating rules that are more demanding than the ECA limits. For example, the EU already requires use of 0.1 percent sulfur fuel (or use of equivalent technology to meet this standard), and

in 2006 at the San Pedro Bay area in California, the Ports of Los Angeles and Long Beach introduced the Clean Air Action Plan that included various measures to reduce supply-chain air emissions in the vicinity of the ports. Such efforts in Europe and the United States helped set international precedent and drove changes in shipping line operations.

Hong Kong and the Pearl River Delta (PRD), consisting of Guangdong, Shenzhen, and Macau—in size, about equal to the San Francisco Bay area—are home to approximately 50 million people. The region is a major source of global production, handling approximately 10 percent of all container traffic as goods are shipped to consumers around the world. Air pollutants from waterborne traffic are significant. A series of studies sponsored by the Hong Kong Environmental Protection Department found nearly 4 million people in Hong Kong alone were directly affected in by container port emissions, with container vessels accounting for approximately 80 percent of all vessel emissions. The research linked SO_2 emissions to increased rates of hospital admissions and death. As more data became available and the public health issues were better understood by the communities, interest grew in addressing maritime emissions.

Program Components

Regulatory Context. Achieving a significant improvement in the region's overall air quality would require the adoption of common rules across Hong Kong and the PRD. Such an achievement would necessitate coordination across multiple lines of government. Unlike ports in the United States and Europe, Hong Kong has no port authority. Rather, all five terminals are privately owned. Although there is a port association, it lacks any regulatory authority. In addition, jurisdictional boundaries between Hong Kong and the PRD undermine the potential for common environmental goals, policy setting, and regulation. Further, the creation of an ECA would require liaison with the IMO and the agreement of the Central People's Government in Beijing, which would also need to apply for ECA recognition.

The Charter. The charter signatories acknowledge the impacts that emissions from their vessels have on air quality in Hong Kong and the PRD Region. These international carriers voluntarily commit to switching to a fuel with 0.5 percent sulfur content or less while at berth and to collaborating with the Hong Kong Special Administrative Region (SAR) and Guangdong governments to introduce regulation on shipping emissions that are consistent with international standards. The initiative began on 1 January 2011 and applies until 31 December 2012. Charter signatories also urge the Hong Kong SAR to take the lead and work with the Guangdong governments to regulate the use of low-sulfur fuel in the PRD by December 2012, and to encourage broader industry participation through the provision of incentives.

Engagement Process

Starting in 2007, Civic Exchange, a nonprofit policy advocacy group, convened regular stakeholder meetings and workshops to develop a Green Harbors vision for Hong Kong. Participants included government officials, shippers, shipping lines, cruise lines, ferry operators, public health officials, and others. Broad agreement on the need for cleaner fuel and practices by the maritime industry was relatively easily achieved. However, agreement on the mechanism by which this would be implemented was elusive.

The shipping lines, already abiding with regulations in Europe, the United States, and elsewhere, preferred regulatory requirements for low-sulfur fuel. There is a financial consequence for using cleaner fuel. If all shipping lines incurred the same cost, it would be passed onto the shippers and end consumers. However, if only some shipping lines are using low-sulfur fuel, they are at a disadvantage. A regulatory requirement would create a level playing field across the industry.

However, government officials in Hong Kong favored voluntary action on the part of the shipping lines as a first step. The ports at Hong Kong and the Greater PRD compete with one another. There was concern that if Hong Kong went alone in mandating cleaner fuel, cargo would divert to the other ports with adverse economic consequences for the Hong Kong ports. There was also concern that achieving common regulatory requirements across the PRD region would take time for the required coordination and approvals.

Gaining Consensus

A middle ground was finally achieved in May 2010. Maersk Line was a key player and agreed to support a "virtual level playing field" if a critical mass of shipping lines would agree to voluntarily switch to 0.5 percent sulfur fuel at berth. Maersk was able to demonstrate the expected cost impacts from its experience at other ports. Civic Exchange drafted the Fair Winds Charter for review by the shipping lines, and in October 2010, 18 shipping lines (about 70 to 80 percent of the market calling at Hong Kong) signed the Fair Winds Charter committing to fuel-switching for a 2-year period. The charter allowed the region to realize benefits while giving the governments of Hong Kong and the PRD time to work together to achieve common legislative requirements by the charter's expiration at the end of 2012 (Fair Winds Charter, 2012). More recently, in response to the Hong Kong government's recent pledge to mandate fuel-switching at berth, Fair Winds Charter members have agreed to extend their voluntary agreement to use cleaner fuel for another year to January

2014, while the legislation to make fuel switch mandatory in Hong Kong is developed. This is intended to keep up the momentum within the industry and is an example of cooperation between the public and private sectors—in this case, led by the private sector.

Outcomes

It has been noted by the authors of the charter that as a voluntary agreement, the charter has limitations. Because not all shipping lines participated, the "virtual playing field" meant that those not participating maintained a competitive advantage. There is no mechanism to document the full benefit and impact of the charter because participating shipping lines are not required to disclose the type of low-sulfur fuel in use or the percentage of their fleet participating. Civic Exchange noted that some shipping lines claim that public disclosure of participation levels are an additional administrative requirement which adds to costs (Civic Exchange, 2010).

As of spring 2012, legislation still had not been enacted in either Hong Kong or across the PRD. Even though a demonstrable track record of progress has been established, the charter's continued success was in question. The shipping industry also was reportedly under significant financial strain in 2011 due to rising fuel prices and container demand had not fully recovered from the financial crisis.

Hong Kong announced financial subsidies of about 40 percent through reduced port fees to support the participating shipping lines, but the continued participation by all charter signatories is in doubt as shipping lines continued to hope for broader regulatory requirements.

Summary

1. Data, analysis, and evidence in respect to the impacts of emissions on public health (gathered and disseminated by public-sector and nongovernment organizations) provided a starting point for the education of the public and industry on the adverse impacts from shipping activity. This drove demand for change and prompted action on the part of the private sector.
   - The Hong Kong Environmental Protection Department commissioned a series of studies to document public health impacts from the maritime sector.
   - Civic Exchange prepared communication documents to explain the findings and promote awareness among the public.
2. Regulation in other parts of the world also provided a catalyst that drove voluntary activity in Hong Kong. Private-sector ocean carriers were ahead of the public sector, calling for tighter regulation around air emissions and acting sustainably. Tighter emissions regulation applied in one part of the globe also indicated that shipping lines were potentially more willing to take action in Hong Kong, particularly when all were acting together and able to pass the costs on to shippers, thus reducing any unfair advantage on the part of nonparticipants.
3. Trust and partnerships, established through ongoing engagement, dialog, and collaboration among the nonprofit sector, government, and industry were essential to finding workable solutions. For example:
   - Interdisciplinary and collaborative research funded by the Hong Kong Environmental Protection Department and other foundations established a history of trust gained through collaboration between public and nonprofit sectors on scientific research, public health policy, technology pilots, and other efforts.
   - Civic Exchange was a key facilitator, providing a forum and informal channel for representatives from different government agencies (that would not otherwise have worked together) to exchange information with one another and the private sector, public health officials, and other stakeholders. Thus, established silos and difficulties that sometimes preclude different jurisdictions and branches of government from working together, were overcome. For example, although at the beginning of the Civic Exchange's Green Harbors visioning effort, maritime emissions were not a priority for the Hong Kong government, staff participation increased awareness and escalated the issue. Civic Exchange also was afforded access to officials throughout the PRD region that would likely be harder for officials from public agencies to gain on their own due to jurisdictional and political divisions (Galbraith et al., 2008; Civic Exchange, 2010).
4. The "Green Brand" and sustainability often is focused on carbon. Concerns about criteria air pollutant (CAP) emissions are typically more prevalent in those parts of the supply chain closest to consumers. Manufacturers and shippers frequently focus on carbon because end consumers tend to be concerned about the carbon footprint, and also because there is a direct relationship between carbon emissions reductions and fuel/costs savings. The ability to pass on to shippers the costs incurred through voluntary activities to mitigate CAP emissions in Asia is perceived to be more difficult as compared to such activities in the United States and Europe, closer to the consumer. Consumers tend to be more aware of the impacts closer to home, while activities and practices at the source are not always in focus.
5. Common and consistent regulation is needed on a broader scale, building on voluntary initiatives already underway. The private sector is supportive of regulation where it is applied fairly and, together with the nongovernment

sector, can assist in bringing forward regulation that may take time (particularly in a multi-jurisdictional context). Civic Exchange and the shipping lines, through working collaboratively with government, have achieved notable successes, including the following:

- The *Framework Agreement on Hong Kong-Guangdong Cooperation* (2010), which includes commitment to the progressive adoption of fuel emission standards (Booth and Loh, 2012; Hong Kong Environment Bureau, 2010).
- The Bay Area was identified as the subject for a specific consultation in 2011, in the *Study on the Action Plan for the Bay Area of the Pearl River Estuary Public Consultation Digest.* This study mentioned specifically the potential creation of a joint ECA to regulate emissions from marine vessels (Booth and Loh, 2012; Study Team of the Action Plan for the Bay Area of the Pearl River Estuary, 2010).
- The Regional Cooperation Plan on Building a Quality Living Area was launched in September 2011, outlining specific measures for controlling air pollutant emissions (including the use of low-sulfur fuel at berth and the potential establishment of an ECA) (Hong Kong Environmental Bureau et al., 2010; Booth and Loh, 2012).
- The Hong Kong Environmental Protection Department submitted proposals to the Panel of Environmental Affairs in the Legislative Council and is on a path toward proposing emissions regulations. In the interim, the Financial Secretary announced a $260 million subsidy over a 3-year period to cover reduced port fees for ships that use 0.5 percent sulfur or better while at berth at the Hong Kong ports (Booth and Loh, 2012; Hong Kong Financial Secretary, 2010).

6. One of the downsides of this voluntary initiative is that as there was no requirement for monitoring and reporting, it is not possible to ascertain the emissions-reduction outcome.

Conclusions

This case study cluster compares mandatory emissions trading schemes with voluntary emissions-reduction initiatives in a non-U.S. context. Comparison of these schemes yields several lessons.

Voluntary initiatives (such as the Fair Winds Charter) can only go part way in achieving emissions reductions. In the case of CAP emissions particularly, participants in voluntary initiatives to reduce emissions generally incur higher costs (e.g., by using lower sulfur fuel) and carriers may find themselves at a commercial disadvantage, unable to pass these costs on to customers or to compete. Regulatory requirements can create a level playing field, requiring all carriers to meet the same requirements, and incur similar financial consequences. As an interim measure, voluntary initiatives can achieve emissions reductions, particularly where legislative and regulatory processes take time, and where coordination is required between multiple agencies, which can be difficult to achieve. However, common and consistent regulation is required to build upon the voluntary initiatives already underway.

Cooperation between private-sector interests and involvement of the nongovernment sector can be instrumental in reducing emissions and driving regulatory change, as evidenced by the Fair Winds Charter case study in Hong Kong. Here, Civic Exchange and the shipping lines engaged the public sector in ongoing dialog, undertook collaborative research, and implemented technology pilots. Nongovernment agencies such as Civic Exchange have a role to play in facilitating information exchange and dialog and can assist in overcoming silos within the public sector that may preclude public agencies from working together.

Emissions regulations applied in one region can prompt voluntary behavior on the part of multinational carriers to reduce emissions in other locations. For example, the experience of requiring reduced sulfur content in marine fuels in Europe and the United States, together with their commitment to sustainable development, provided a catalyst that drove voluntary activity on the part of a group of ocean carriers in Hong Kong. Here, the private sector is ahead of the public sector in terms of responding to air quality issues. Their commitment to sustainability and their experience of using reduced sulfur fuels elsewhere, arguably equipped ocean carriers with the knowledge and confidence to engage in fuel-switching along with a greater level of certainty as to impacts on their business. These ocean carriers are now pressing the public sector for regulatory change.

In contrast to the Fair Winds Charter, the EU Aviation ETS is an example of the *imposition* of emissions regulations following the private sector's perceived inability to reach an agreement on a global emissions reductions approach for the aviation sector. The implementation of the EU Aviation ETS was only possible because of high levels of domestic cooperation (on the part of EU countries), as well as the economic power wielded by EU countries acting together (i.e., airlines are unable to divert to other locations to avoid the tax). The EU ETS does include a level of flexibility that enables local jurisdictions to craft their own regulations to qualify for equivalency, keeping emissions fees at home, rather than paying these to the EU. This has prompted action of the part of other governments (for example, China is now exploring options to reduce emissions from its own airlines).

Regulatory measures have a better chance of success where substantial consultation and stakeholder involvement occurs from the outset, as evidenced by the New Zealand Emissions Trading Scheme case study. Early consultation resulted in an

agreement to pursue the emissions trading scheme route as it was perceived to provide business with greater flexibility in managing GHG emissions. Ongoing engagement in the design and implementation of the scheme improved acceptability among stakeholders.

Inputs from an independent panel as to the evolution of the New Zealand ETS also assisted in ensuring flexibility in response to the worldwide economic downturn, for example reducing the number of emissions allowances to be surrendered and providing the option for participants to buy NZUs at a fixed price. Thus, the government was able to ensure sensitivity to the needs of the economy during the downturn, while remaining committed to the cap-and-trade path. (Note, however, that New Zealand is a country of less than 4.5 million people, about a quarter of that in the greater Los Angeles area, for example. Thus, extensive consultation in this context is a relatively easy process which will likely be significantly more challenging in different contexts.)

A further factor potentially underpinning the success of the NZ ETS is the fact that the onus for reporting lies with the fuel wholesalers rather than with the emitters (e.g., small carriers and owner-operators) themselves, thereby alleviating the administrative burden on small businesses. Thus, while the ETS results in additional costs to freight transport as a result of increased fuel prices, these are applied across all sectors (with higher costs for more polluting modes). Such price increases can encourage more efficient truck fleets and driver behavior. Further, because the relative fuel price increases to the rail freight sector are just 34 percent of that of road freight, this may have the effect of promoting a shift to rail.

Jurisdictional consistency is a further feature of the New Zealand ETS, which has been designed to be consistent with other international emissions trading schemes. For a small country such as New Zealand, this was particularly important because it means that emission units may be traded without causing a significant movement in the domestic price, thereby permitting local businesses, which may have limited low-cost ways of reducing their own emissions, to fulfill their obligations by buying emission reductions from outside of the country. Similarly, although arguably enacted unilaterally, the potential for jurisdictional consistency is built into the EU Aviation ETS through equivalency measures. In practice, however, jurisdictional consistency is proving difficult to realize in the short term because of differences in the design of the EU ETS and that of New Zealand. Similarly, integrating the Australian ETS with that of New Zealand poses difficulties for New Zealand because Australia is not a party to the Kyoto Protocol.

APPENDIX B

National Initiatives

Introduction

This case study cluster considers programs based in the United States that provide single, integrated approaches to address the energy, economic, and environmental impacts of goods movement at the national scale. Two programs have been selected:

- The U.S. Environmental Protection Agency's (EPA's) SmartWay Program, which aims to improve fuel efficiency and reduce greenhouse gases (GHGs) and criteria air pollutants (CAPs) from the transportation supply chain. SmartWay is an example of a successful public initiative to manage emissions, based on voluntary involvement and close interaction with the private sector. This incentive-based program was most frequently cited during the Phase 1 stakeholder interviews as an example of a win-win initiative that addresses the energy, economic, and environmental impacts of goods movement. It demonstrates how the public sector can work productively with carriers, railroads, and shippers to make a positive contribution to supply-chain sustainability with both environmental and economic benefits.
- The not-for-profit company, Cascade Sierra Solutions (CSS), assists truck carriers across the United States in obtaining the technology and knowledge necessary to improve their fuel efficiency, switching to less polluting technologies, and reducing emissions. CSS provides unbiased advice to the trucking industry, along with low-cost financing and access to government grants, enabling truck carriers to reduce fuel consumption and access cleaner technologies. This initiative provides a clear example of cooperation and partnerships between the nonprofit, public, and private sectors to reduce emissions, improve carrier profitability, and enhance energy security.

Case Study: EPA SmartWay Transportation Partnership Program

Inception and Objectives

Context

The EPA SmartWay Program was formed in 2004, at a time when shippers and carriers sought a common way to address their supply-chain energy emissions while energy prices were escalating and fuel usage and emissions in the sector were growing. The industry itself was searching for new ways to improve performance and its public image, while the EPA was looking for innovative ways to collaborate with the freight sector to reduce emissions and improve the efficiency of legacy fleets in a manner that would complement other agency regulatory programs (EPA, 2011, pers. comm.).

Between 1980 and 2006, the average fuel economy for combination trucks remained mostly constant, at 5 to 6 miles per gallon (MPG), despite the availability of more fuel-efficient technology. Significant market inefficiencies and challenges to the optimal uptake of technology in the heavy-duty truck sector included the lack of accurate, verifiable fuel economy information and not incorporating the costs of CO_2 emissions and other air pollutants into logistics operations (Tan and Blanco, 2009).

The structure of the truck manufacturing and component industry also posed challenges to the flow of accurate and useful information. This led to much uncertainty regarding payback from technology investment. Further, there were no clear standards or methodologies for measuring the efficiency of heavy trucks that were easily replicable.

Engaging the Private Sector

SmartWay was intended to provide a single integrated, national program that offers consistent and measurable

approaches to reduce the energy, economic, and environmental impacts of goods movement (EPA, 2011, pers. comm.). The program built upon industry and civil society participation from the outset. In early 2003, the EPA met with industry stakeholders including representatives from multimodal carriers and shippers, environmental groups, the American Trucking Association and Business for Social Responsibility (which later became SmartWay Charter Partners). This group evaluated the core principles, tools, and recommendations that make up the SmartWay Program (EPA, 2011, pers. comm.; EPA, 2012a). The stakeholders assisted the EPA in building a sound business case for a program that would meet the needs of industry and provide value-added benefits by helping the EPA to understand industry challenges.

Because SmartWay was developed to provide technical assistance to carriers and a platform for partners to exchange information regarding the effective use of a broad range of technologies, as well as access to financial assistance, ongoing engagement of the private sector remains critical.

Program Focus and Scope

Components

The SmartWay Program strives not only to reduce freight emissions but also to support key national interests, including energy independence and the sustainability of U.S. businesses and supply chains (that protect and generate jobs and contribute to the economy). Specifically, the program is structured into the following five components (EPA, 2011a):

1. **SmartWay Transport Partnership**—Partnership by which freight carriers and shippers commit to benchmark operations, track fuel consumption, and improve performance annually.
2. **SmartWay Finance Program**—Competitive grant program that makes investing in fuel-saving equipment easier for freight carriers by providing better access to financial mechanisms such as reduced-interest loans with flexible terms.
3. **SmartWay Technology Program**—Testing and accreditation program to identify low-emission freight equipment, technologies, and strategies such as idle reduction technologies that allow drivers to refrain from long-duration idling of the main propulsion engine by using alternative technology; aerodynamic technologies that minimize drag and improve air flow over the entire tractor-trailer vehicle (e.g., gap fairings that reduce turbulence between tractor and trailer and side skirts that minimize wind under the trailer); low-rolling-resistance tires that can reduce NO_x emissions and fuel use by 3 percent when used on all five axles on long-haul Class 8 trucks; and retrofit technologies like diesel oxidation catalysts and diesel particulate filters. Fleet owners are therefore provided with the necessary information to enable informed decision making. Equipment purchased with funds from National Clean Diesel Emission Reduction Act (DERA) grants are required to be from the SmartWay-verified list to be eligible.
4. **SmartWay vehicles**—Program that ranks light-duty cars and small trucks and identifies superior environmental performers with the SmartWay logo, publicizing their performance on the SmartWay Partner List.
5. **SmartWay international interests**—Guidance and resources for countries seeking to develop freight sustainability programs modeled after SmartWay.

Partnering

Private-Sector Partners Joining SmartWay is voluntary and free for partners. As a SmartWay partner, shippers and carriers agree to undertake an assessment of their freight operations, calculate fuel consumption and carbon footprint, and track fuel efficiency and emission reductions annually. EPA has developed the methodology for reporting and works with each partner to collect and verify data received. Reporting is a core aspect of SmartWay accreditation.

In exchange, partners are provided with access to SmartWay funding provided through DERA grants, the SmartWay Finance Program, and public-private partnerships. Partners are also entitled to use the SmartWay brand and logo, which recognizes their sustainability efforts and can be used in marketing. This is reportedly a strong incentive for carriers to join the program, because shippers are increasingly committing to SmartWay-certified carriers (EPA, 2011, pers. comm.).

Initiated by the EPA and 15 charter organizations in 2003, at the time of the program's launch in 2004, SmartWay had already recruited 50 industry partners. As of December 2011, the EPA listed a total of over 2,900 companies and associations in the program (see Exhibit B-1). These include "the 100 largest truck carriers [in the United States] and over 1,000 medium-small carriers" as well as "all Class 1 rail lines, major logistics firms, and shippers from every sector" (EPA, 2011, pers. comm.). The program is supported by major freight industry associations, environmental groups, states, companies, and trade publications.

EPA is considering expanding its program to include partnerships with marine and air carriers, resources permitting. SmartWay also provides an avenue for other stakeholders, such as nonprofits, dealers, and truck stops, which encourage their members to join the program as a SmartWay Affiliate. All other organizations that support the goals of SmartWay can join as a SmartWay Community Member (EPA, 2012b).

Exhibit B-1. Summary of SmartWay transport partners.

Type of Partner	Number of Participants	Share of Total (%)
Logistics	435	14.8
Multimodal Carriers	11	0.4
Rail Carriers	18	0.6
Shippers	229	7.8
Truck Carriers*	2,250	76.5
Total Partners (Dec. 2011)	2,943	100.0**

Source: EPA, 2011b

Notes:

* Of the total number of truck carriers, 63 have joined as Drayage Carriers as part of the SmartWay port drayage truck initiative aimed at cleaning up the trucks that deliver freight in and around ports.

** Due to rounding, total does not sum to 100 percent exactly.

Public-Sector Partners The SmartWay Program also is based on strong partnerships and linkages within the public sector. For example, SmartWay routinely coordinates with other federal, state, local, and regional authorities to ensure the program is compatible and supplementary to their efforts. SmartWay's tools and approaches draw upon and complement EPA's existing resources, (e.g., by using emission factors from EPA's national transportation regulatory air quality model, MOVES) (EPA, 2011, pers. comm.).

SmartWay is part of the EPA's Legacy Fleet Programs (which include the National Clean Diesel Campaign and Clean Ports USA), enabling a comprehensive approach to addressing the legacy truck fleet. Through this synergy, SmartWay has demonstrated that test methods, technologies, and trucking industry knowledge can serve as a technical basis for formulating new large truck standards to improve the efficiency and reduce GHGs from new commercial trucks. The EPA and Department of Transportation (DOT) plan to implement these new standards in the near future (EPA, 2011, pers. comm.).

Further, SmartWay's test data was instrumental in the development of a vehicle simulation model that EPA and DOT will provide to businesses to help demonstrate compliance with new emissions standards. The EPA has incorporated certain SmartWay-demonstrated technologies into its state implementation plan (SIP) guidance, giving states more tools to meet national health-based standards for air quality (EPA, 2011, pers. comm.).

Working with the Coalition for Responsible Transportation and the Environmental Defense Fund, the EPA also has lunched a port drayage truck initiative under the SmartWay Transport Partnership aimed at reducing emissions from drayage trucks. The port drayage initiative will provide technical assistance, emission assessment tools, and partnership recognition to port truck companies that commit to cleaner trucks. It will also provide recognition for shippers using cleaner trucks at ports. Through this initiative, SmartWay will help ports continue to contribute to their local economies while protecting air quality, the environment, and public health, especially that of the surrounding communities.

Funding

DERA is a federally funded program established under the Energy Policy Act of 2005, which gave the EPA new grant and loan authority for promoting diesel emission reductions (EPA, 2012c). The SmartWay Clean Diesel Finance Program is one of four financing programs that help fleets reduce diesel emissions that fall under these guidelines. Under the Clean Diesel Funding Assistance Program, competitive grants are awarded to fund projects that reduce emissions from existing diesel engines through, for example, the use of SmartWay-approved emission control and idle reduction technologies; cleaner fuels; and engine, vehicle, or equipment upgrades and replacements. Particular emphasis is on establishing low-cost loan programs for the retrofit of used pre-2007 highway vehicles (EPA, 2011, pers. comm.).

Under the SmartWay Clean Diesel Finance Program, competitive grants are awarded to nonprofit organizations and local governments for the purposes of providing financial incentives (in the form of low-cost loans, rebates, other) to vehicle/equipment owners for the purchase of eligible vehicle replacements, idle reduction technologies, and emission control retrofits. Between 2008 and 2010, EPA awarded a total of $46.9 million in loan and financing programs to assist trucking

companies in reducing their fuel costs and air emissions (EPA 2012b). A particular focus is on providing access to truck owners, especially small- and medium-sized firms, to buy cleaner, more fuel-efficient trucks.

Data Monitoring and Reporting

Although SmartWay is a voluntary program, transparency in carbon accounting, reporting, and benchmarking is a core aspect of the accreditation process and a requirement for accreditation. The EPA has developed a methodology for reporting of data and program impacts by working with each partner to collect and verify data received. Only after rigorous data review and validation is the data uploaded to a database (EPA, 2011, pers. comm.). In addition, the SmartWay Program reports on various metrics including the following (EPA, 2011, pers. comm.):

- Number of partners;
- Fuel savings (in cost and gallons) relative to a base case without the SmartWay Program initiatives as a measure of business sustainability;
- Oil savings (barrels) relative to a base case without the SmartWay Program initiatives;
- Absolute, average, and percent reductions in CO_2 and CAP emissions per year achieved as a result of the SmartWay Program (in kilograms and pounds/ton-mile);
- Environmental justice: number of susceptible populations (poor, minorities, children, the elderly) affected by pollution;
- Freight mode split/shift;
- Protection of economy and jobs (qualitative); and
- Reduction of business uncertainty.

Tools also have been developed specifically for shippers that enable them to:

- Evaluate individual transportation providers based on their emission rates;
- Estimate reductions due to reducing miles or weight in their transportation network using the emission rates from their carriers;
- Evaluate mode switching impacts across all emissions and metrics; and
- Determine their SmartWay shipper score and SmartWay logo eligibility.

Operations

The EPA SmartWay Program is staffed by 10 people who are involved in helping companies in the enrollment process, submitting their annual updates, and providing technical and marketing assistance where needed (Tan and Blanco, 2009).

Benefits

Industry Benefits

The SmartWay logo provides partners a recognized brand within the industry by allowing carriers and shippers the ability to differentiate themselves as active participants of the sustainable freight movement (EPA, 2011, pers. comm.). The program provides a means of bringing carriers that have adopted these strategies together with shippers looking to reduce their transport carbon footprint, making it easier for both parties to "talk the same language" with common tools and approaches (EPA, 2011, pers. comm.). It provides a consistent means to assess optimal mode choices as well as evaluate, track, and reduce supply-chain fuel use and emissions. This was important to industry leaders and small firms that lacked the resources to independently research and finance new technologies (EPA, 2011, pers. comm.).

Through its grants, SmartWay has been able to increase the availability and market penetration of fuel-efficient technologies, particularly for small-medium carriers with fewer resources that otherwise would not have made a switch (EPA, 2011, pers. comm.). As these technologies are proven to be cost-effective, they get shared with other companies through the program, thereby increasing industry confidence in them, and small carriers start to implement them as well (Tan and Blanco, 2009).

Freight sustainability is now part of the business model of an increasing number of companies as they recognize the financial and environmental benefits of reducing fuel use. Carbon benchmarking and transparency is growing throughout the trucking industry. By serving as an independent resource about technology benefits, fuel savings, and partner performance, the SmartWay Technology Program helps fleets identify which technologies or strategies will improve their efficiency and reduce emissions as best fits their business needs. Companies can hence make informed purchases (EPA, 2011, pers. comm.).

Program Achievements

EPA (2011, pers. comm.) reports that the SmartWay Program is meeting its annual goals—developed through rigorous forecasting—and is on target to reducing 33 to 66 million metric tons (MMT) of freight emissions (from ocean-going vessels, rail, and truck) by 2012.

As of early 2011, SmartWay reported that their partners had saved 16.5 MMT of CO_2, 235,000 tons of NO_x, and 9,000 tons of particulate matter (EPA, 2011b). This is the equivalent of 50 million barrels of oil saved, which is equal to taking more than 3 million cars off the road for an entire year.

SmartWay partners also have saved an estimated $6.1 billion in fuel costs as a result of the program (EPA, 2011b). The

reduction in air pollution has had economic and environmental impacts as well as providing social and health benefits, particularly in low-income communities near ports, intermodal yards, truck stops, and border crossings.

Further, EPA (2011, pers. comm.) adds that many SmartWay partners are leading the way for industry. For example, groups like American Trucking Association, Campaign for Responsible Transportation, Council for Supply Chain Management Professionals, Business for Social Responsibility, and Clean Cargo Working Group are investing in programs and projects that will ensure their stakeholders and others are competitive and prepared for a carbon-constrained world and higher energy prices.

The EPA also is creating a positive impact outside of the United States through its SmartWay International Interest subprogram. Governments such as China, Mexico, and Canada, along with international organizations including the World Bank and the Commission for Environmental Cooperation, have projects or programs that rely upon SmartWay's technical assistance, methods, and tools (EPA, 2011a).

Success Factors

Early and ongoing involvement of stakeholders in the design of the program ensured its responsiveness to business and environmental needs and is a key factor underpinning the program's popularity. Although voluntary, the program's success is also due to the snowball effect of enrollment and partnership that has occurred through the following:

- **Word of mouth—**As more companies become aware of SmartWay and as they realize a growing number of companies are enrolling in the program, they themselves become more receptive to participating. It was reported that industry awareness of the program increased from 13 percent in 2005 to 32 percent in 2007 (based on a tracking survey cited by Tan and Blanco [2009]). In this way, the SmartWay Program has propagated the concept of the sustainability brand.
- **Consumer pressure—**As consumers become more aware of the program, they place pressure on shippers to enroll in the program through their purchasing decisions and direct communications.
- **Shipper pressure—**Shippers participating in the SmartWay Program are required to have at least 50 percent of their shipments moved by carriers enrolled in the program. This requirement has a large multiplying and reinforcing effect with regard to program participation. For instance, Wal-Mart has offered fuel subsidies to carriers who enroll in SmartWay, while IKEA has made participation in the program mandatory for carriers they employ (Tan and Blanco, 2009). More efficient carrier performance leads to lower operating costs and greater savings that are distributed back to the shippers as well—making shippers strong proponents of SmartWay.
- **Strategy evaluation/validation—**Shippers and carriers may share best practices and confirmation of the performance of various vehicle technologies. This helps many small carriers save time and resources in testing technologies themselves (Tan and Blanco, 2009).

Views from Operators

According to many SmartWay partners, the fact that the program is voluntary rather than regulatory is highly desirable, allowing them to select the emissions-reduction path that makes most sense for their businesses, and providing the necessary assurances and verification of fuel-saving technologies. Voluntary public-private partnerships provide an alternative policy option to regulation, which is often a contentious process and opposed by industry. They are also less costly than grants and tax incentives and directly target the market efficiency problem regarding lack of reliable information (Tan and Blanco, 2009).

Messages heard from the EPA and SmartWay Partners interviewed in this research that are important for public policymakers in the consideration of future initiatives to improve supply-chain sustainability are as follows:

1. Any solution, whether policy-, market-, or technology-based, should consider the business case. From an end-user perspective this is a highly salient factor, because companies that do not consider the bottom line do not stay in business. Additionally, businesses want certainty against unknown risks. SmartWay is effective because it helps businesses assess and measure what used to be an unknown or an uncertainty—the energy, economic, and environmental impacts of goods movement—and to mitigate risks.
2. The shift to sustainability is more challenging for small businesses (such as small truck fleets, independent owner-operators, and small businesses that ship and receive freight on a regular basis). These enterprises require expertise, tools, resources, and support that can help them operate more efficiently and distinguish their businesses to customers looking for greener choices. Many of these small trucking companies and owner-operators drive older trucks. Thus, technical and financial assistance (e.g., in respect of retrofits and fuel savings) are useful in improving these companies' performance and carbon footprint. Bringing these technologies and approaches within the reach of small businesses allows them to be more competitive in the mar-

ket place and to pass on these financial and sustainability benefits to their customers.

3. The marketplace increasingly requires transparency in business operations. More consumers, shareholders, suppliers, and others want to understand whether the companies with which they do business have sustainable practices. Because carbon is a leading indicator of fuel and energy use, it is poised to become a new indicator for sustainability, quality of life, and economic efficiency. Better market information in respect of fuel efficiency will help send the right market signals to further reduce carbon emissions.
4. Initiatives should capitalize on the growing opportunities for collaboration between stakeholders to optimize transportation efficiency, allowing shippers and carriers to "talk the same language" in respect to energy savings and efficiency, with common tools and approaches.

Conclusions

SmartWay has demonstrated that supportive public-sector initiatives are instrumental in promoting the sustainability of the supply chain. The program has penetrated a part of the supply-chain industry that generally is relatively inaccessible to regulation—that of in-use trucks. In particular, the success of the program has been in its ability to address common market challenges facing carriers such as the lack of information about energy efficiency options and technologies, high transaction costs, lack of reliable technical assistance, and the absence of an objective yardstick for measuring environmental stewardship (Tan and Blanco, 2009). It has helped to build stronger market confidence, awareness, and demand for sustainable freight practices, reduced obstacles to freight, and promoted the adoption of greener and cleaner technologies on the part of carriers.

Importantly, SmartWay has demonstrated that voluntary public-private partnerships can result in innovative and effective policy design without being unnecessarily intrusive to the market. The increased awareness of the carbon footprint and freight sustainability is helping businesses to address in a single, comprehensive approach, what had previously been an area of considerable uncertainty and confusion (EPA, 2011, pers. comm.). By providing resources that assist and educate both large and small businesses, SmartWay has helped to facilitate and accelerate an industry transition to sustainability among both shippers and their carriers (EPA, 2011, pers. comm.).

Although national in scale, focused initiatives such as the port drayage program enable SmartWay to concentrate efforts on specific locations where emissions are a particular concern, and on sectors that are the most polluting (because of the age of drayage trucks). Through this initiative, SmartWay will help ports continue to contribute to their local economies while protecting the air quality, environment, and public health of the surrounding communities.

Cascade Sierra Solutions

Inception and Objectives

Founded in 2006, Cascade Sierra Solutions (CSS) is a not-for-profit company whose overall objective is to save fuel and reduce emissions from heavy-duty engines. CSS does so by assisting trucking companies in gaining access to the technology and expertise needed to improve fuel efficiency, thereby reducing emissions and costs.

Such win-win solutions improve the environment, contribute to business needs, and also can have benefits in terms of contributing to energy security and improving the domestic economy (e.g., by switching to locally available fuels such as natural gas).

Program Focus and Scope

Components

CSS provides truckers with advice on technology, driver training, and access to low-cost financing and government grants, bringing sustainable technologies within reach of trucking companies.

Specifically, the CSS program emphasizes older trucks, because these are the most polluting. CSS also focuses its activities on areas around ports and large cities in recognition that port trucks tend to be the older, more polluting models, and urban areas are where air emissions impacts are greater due to volumes, congestion, and the proximity of receptor communities.

The goals of CSS are to

- Improve the efficiency of existing commercial vehicles by promoting technologies and solutions approved by the EPA's SmartWay Transport Partnership;
- Evaluate and promote existing solutions and identify emerging technologies that fuel efficiency improvements and reduce emissions;
- Execute truck replacement programs to permanently remove older, more polluting trucks and replace them with cleaner and more fuel-efficient vehicles including clean diesel, natural gas, hybrid, and electric vehicle solutions;
- Implement alternative fueling infrastructure such as natural gas (both compressed natural gas [CNG] and liquefied natural gas) and biofuels as clean, efficient, and affordable transportation fuels for commercial heavy-duty diesel vehicles; and

- Provide electrification of truck stops along major freight corridors in the United States as an alternative to burning diesel fuel during rest periods (CSS, 2012).

Partnering

CSS operates in a space between the public and private sectors, bringing together multiple government and private stakeholders across geographic boundaries to reduce fuel usage and emissions while growing the economy. The organization works in partnership with fuel producers, grantors, lenders, investors, manufacturers, utilities, truck stops, ports, government agencies, motor carriers, and owner-operators to facilitate the transformation of freight movement.

As a not–for-profit, CSS is able to effectively bridge the gap between the trucking industry and public- and private-sector technology providers. In fact, their funding is dependent on their ability to forge partnerships, with one-third of their funding derived from managing federal grants, one-third from donations and client relationships, and one-third from their own lending activities.

Perhaps most important are the partnerships CCS is able to create with the trucking industry, providing independent advice to assist truckers in selecting the best technologies for their needs and facilitating trucking company access to public (and other) financing. The organization is staffed by people with a background in trucking. The advice they provide is grounded in a solid understanding of the industry and is technology neutral. Their objective is to match technologies with trucking business needs. Because they are independent, not government affiliated, not pushing a particular product, can speak the language of truckers, and are able to advise on best practices, they are perceived as trustworthy partners. CSS CEO Sharon Banks has previous experience in governmental finance at an air protection agency. This independence, together with the broader perspective of the industry, underpins the success of the initiative and their ability to forge relationships across the public and private sectors.

Generally, the trucking industry is composed of small businesses and is highly fragmented. It can thus be hard to reach, because owners (particularly owner-operators) are highly mobile, with limited time and resources, and often operate on razor-thin margins. CSS effectively acts as the research and development arm for these small businesses. A critical aspect of their partnering approach is to take their expertise out to the trucking community by operating outreach centers in eight locations across the United States (often linked to truck stops where truckers spend significant amounts of time). Here, CSS showcases more than 70 products that save fuel and reduce emissions. They also provide access to the necessary financing to bring these technologies within reach of small operators, as well as helping them to realize the public relations and marketing advantages of alternative technologies (Stifel Nicolaus, 2012, pers. comm., July 25).

CSS also coordinates resources from a coalition of public and private partners who work together to fund truck replacements as part of the Green Highways Initiative. Under this scheme, owner-operators are provided with incentives to relinquish their old trucks and purchase new, clean, and fuel-efficient models along multiple corridors across geographic boundaries. In return for donations, private-sector contributors gain recognition through the media and CSS publicity, enabling them to demonstrate their sustainability credentials.

CSS has direct links to the public sector and is a SmartWay Finance Program grantee—assisting truckers in gaining access to public funds for fuel efficiency improvements. For example, the CSS "Everybody Wins USA" Lease Program is funded by SmartWay and provides financing for the purchase of SmartWay-verified emission control and/or idle reduction technologies nationwide. Grant funding for projects is provided by DERA.

Win-Win Opportunities

Win-win outcomes are a core aspect of the CSS partnering approach whereby parties working together are able to reap environmental, economic, and societal benefits. A particular area where multiple benefits can be realized is through fuel-switching.

CSS is currently assisting truckers in switching to natural gas, which is locally abundant at low cost. CSS estimates that switching to natural gas could save truckers $20,000 in fuel costs per vehicle each year (or more for a long-haul truck). For example, CNG, currently priced at $1.90 per gallon, is half the price of the diesel gallon equivalent (Stifel Nicolaus 2012, pers. comm., July 25). CSS predicts that with growing demand for natural gas as a transportation fuel, prices will decline further. Thus, although the cost difference between a new diesel and a new natural gas truck is between $40,000 and $50,000, the payback time is relatively short (2–3 years) and could decline even further. The GHG and particulate matter (PM) emissions from natural gas–powered vehicles also are lower according to CSS which reports that carbon emissions from natural gas–powered vehicles are 20–30 percent lower than those from diesel engines (Stifel Nicolaus, 2012, pers. comm., July 25). Note, however, that taking into account lifecycle emissions, the GHG emissions reductions benefits may be less than this estimate when natural gas is derived from hydraulic fracturing of shale gas.

However, impediments to switching vehicles from diesel to natural gas include lack of fueling infrastructure; limited access to financing (not many lenders want to be the first to finance alternative-fuel vehicles); and the time-consuming EPA and California Air Resources Board (CARB) technology verification process (Stifel Nicolaus, 2012, pers. comm.,

July 25). CSS has a goal of supporting the implementation of alternative fueling infrastructure and is working to help private-sector companies secure funding (e.g., from the U.S. Department of Energy and EPA) to help facilitate fueling infrastructure projects. They also are lobbying to obtain government support for technologies that have environmental, as well as economic, benefits.

CSS also is supporting truck-stop electrification, providing pedestals allowing trucks to plug in to the grid during mandatory rest stops. This can result in considerable savings to truckers, as the cost of electrified power is just $1 per hour—whereas trucks consume upwards of 1.2 gallons of fuel while idling (more for reefers). However, substantial trucker take-up is needed for the electrified truck stops to break even and operate profitably. Thus, the role of CSS in facilitating this change to sustainable practices is critical. For example, CSS is currently providing a bridge between public and private sectors, channeling $10 million in finance from the U.S. Department of Energy to subsidize the retrofit of 5,000 trucks, which will enable them to plug in to the grid (Stifel Nicolaus 2012, pers. comm., July 25).

Benefits

Since its inception in 2006, CSS has achieved the following (Cascade Sierra Solutions, 2012):

- Upgraded or replaced more than 9,000 trucks across the United States;
- Secured more than $45 million in grants for truckers;
- Provided over $54 million in financing clean, fuel-efficient vehicles and upgrades;
- Educated thousands of small trucking companies on best practices to save fuel and reduce emissions;
- Saved an estimated 350 metric tons of carbon dioxide emissions through promoting a switch to natural gas trucks;
- Retrofitted 5,000 trucks, enabling them to plug into the grid rather than idling; and
- Is in the process of installing 1,250 electrified parking spaces on five major freight corridors nationally.

Conclusions

Both SmartWay and CSS aim to achieve win-win outcomes, based on fuel efficiency (and hence reduced costs) as well as emissions reductions with benefits to industry, the environment, and local communities. Additional benefits include reduced dependence on foreign oil, and in some cases, support for the local economy (e.g., through switching technologies to locally available natural gas), as well as creating value-added benefits to partners who are able to market their participation in these programs to potential clients and customers as evidence of their "green" credentials.

A significant aspect underpinning the successes and popularity of these initiatives among truckers is that they are enabling rather than restricting. Their role in enabling small trucking companies and owner-operators to embrace sustainable practices where they would otherwise not have the capacity to do so is particularly relevant. For these small companies, SmartWay and CSS effectively perform a research and development function, granting access to expertise and best practice. These agencies also provide access to funding, often offering a bridge between private operators and public and private funding sources, bringing funding within reach of small operators.

Because they are able to meet truckers where they are (e.g., having staff with strong trucking industry experience who understand the business and by means of physically locating expertise in outreach centers) these programs have established considerable trust and credibility within the sector. The added benefit in the case of CSS is that their not-for-profit status means that they are not affiliated with any particular private-sector technology or regulatory authority, thereby allowing them a degree of independence and the ability to develop relationships that might otherwise not be possible.

Further, given their national perspective, both SmartWay and CSS are able to appeal to a wide range of companies that operate across geographic boundaries. They also are able to focus their efforts on sectors that are the most polluting (e.g., older trucks and drayage trucks) and locations most severely impacted (e.g., ports and urban areas).

APPENDIX C

Ports and the Coastal Context

Introduction

Ports are nodes in the supply-chain network, where concentrations of goods movement occur. Ports and the areas that surround them are likely to experience air emissions impacts associated with freight movements due to the volume of traffic that passes through them and along the road and rail corridors that connect them to other areas. Ports have developed various approaches to managing and mitigating air emissions impacts. This case study cluster compares and contrasts the approaches of three ports:

- The Port of Charleston, which has ambitious growth plans, is located in an area currently in attainment for air quality;
- The Port of Houston, which is located in an ozone nonattainment area; and
- The Port of Los Angeles (POLA), the nation's busiest port, located in a region that suffers some of the worst air pollution in the country.

Given the significant initiatives to regulate freight emissions in California, California is examined in detail, considering the approaches taken to managing freight growth and air emissions in the South Coast region and across the state.

Port of Charleston—Pledge for Growth

Port Overview

Operated by the South Carolina State Ports Authority (SCSPA), the Port of Charleston is the nation's fourth busiest container port, handling about 1.4 million 20-foot equivalent units (TEUs) annually, as well as break-bulk. The SCSPA is undertaking a major expansion effort, investing nearly $1.3 billion on capital projects, including a new, three-berth 280-acre container port, which will boost port capacity by 50 percent. The first phase of this development is underway.

Although Charleston's air currently meets federal quality standards, the SCSPA recognizes the link between port air emissions, air quality, and public health. As part of its plans for future growth, the port is taking steps to manage the impacts of its operations on the surrounding community. The SCSPA's environment policy, "Pledge for Growth," was developed through collaboration with partners. It pledges to manage impacts on air, land, water, and people resources with a $12.2 million environmental and community mitigation program, including an air emissions–monitoring component.

Initiatives

The SCSPA's proactive approach to addressing supply-chain air emissions includes a voluntary agreement with the South Carolina Department of Health and Environmental Control (DHEC), designed to reduce port-related air impacts. This committed the SCSPA to the following actions:

- Switching to ultra-low-sulfur diesel fuel to power port equipment 3 years ahead of the federal mandate. This action reduced emissions from affected equipment by an estimated 10 percent.
- Modifying operations to reduce turn times, minimizing the amount of time ships spend at berth and reducing at-berth emissions, reducing truck idling, and improving crane operations. These combined efficiencies have decreased port-related air emissions.
- Requiring port contractors to adopt best management practices in construction, including use of low-emission construction equipment, idling minimization, and dust control plans.
- Implementing an air emissions inventory and ongoing monitoring, even though the Charleston area is in compliance with the Clean Air Act active air emissions, and monitoring is not a federal requirement.

- Implementing numerous programs, with partners, to reduce diesel emissions from drayage trucks and port cargo-handling equipment. The port estimates that over 2,310 tons of emissions will be reduced over the life of the projects.

The SCSPA also has implemented an environmental management system to monitor environmental efforts going forward. This will include identifying further steps to reduce emissions, and SCSPA a full member of the Coalition for Responsible Transportation.

Partnerships and Working Together

The port is partnering with the following entities to improve air quality and reduce impacts on surrounding communities:

- **Public agencies**—The SCSPA has developed a close working relationship with DHEC. Rather than submitting competing grant applications to the U.S. EPA, both parties collaborate on grant applications. This funding partnership allows the port and state DHEC to each leverage their available funds to common ends.
- **Maritime community**—The SCSPA reached out to the port community offering assistance in providing access to public funding for emissions reductions. A tug boat operator, dredge company, and local trucking company responded. SCSPA incorporated all these projects into an EPA application that was backed by support letters from 23 organizations (including the DHEC, Chambers of Commerce, and trucking association). SCSPA secured $2 million from the EPA and $750,000 in stimulus grants. The total project value was for $5.26 million because of the 48 percent local match from partners. The SCSPA attributes success to extensive outreach and engagement.
- **Drayage operators**—In developing their drayage truck rebate program, the SCSPA undertook a year-long stakeholder process to fully understand the issues, challenges, and perspectives of the trucking community, and worked with the Charleston Motor Carrier Organization on how to structure a program. The SCSPA brought together five partners in an application for grant monies to improve port truck fleet. They were awarded a $1.7 million grant for a drayage truck replacement program, which will result in at least 67 percent reduction in PM_{10} emissions and 78 percent reduction in NO_x from new trucks. As part of their ongoing stakeholder consultation process, SCSPA found that many owner-operators struggle with poor credit worthiness and are unable to secure loans at reasonable rates without large down payments. Understanding this problem and recognizing the interdependence of the port and drayage operators, SCSPA did not seek a mandate for 100 percent truck replacement, since they did not want to push operators to finance trucks they could not afford. Rather, the port instituted a voluntary truck replacement program without a truck ban. The SCSPA is increasing the truck credit offered in the next round of grants. With the changes to the program, they hope to meet their goal of 85 percent drayage truck replacement.
- **Neighboring communities**—As part of the development process for the new container terminal, the SCSPA worked with the Low County Alliance for Model Communities to develop a $4 million mitigation plan addressing housing, job training, economic development, and air impact monitoring, among others. The SCSPA received an environmental justice award from the EPA for this effort in 2010.
- **Nongovernmental organizations/advocacy organizations**—The SCSPA joined the Coalition for Responsible Transportation to help drive change. SCSPA describes the coalition as an important partner because of their power of influence.

Unintended Consequences and Challenges

Working closely with partners in the development of their programs, and implementing voluntary initiatives only, the port has not encountered unintended consequences. Because their programs are voluntary, parties that deem the programs to be insufficiently beneficial can choose not to participate. However, lack of program funds was cited as a big challenge. South Carolina does not have a dedicated state program for funding air emission projects equivalent to the Texas Emissions Reduction Plan (TERP) or similar funding in California. The port has to be more resourceful and collaborative in seeking and leveraging public funds.

Overall, the SCSPA takes the view that successful emissions reductions efforts are those developed in partnership between the public and private sectors, with incentives provided to assist implementation. They advise policymakers to engage in dialog with the private sector to establish priorities and incentives, rather than developing unfunded regulations that may lead companies to avoid compliance and, in the end, may not achieve environmental improvements.

Port of Houston—Balancing the Interests of Business, the Environment, and the Community

Port Overview

The Port of Houston is ranked second in the United States in total tonnage and is the nation's leading break-bulk port. The Houston-Galveston-Brazoria (HGB) region is an ozone nonattainment area. Realizing early on that public agencies did

not have a good understanding of Port of Houston Authority (PHA) activities and the emissions sources within their control, the PHA took action and engaged an air quality consultant. They participated in air emissions discussions to educate public agencies and become engaged in the air emissions policy-making process.

PHA developed a Clean Air Strategy Plan (CASP) in 2009, which sets out the ways in which the port will contribute to meeting air quality standards for ozone within the region. The focus of the CASP is to strategize economically feasible ways to implement emission reductions from maritime-related sources in the greater Port of Houston area and to promote air quality awareness. In developing the CASP, the PHA sought to act in the best interests of business, the environment, and the community.

CASP Initiatives

Through the CASP, the PHA, working with the private sector, introduced a range of voluntary initiatives, including (PHA, 2011):

- **Use of cleaner fuel**—Texas low-emission on-road diesel (sulfur content of 15 parts per million) is used for on-road and off-road fleets.
- **Diesel equipment replacement**—PHA, along with six private partners, is replacing, repowering, and retrofitting over 128 pieces of old diesel equipment, including cargo-handling equipment, on-road trucks, and marine engines, following the award of $3.4 million of American Recovery and Reinvestment Act (ARRA) funding.
- **Fuel-switching demonstration**—In partnership with EPA, Maersk, and Hamburg Sud, PHA is demonstrating "fuel-switching" to 0.1 percent sulfur marine gas oil for container ships in the Gulf of Mexico. The project achieved more than a 95 percent reduction in SO_2, and 85 percent reduction in PM emissions from participating vessels. This demonstration has led to a longer-term partnership with Maersk Line to conduct fuel-switching in all of its vessels calling at PHA facilities, with the incremental fuel costs covered with a Diesel Emissions Reduction Act grant.
- **Public/private partnerships**—The port is developing partnerships with private-sector entities, with the PHA providing a conduit to federal funding. For example, PHA was awarded over $600,000 in Diesel Emissions Reduction Act grant funds to replace 14 yard crane engines with new, cleaner engines.
- **SmartWay drayage truck program**—PHA committed $50,000 toward the EPA SmartWay Program in the HGB nonattainment area. PHA partnered with Houston Galveston area government to leverage the funding for this program, and secured a $9 million EPA SmartWay drayage truck grant to provide loans to truck owners and operators who will replace more than 200 old trucks with newer, cleaner trucks.
- **On-dock equipment replacement**—Nine new rubber tire gantry cranes with fuel-saving technology and anti-idling devices were purchased.
- **Technology demonstration**—PHA committed funding and support to the demonstration and implementation of advanced powertrain technology ahead of the regulatory requirements for locomotives and harbor vessels. They also committed $20,000 toward an EPA fuel-switching feasibility study.
- **Environmental leadership group**—PHA participated in the C40 World Ports Climate Initiative in Rotterdam, an alliance of the world's largest cities committed to tackling climate change, resulting in the World Ports Climate Declaration. PHA, along with EPA, is encouraging Mexico to join the North American Emissions Control Area in the future.
- **Environmental management system**—PHA has introduced an environmental management system.

Implementation has strong management support, includes active staff participation with a strong emphasis on education and outreach, as well as program tracking and reporting, with an annual review and update process. The PHA Environmental Affairs Department is responsible for monitoring of impacts, data gathering, and reporting.

Partnerships and Working Together

The CASP was developed as a joint initiative with stakeholders including PHA tenants; terminal operators; the trucking community; ocean carriers; harbor craft and stevedoring owners and agents; the City of Houston; Harris County; the Metropolitan Planning Organization, the Texas state environmental agency; the EPA; various nongovernmental organizations; and local communities and citizens' groups. Consultation was undertaken with more than 150 private industries. The CASP is a "fluid" strategy that incorporates ongoing input from stakeholders. For example, PHA established a quarterly truck policy working group to develop and review strategic recommendations for PHA and tenant operations. This includes an education/outreach program to drayage truck owners/operators.

The PHA also has formed partnerships with port tenants and users, in order to apply for state and federal grant programs. Access to funding is a key driving force behind these partnerships. PHA continues to serve as the local maritime industry pass-through agency for applications and grant administration.

The PHA has taken on a leadership role in air emissions reduction, for example by supporting the Texas Waterways Operator Association's Memorandum of Understanding for

emission reduction in the HGB area; participating in the Regional Air Quality Policy Committee; chairing the American Association of Port Authority's Environmental Committee and the Authority's Sustainability Task Force (part of the Environmental Committee).

Parallel Initiatives

EPA mobile source emission standards apply in Texas. TERP provides financial incentives to eligible individuals, businesses, or local governments to reduce emissions from polluting vehicles and equipment. Grants are provided for a range of projects including upgrade or replacement of on-road vehicles, locomotives, marine vessels, idle reduction infrastructure, replacement or repowering of existing diesel or gasoline vehicles with natural gas vehicles or engines, and alternative fueling facilities.

TERP has committed almost $20 million to reduce locomotive emissions in the Houston Galveston area, which suffers from the most severe locomotive emissions and the highest ozone concentrations in the state. TERP funds projects in nonattainment counties for the purchase of new locomotives; replacement of old engines; retrofit or addition of emission control technologies. New locomotives must emit 25 percent less NO_x than the engine replaced or 25 percent less than the federal standard (if new). These projects are expected to reduce NO_x emissions by more than 3,300 tons at an average cost of $5,900 per ton (Scott and Sinnamon, 2006).

Managing Air Emissions at POLA

Port Context

The Port of Los Angeles (POLA) is the busiest container port in the United States, typically handling over 7.5 million TEUs per year. The port is located within the South Coast Air Basin, and designated as a nonattainment area for ozone, carbon monoxide, and PM. Port operations collectively contribute substantial amounts of NO_x emissions (precursors to the formation of ozone) to the regional airshed. Beginning in the 1990s, communities adjacent to the port and lobby groups began voicing concerns over the impacts of port air emissions (particularly in relation to NO_x and PM emissions) on human health. Litigation brought by local community and environmental lobby groups stalled the Port's Capital Improvement Program for 5 years.

Clean Air Action Plan

The port, in conjunction with stakeholders, forged their own solutions to manage air emissions in the form of the San Pedro Ports Clean Air Action Plan (CAAP). In developing the CAAP, POLA went beyond what the regulators require, and through a partnership with regulatory agencies, their customers, and the community, was able to achieve significant emissions reductions. Building these beneficial relationships has required significant outreach and the demonstration of a commitment to reducing emissions on the part of the port. Outreach efforts and results have earned the port credibility with regulatory agencies, the community, and nongovernment organizations, allowing POLA to go ahead with its expansion plans. The CAAP made port expansion and growth in cargo volumes possible, with the estimated benefit of creating between 300,000 and 600,000 jobs over 20 years, while reducing air emissions from port-related sources by 45 percent or more (Knatz, 2009).

Partnerships with Customers

As large multinational corporations with significant capital invested in the San Pedro Bay operations, port tenants had an interest in improving their own environmental performance in exchange for the ability to expand their terminals and operations. The San Pedro Bay Ports were also in the fortunate position of being able to leverage landlord tenant leases and tariffs to ensure environmental requirements were met. Being at the intersection of freight transportation modes including shipping, rail, and road, they were also able to exert influence over different emissions sources. Through these partnerships, the port has been able to extend its reach beyond the port gates, and has arguably achieved wider air emissions reductions more quickly than might have been possible through regulation alone.

For example, the OffPeak or PierPASS Program, introduced in 2005 in collaboration with the marine terminal operators (MTOs) and steamship lines, provides a financial incentive to move cargo outside of the peak daytime traffic hours. A traffic mitigation fee of $40 per TEU is imposed on eligible cargo. Fee revenue (less operating costs) is returned to MTOs to cover the costs of extended hours of operation. The initiative shifted 22 to 30 percent of cargo to the offpeak period, exceeding targets in its first year of operation (Giuliano and O'Brien, 2008). Previous attempts to regulate operating practices (such as the Port Gate Appointment System) implemented via Assembly Bill 2650, were less sensitive to operational practices and proved difficult to enforce. In contrast, the PierPASS program is perceived positively by MTOs, allows MTOs to control implementation, avoids competition, and enables costs to be offset. Shifting cargo movements to the offpeak period has enabled growth in container activity to be accommodated (Giuliano and O'Brien, 2008). The PierPASS Program illustrates the capacity of ports and MTOs to respond to increased pressures for resolving congestion and environmental problems outside of the traditional regulatory measures.

Since 2005, voluntary emission reduction programs have yielded substantial reductions in diesel PM (68 percent) and sulfur oxide emissions (74 percent) at POLA. Nevertheless, based on current forecasts, further additional emission reductions are needed to meet goals established in CAAP. By 2023, the plan calls for 77 percent diesel PM reductions and 59 percent NO_x reductions (http://www.portoflosangeles.org/environment/ogv.asp, POLA, 2013). The port has introduced various voluntary and compulsory emissions to curb emissions, as described in the remainder of this section.

Environmental Ship Index Program

The Environmental Ship Index (developed through the International Association of Ports and Harbors [IAPH] World Ports Climate Initiative [WPCI]) is intended to promote collaboration among ports and shipping lines to reduce air emissions and greenhouse gases. POLA has introduced an incentive program that provides financial rewards to ocean carriers who voluntarily reduce ship PM and NO_x emissions beyond regulatory requirements. It is intended to encourage ocean carriers to bring their newest, most efficient vessels to the port. In addition to financial incentives, the rating system enables shipping lines to demonstrate that they have a green vessel and for shippers to claim that their goods are moved by green ships. It is thus an effective marketing tool, ensuring both environmental and economic benefits.

Vessel Speed Reduction Program

Identified in CAAP, the port's voluntary vessel speed reduction program is intended to reduce NO_x emissions from ocean-going vessels. The port introduced an incentive program that provides reduced dockage fees to vessels that reduce their speeds within 40 nautical miles of the port. The port regularly publishes data that indicates high rates of compliance (http://www.portoflosangeles.org/environment/ogv.asp, POLA, 2013).

Clean Truck Program

The POLA Clean Truck Program addresses emissions from drayage trucks, which are responsible for as much as 25 percent of port-related air pollution (Knatz, 2009). In contrast to programs introduced at the Port of Charleston, for example, this program established a progressive ban on dirty trucks, with noncompliant trucks eligible to pay a Clean Truck Fee of $35/TEU container moved. These fees, collected by the marine container terminals, contribute to grants for clean truck purchases. Early consultation with carriers, cargo owners, terminal operators, and manufacturers, was essential to the identification of options that were both technically feasible and economically viable, as well as to ensure that carriers had sufficient time to plan for the transition in advance of implementation. Because the port had to sustain commercial operations, they were obliged to ensure that the trucks specified by the Clean Truck Program were readily available commercially. POLA worked with manufacturers to obtain volume discounts of between 10 and 20 percent for newer, cleaner trucks, as well as providing financial support to carriers.

There was value in this arrangement for the drayage operators and manufacturers, too. Once established goals were in place, the initiative gained a momentum of its own, and truck manufacturers played a key role in marketing it. Shippers also got involved. For example, Target purchased trucks on behalf of carriers (on the understanding that they would be paid back later) to ensure the availability of carriers to move their merchandise. In many cases, carriers gained access to cleaner and greener trucks more easily than would otherwise have been possible. In turn, shippers were able to market their supply chain as being green (POLA, May 12, 2012, pers. comm.).

The port reports that in its first year, the program reduced the rate of port truck emissions by an estimated 70 percent, and is expected to reduce emissions by more than 80 percent when fully implemented (POLA, 2011). POLA reports no delays in cargo movement with 99 percent compliance (Knatz, 2009).

Electric-Powered Container Drayage Trucks

Working jointly with the South Coast Air Quality Management District (SCAQMD), POLA jointly funded a pilot program using heavy-duty electric-powered container drayage trucks at port terminals between the docks and warehouses within a 10-mile radius. This emissions-free alternative to diesel engines could save over 35,000 tons of tailpipe CO_2 emissions, along with 22 tons of PM, and 428 tons of NO_x if used as an alternative to the diesel drayage trucks, which make over 2 million trips annually between the port and near-dock rail facilities (Knatz, 2009).

Notwithstanding the high capital costs (each truck currently costs about $200,000), the operating cost of electric trucks is just 10 to 20 percent that of diesel drayage trucks. Taking into account time spent idling, it is estimated that electric trucks could save operators about $35,000 per year. POLA has since approved production of 20 electric trucks for use at the port, and 5 more on-road trucks. The port has been able to exercise its authority to ensure wider benefits for the City of Los Angeles by requiring that the manufacturer establish an assembly plant near the port, thereby creating local green jobs (Knatz, 2009).

Locomotive Emissions

In 2005, Pacific Harbor Line's (PHL's) fleet of switchers was of 1950s and 1960s vintage. Assisted by grants from

California's Carl Moyer Fund, PHL has flipped its fleet to become the cleanest switcher fleet in the country. In return for upgrading to state-of-the-art equipment, the port granted PHL a permit to operate as a sole-source provider until the year 2024—thus ensuring the commercial viability of the investment.

Successes

POLA's success in reducing port-related air emissions has been achieved through stakeholder contribution to the air emission reduction efforts through their use of cleaner fuels, new technology, and introducing operational changes. Port customers are reaping financial rewards from fuel savings—a co-benefit of air emissions reductions.

A core part of the port's strategy is the stimulation of innovation within private industry to assist in the development of air emissions-reduction goals. POLA has introduced Clean Air Action Plan Awards that receive annual nominations from industry stakeholders. In 2012, POLA received 18 nominations that POLA staff believes is evidence that the private sector is competing to be the best, and wants this distinction.

POLA seeks to push practices up and down the supply chain. They consider themselves accountable for rail and truck movements—as well as for vessels up to about 100 miles out. As a consequence, they are keenly interested in the scalability of technologies (e.g., electric trucks) introduced at the port and their wider application.

The San Pedro Bay Ports are perhaps in a unique position because of the acute air quality issues in the South Coast region, as well as the volume of cargo they handle, which to some extent gives them more leverage than other ports in exerting environmental requirements on tenants, marine carriers, and drayage operators. Thus, measures introduced here may not be directly comparable with other locations or precisely replicable. Nevertheless, the success of the San Pedro Bay Ports' environmental programs has been based on collaboration between ports and their stakeholders and the sharing of costs, as well as the provision of rewards and incentives for improved environmental practices. This principle is something from which all ports can learn. Through partnerships, the port has been able to extend its reach beyond that of public-sector regulators, and has achieved air emissions reductions more quickly than would have been possible through regulation alone.

State- and Local-Level Plans and Regulations in California

Overview

Due to its high volume of trade flows, acute air quality issues, and unique position under the Clean Air Act, California has led efforts in the regulation of air emissions and the integration of air emissions mitigation into the freight planning process. Other jurisdictions that face less acute air quality issues, have adopted voluntary approaches to managing emissions with less in the way of actual regulation of freight air emissions. Because California is leading the field in the management and regulation of air emissions, some of these initiatives are reviewed in this section to foster understanding of their impacts.

Plans and Strategies

California Goods Movement Action Plan 2007—The California Goods Movement Action Plan (GMAP) considers infrastructure improvement needs alongside public health, environmental, and community impacts. The statewide multimodal perspective presented in the plan enabled the assessment of projects as part of a wider goods movement system, allowing comparison between port, rail, and highway projects within a common performance measurement framework. The framework included defined metrics for infrastructure and operational improvements, environmental impact, community impact, workforce development, and public safety and security. This enabled the prioritization of projects ensuring that the most important needs are addressed first, ensuring funding proceeds in an orderly fashion. The GMAP sets out multimodal policies and programs to reduce congestion and to address the environmental impacts resulting from the growth of movement of goods in California. It identifies projects to be considered for Proposition 1B funding, including the $2 billion Trade Corridor Improvement Fund (administered by the California Transportation Commission) and $1 billion for emission reduction projects (administered by CARB).

Prepared by the Business, Transportation and Housing Agency (which incorporates the California DOT, Caltrans) and the California EPA, GMAP is widely recognized for the cross-agency coordination that underpins it and for its success in enabling economic development while addressing environmental priorities. The planning process brought together a range of public- and private-sector stakeholders. Access to Proposition 1B funding was itself key in bringing these parties to the table.

Regional Transport Strategy 2012—The Southern California Association of Governments (SCAG) Regional Transport Strategy (RTS) includes a goods movement component that encompasses sustainable freight initiatives including clean freight corridors, congestion relief, rail improvements, and capacity expansion. The plan includes an evaluation framework, and each strategy is evaluated in terms of impacts on mobility, safety, environment, community, and the economy. Because goods movement and air emissions are inextricably linked in Southern California (which is classified

as an extreme nonattainment area), SCAG developed a parallel Goods Movement Environmental Strategy that forms part of the RTS. Close working with agencies such as CARB and SCAQMD were critical to developing this strategy.

The environmental strategy defines a path for achieving federal air quality standards. In the short term, this encompasses enhanced deployment of commercially available low-emission technologies and investments in improved system efficiencies. In the long term, the focus is on advancing technologies and the phased implementation of a zero- and near-zero-emission freight system, in order to accommodate economic growth and environmental protection. The RTS identifies a near-term project for the demonstration and initial deployment of zero-emission trucks receiving wayside power. A phased implementation process is identified that involves substantial research; close working with public and private-sector partners; testing and evaluation of technology; feasibility and funding availability; as well as ongoing assessment of impacts on emissions objectives, efficiency, safety, and reliability of the goods movement system (SCAG, 2012, pers. comm., May 21).

Regulations

Truck drayage rule—Heavy-duty diesel drayage trucks have a disproportionate impact on the air quality of communities surrounding major freight-handling facilities such as ports and intermodal yards. CARB has established new emission standards for in-use, heavy-duty diesel-fueled vehicles that transport cargo to and from ports and intermodal rail facilities, banning older trucks and requiring new emission control requirements for drayage trucks. The rule includes requirements for drayage truck owners; it also establishes obligations for motor carriers that contract with drayage truck operators and facilities where the drayage trucks do business. The regulation is projected to enable significant emission reductions in and around affected ports and intermodal railyards. PM emissions are projected to be reduced by about 2.6 tons per day starting in 2010, and NO_x emissions are projected to be reduced by 34 tons per day starting in 2014. CARB estimates that approximately 580 premature deaths would be avoided by 2014 in addition to 17,000 fewer cases of asthma-related symptoms (CARB, 2012).

Shore power rule—At-berth emissions were a key consideration in the San Pedro Bay Ports CAAP. While the port pursued various voluntary initiatives to emissions reduction, CARB began to consider their regulatory options to ensure ambient air quality standards can be attained in the region. (The Port of Long Beach had already begun to introduce the requirement for shore power as part of the renegotiation of terminal lease agreements. However, given the long-term nature of these agreements with tenants, it was recognized that this approach would involve a protracted lead-in time with negotiations being tied to the expiry of leases.) Following successive studies and workshops with stakeholders, CARB concluded in 2007 that shore power could provide sufficient criteria air pollutant (CAP) emissions reductions to render regulation feasible.

The regulation sets emissions reductions targets for at-berth ships and provides the regulated entities with choices of how to achieve emissions reduction. The final regulation includes two compliance options: use of shore power or use of alternative technologies (including after-treatment technologies, the use of non-grid-based shore power, and the use of portable generators for power) to achieve the equivalent reduction.

The Ports of Los Angeles and Long Beach were receptive to the regulation, recognizing that it would level the playing field by having the same requirements at all California ports, thereby reducing the risk of diversion (at least within California). Another benefit to the regulatory process in CARB's view was the process of getting to know stakeholders and the emergence of positive working relationships. CARB had several meetings with ports, terminal operators, and shipping lines as part of the rulemaking. The ports were viewed as an important partner in this process, providing the data, and reaching out to carriers and terminals. As part of the regulatory process, a socioeconomic impact assessment was undertaken, which examined the air emissions reductions expected and costs to industry. To mitigate costs to carriers, the rule applies to frequent callers only, with emissions reductions targets phased in over time. The goal was to achieve at least some reductions as soon as possible. Proposition 1B funding was made available for dockside infrastructure (CARB, 2012, pers. comm., May 21).

Tractor-trailer regulations—California AB32, Global Warming Solutions Act, is the driver behind tractor-trailer regulations. The regulation aims to increase fuel efficiency through improvements in tractor and trailer aerodynamics using SmartWay-approved technologies and low-rolling-resistance tires. CARB worked cooperatively with the private sector to generate support for the regulation, by setting up stakeholder groups. A working group (composed of private-sector players) proved useful. They identified issues such as those with the low-rolling-resistance tires required: many in the industry buy retreads, whereas only new tires are SmartWay verified. As a consequence of the working group consultation, retread of SmartWay tires has been made possible. Further, non-SmartWay tires can now be retreaded to be SmartWay compliant. This has resulted in the diversion of unusable tires from landfills—an additional benefit.

Nevertheless, interviews with industry conducted as part of this research revealed concerns that benefits of investments in trailer skirts required by this regulation cannot be fully

realized in California. A large national truckload carrier cited three issues in particular:

- Carriers generally use a drop-trailer system, running an average of three trailers per tractor. This rule requires installing skirts on all trailers, yet the benefit only accrues to the one trailer being towed. The carrier's view is that this investment could yield more beneficial environmental results if applied elsewhere.
- In California, the motor vehicle code prohibits a truck from exceeding 55 miles per hour. Fuel efficiency benefits of trailer skirts are only realized at 50 miles per hour, with optimal benefits gain at speeds of 65 miles per hour. At 55 mph, trailer skirts yield little benefit.
- The reporting requirements associated with this regulation add to administrative effort and costs.

Concerns about the burdens these measures have on interstate commerce have been voiced, particularly as this regulation presents cost and administrative burdens to interstate fleets that often do not know in advance which equipment will be used in a particular region on a given day. They may be required to shift loads to differently designed vehicles when traveling between states. Concerns also were expressed that trailer skirts could present safety risks as they are easily damaged (while crossing railroad tracks and driveways, and during loading and unloading). Drivers face a liability risk of damaged devices detaching from the trailer while driving. Moreover, some in the industry claim that the operation of aerodynamic side skirts under treacherous weather conditions could compromise the devices' safety and result in failure at high speeds (Tata, 2010).

However, CARB staff reports that attitudes have changed because of the realization of savings. (CARB estimates the cost of trailer skirts, for example, is less than $1,200, while devices with the skirts are getting twice the benefits in one year.) Despite initial concerns, there is no evidence of safety issues. In fact, in rainy conditions, trailer skirts are reportedly safer as they result in less spray on the side of trailers. Anecdotal evidence also suggests that accidents have been prevented; for example, in cases where cars have swerved and bounced off skirts. It is noted that trailer skirts also provide more stability at high speeds and under windy conditions (CARB, 2012, pers. comm., May 21).

Memoranda of understanding with the railroads—CARB has powers to regulate fuel use and use of old locomotives, but cannot develop in-use standards or new standards for locomotives. CARB has used this influence to ensure that the railroads do more to curb emissions in California than they are required to do nationally. For example, under the Federal Clean Air Act, CARB may require retirement of the oldest locomotives in California. Although this will not have a significant impact of air emissions in California, there is a risk for the railroads that if California were to introduce this requirement, other states such as Omaha, Illinois, and Texas could follow suit, with cost implications for rail business. CARB has entered into binding legal agreements with the Class 1 railroads (e.g., in 1998, 2005) and is currently into the third round of agreements with the four railroads whose emissions pose the highest health risks in California. Ongoing dialog and engagement is enabling a relationship of mutual trust and respect to be established. CARB believes the railroads view them as pragmatic, and they are often called upon as a broker between the railroads and other agencies that may be less sensitive to railroad technology and operational issues. Data sharing (in respect of technology, operating characteristics, and inventory) has been a by-product of their relationship with the railroads. CARB reports that the railroads' levels of compliance with the memoranda of understanding are good (CARB, 2012, pers. comm., May 21).

South Coast Air Quality Management District (SCAQMD)—Technology Advancement Office—The Technology Advancement Office is required as part of the implementation of state law because of the particular air quality challenges in Southern California. The office engages private industry, academic and research institutions, technology developers, and government agencies in cooperative partnerships to cosponsor projects intended to demonstrate the successful use of clean fuels and technologies that lower or eliminate air emissions. It also promotes the use of commercially available, low-emission mobile and stationary technologies.

The office is funded in part by grants from the federal government. However, public-private partnerships have enabled SCAQMD to leverage its public funds, with an average $3 of outside investment for every public dollar contributed. Many of the advanced technologies funded though these public-private partnerships are now being commercialized in the South Coast Air Basin (SCAQMD, 2009). SCAQMD offers incentive programs designed to promote voluntary take-up of new technologies on an accelerated schedule. This also provides manufacturers with justification to gear up for large-scale production of cleaner technologies (SCAQMD, 2012).

SCAQMD emphasizes technologies that use various nonconventional energy sources (fuel cell, natural gas, and electric/hybrid electric). Recognizing that there is no one fuel or technology that is appropriate to all uses, the SCAQMD is fuel- or technology-neutral. SCAQMD has submitted an application for a $19.2 million federal grant to co-fund a demonstration project for zero-emission container transport between the San Pedro ports and the Intermodal Container Transfer Facility, both 5 miles apart. This countywide Zero Emission Truck initiative is intended to catalyze the development and

deployment of zero-emission trucks in Los Angeles County. It is being developed in conjunction with the Ports of Long Beach and Los Angeles, Caltrans, SCAG, Gateway Cities Council of Governments, and LA Metro and is being undertaken with the cooperation of Siemens (technology provider) (SCAQMD, May 2012, pers. comm.).

Conclusions

Unique Role of Ports

Ports are in a unique position as public agencies that have both a clear understanding of supply-chain economics and operations at the same time as being attuned to environmental issues. Surrounded by local communities, they are obliged to take steps to mitigate the impacts of their operations on public health. As businesses, they are acutely aware of the need to mitigate risks and sustain port traffic. More so than other public or private-sector agencies, they generally have the capacity and resources to undertake market, environmental, and technical analysis relating to emissions reductions. Being at the intersection of freight transportation modes, including shipping, rail, and road, they also are able to exert influence over various different emissions sources.

Ports are continually required to balance environmental, economic, and social considerations and are regularly at the forefront of the interface between different stakeholder groups (private business, regulatory agencies, and communities). Although they are not regulatory agencies, they do exercise some power (through port leases and tariffs, operating permits, and their ability to provide access to public funding for emissions reductions efforts). They are well positioned to enter into partnerships with various stakeholders, including local communities, carriers, private-sector clients, as well as planning and regulatory authorities. Through such partnerships, ports have been able to achieve air emissions reductions more quickly than is possible through regulation alone.

They are also able to extend their reach beyond the port gates (for example, through influencing drayage truck emissions). Through their buying power they are able to influence the local economy. For example, POLA was able to secure discounts from manufacturers from clean drayage truck purchases and require electric truck manufacturers to establish an assembly plant near the port.

Partnerships and Working Together

The experiences of the three ports in this case study cluster highlight the importance of cooperation between public agencies as well as stakeholder engagement and partnerships with the private sector in securing air emissions reductions. The experience of POLA provides a stark reminder of the risks of ports not working with local communities and stakeholders. The case studies indicate that working together in the pursuit of shared outcomes has enabled significant air emissions reductions, often ahead of regulatory requirements.

In the cases of all three ports, partnerships have been aided through access to funding and financial incentives that have driven implementation of air emissions-reduction efforts. For example, the Offpeak Program provides a financial incentive for moving cargo outside of peak daytime traffic hours. As large multinational corporations that have significant capital invested in port operations, port tenants are interested in improving their own environmental performance in exchange for the ability to expand their terminals and operations (e.g., at the Port of Charleston and POLA). The POLA Vessel Speed Reduction Program includes lower dockage fees to vessels that reduce their speeds when approaching or leaving the port, and it indicates high levels of compliance. Marine carriers have a similar interest in proving their sustainability credentials. The lower dockage fees provide an added incentive.

Recognition of the private sector's initiatives is also a factor in the success of port initiatives, for example, the POLA Environmental Ship Index can also be used by shippers and ocean carriers as their own promotional instrument. Similarly, the POLA Clean Air Action Plan Awards provide industry recognition and reward for outstanding effort in environmental performance and have received active participation from the private sector.

Interestingly, in the case of the Port of Charleston and the POLA, the community was a key catalyst in the ports' clean air initiatives. In both instances, it has been necessary to get the community to commit to air emissions reductions in order for the ports to realize their expansion ambitions.

California Context

Because of the economic position of POLA, the particular air quality issues in California, and the unique powers afforded to the state under the Clean Air Act, both the port and CARB have taken significant steps in the management and regulation of air emissions from freight-related sources. The port and the State of California are faced with an urgent requirement to reduce emissions to meet National Ambient Air Quality Standards, as well as to address community concerns.

Nevertheless, stakeholder engagement and access to public funding have also been key in shaping plans, strategies, and regulation to achieve emissions reductions in the California context. For example, access to Proposition 1B funding is, in part, what brought stakeholders to the table in developing the Goods Movement Action Plan. Stakeholder involvement and financial incentives and have been important in the shaping of port initiatives in the context of POLA (e.g., with the Clean

Truck Program and locomotive emissions reductions) and in enabling compliance with California regulations.

Changes in Port Operational Practices

The POLA Offpeak Program and the initiatives at Port of Charleston provide good examples of how proactive engagement of the private sector can result in modifications to port practices with emissions-reduction benefits. By incorporating operational efficiencies and reducing turn times, the amount of time vessels spend at berth has been minimized at the Port of Charleston, thereby reducing at-berth emissions from vessels.

The shore power regulations introduced in California require technology-based solutions to the reduction of at-berth vessel emissions (although the legislation allows some flexibility in the technology to be employed). The regulation-based approach in the Californian context needs to be understood in terms of the seriousness and urgency of the air quality issues in that state, and the fact that other options in respect of improved port practices have already been largely exhausted.

APPENDIX D

Inland Perspectives

Introduction

This case study cluster provides an overview of the inland perspective, focusing on Kansas City and Chicago, two major interchange points for rail shipments from the West Coast. Both locations are characterized by significant through (rail and truck) traffic, as well as cross-town "rubber tire" movements between intermodal facilities.

Both the Kansas City and Chicago case studies consider initiatives to improve conditions around rail intermodal facilities. Rail intermodal transportation can reduce costs for shippers and diversion of truck to rail can result in significant greenhouse gas (GHG) benefits. However, intermodal shipment creates additional truck movements for pickup and delivery to the rail ramps, typically in more urban areas where criteria air pollutant (CAP) emissions issues are acute. (Research has yet to be completed that compares the long-haul environmental benefits to CAP emissions and social justice issues at the rail facilities.)

These case studies provide evidence of an approach to managing freight air emissions, which is based on partnership between the public and private sectors, an integrated approach to transportation and freight planning, and investment in infrastructure and technology that enables efficiency improvements in the freight sector at the same time that air emissions benefit.

Kansas City

Overview

This case study considers various initiatives underway in Kansas City and provides a review of the SmartPort concept; the integration of transportation and environmental considerations through the freight planning process, led by the Mid-America Regional Council (MARC) and SmartPort; the Cross-Town Improvement Project (C-TIP); and the new intermodal facility at Gardner. This latter development comprises a logistics park and a 440-acre intermodal facility that is predicted to handle 790,000 and 870,000 annual lifts by 2030 (U.S. Army Corps of Engineers Kansas City District, 2009).

Context

Kansas City owes much of its historical growth to its strategic position as a major trans-shipment point for freight, and today remains an important center for rail, truck, barge, and airfreight industries. Located at the intersection of four Class I railroads, Kansas City is home to five intermodal railyards and numerous switching yards, classification yards, and transload facilities. It is the second largest rail center in the United States based on number of carloads and tonnage that pass through the region. Kansas City is also among the top five trucking centers in the nation because of its excellent highway connectivity: 440 miles of interstate facilities provide east-west and north-south linkages (including to the Mexican border). Kansas City International Airport provides a cargo terminal for the region, while two port authorities operate on the Missouri River (although commercial waterway traffic is limited).

Although currently not designated an air quality nonattainment area, the metropolitan area typically experiences 10 to 15 days each year during which air quality does not meet federal standards, primarily due to high concentrations of ground-level ozone. The region is classified as a "maintenance area" with respect to the 1-hour ozone air quality standard. Although the largest emission sources are utility power plants, diesel emissions are a contributor, and there is concern that Kansas City could be designated a "nonattainment" area in future.

The 18-county Kansas City region handled an estimated total of 291 million tons of freight in 2007, with an estimated total value of $826 billion. An additional 650 million tons of through-rail volume passed over the region's rail network. Regional rail and truck freight is projected to increase from 246 million tons in 2007 to 349 million tons in 2027, a 20-year

compound annual growth rate of 1.8 percent (Kansas City SmartPort et al., 2009). Kansas City is not only a "through" location but is also home to a strong manufacturing base. However, the vast majority of goods consumed in the region are produced outside of the metropolitan area, and most goods produced in the region are consumed elsewhere, emphasizing the importance of freight to the local economy.

Cooperation in Freight Planning

The Kansas City region has a strong tradition of interagency cooperation in freight planning, as well as partnership between the public and private sectors to promote Kansas City as a freight hub. There is also a close link between freight planning and environmental planning, with responsibility for these functions housed within a single agency, thereby enabling a degree of coordination. Public engagement is a core aspect of the planning process.

Kansas City SmartPort

Recognizing the role that freight and distribution play in the regional economy, the Kansas City region had been actively engaged in freight planning since 1995. The Mid-Continent Tradeway Study (MARC, 1998) identified the need for an agency whose focus is the growth of the transportation sector. This led to the formations of Kansas City SmartPort—a nonprofit, investor-based economic development organization supported by both the public and private sectors, whose aim is to promote the Kansas City region as a leading North American logistics hub. SmartPort has a twofold mission:

- To attract businesses with significant transportation and logistics elements;
- To make the industry and the region more competitive in goods movement.

Funded by both public and private interests, SmartPort has played a key role in connecting the public and private sectors to promote a strong image of Kansas City outside of the region and identifying solutions to business needs related to transportation.

Mid-America Regional Council

MARC is the metropolitan planning organization. It consists of an association of city and county governments promoting regional cooperation and innovation in the Kansas City region. MARC provides a forum for

- Dealing with regional issues and engaging the public in decision making;
- Coordinating regional planning policies and developing regional transportation and environmental plans; and
- Advocating for regional issues at the state and federal levels and allocating regional resources.

MARC coordinates planning for all types of transportation, including freight movement and is responsible for directing the investment of federal and state funds to address the region's long-term goals. Projects are developed through public input and an evaluation process.

Freight Plans

MARC's Efficient Transportation and Healthy Environment functions worked closely together in developing "Transportation Outlook 2040" (MARC, 2009)—the new long-range transportation plan adopted by June 2010. The plan will guide $18 billion in multimodal investments in the region to 2040 and includes a specific section on freight.

"Kansas City Regional Freight Outlook" was completed in 2009. The study was a joint effort of Kansas City SmartPort, MARC, the Federal Transit Administration, and Federal Highway Administration (FHWA), and was administered by the Missouri and Kansas Departments of Transportation. The study findings are intended to guide and manage freight growth in the Kansas City region, identifying freight infrastructure needs and outlining a strategic freight plan to attract future freight growth. The overarching aim of the study is to build a "comprehensive freight plan that balances the needs of the community with freight interests." The study fed into the long-range transportation plan, "Transportation Outlook 2040."

"Transportation Outlook 2040" outlines a new vision for how transportation investments will relate to land use in the future. Policy goals address transportation's impacts on climate change and energy use, place making, and the condition of existing transportation systems. The plan was developed through an extensive public outreach process that spanned 2 years and involved thousands of elected officials, planners, businesses, community organizations, and citizens across the region.

The plan includes a comprehensive framework to review conditions, assess needs, and provide direction for prioritizing freight infrastructure investments, based on the designation of Corridors of Freight Significance linked to traffic volumes. A key strategy identified in "Transportation Outlook 2040" is the development of freight corridor plans for the Corridors of Freight Significance. The plan calls for review of physical conditions and use of the system network for safety and a mobility index along these corridors to help identify freight-specific improvements or opportunities.

In recognition of the importance of data to the freight planning process, the region is expanding the use of existing

technologies and tools to monitor freight-specific data. Kansas City SmartPort's Trade Data Exchange, C-TIP, and the Kansas City Scout traffic-management system are all technology-based solutions designed to facilitate and improve the region's freight transportation system and facilitate economic development.

Engaging the Private Sector and Communities

The region has established strong public-private partnerships to plan for freight and market the region. Beginning with the "Regional Freight Outlook" study, extensive private-sector consultation was undertaken. This included surveys of over 400 businesses and representative of industry sectors. Fifty participants (including representatives of the business community, Kansas City SmartPort investors, city/county staff, elected officials, and local residents) contributed to focus groups. These focus groups identified the need for future investments in freight infrastructure, education on freight issues, and coordinated freight transportation planning across the region. This was necessary to mitigate impacts and to preempt some of the issues and public objections that often arise in response to freight infrastructure development projects.

Although not a mandated agency for freight planning, Kansas City SmartPort provides a forum for collaboration between the public and private sectors, plays an active role in regional freight strategic planning, and provides a platform for the coordination of public and private investment. Through Kansas City SmartPort and MARC's Goods Movement Committee, the region laid the foundation for active dialog on freight transportation. As part of "Transportation Outlook 2040," the region confirmed its commitment to continued dialog and established new channels of communication to ensure agencies are informed and coordinated as growth continues.

Ongoing dialog with stakeholders was identified as being a core strategy for achieving "Transport Outlook 2040" policy goals, which cover aspects such as improved freight accessibility, reduced climate change impact and decreased use of fossil fuels, enhanced economic vitality, protection of natural resources, and improved public health. The plan identified the need for MARC's Goods Movement Committee to meet on a regular basis (at least quarterly) to review freight data and corridor analyses. The plan also called for ongoing freight-planning coordination with other metropolitan planning organizations and continued support for Kansas City SmartPort.

Integrating Economic and Environmental Objectives

One of the ways in which sustainable outcomes can be achieved is to ensure that agencies engaging in freight planning have responsibility for both environmental and economic objectives. For example, in the Kansas City region, MARC is responsible for both efficient transportation (developing the regional transport plan and freight plan) and healthy environment (including developing air quality forecasts and preparing plans for meeting air quality standards).

MARC has made a concerted effort to integrate environmental considerations into the planning process, and was awarded funding from the FHWA Eco-Logical grant program, which they used to create the "Linking Environmental and Transportation Planning Action Plan," along with a best practices guide. The action plan initiative emphasizes interagency cooperation at the local, regional, and state levels. Although it does not deal with freight specifically, the action plan has relevance to the freight sector. Three priority areas are identified as follows:

1. Align decision making with a vision:
   a. Develop plans in the context of a sustainable vision;
   b. Assemble and merge transportation, environmental, and land-use data early in the process;
   c. Convene interdisciplinary teams to advise on decision making;
   d. Align project selection and funding with the vision, goals, and measures outlined;
   e. Coordinate public engagement efforts across agencies; and
   f. Develop new and enhanced environmental policies for construction, operation, and maintenance (including consideration of alternative fuels, anti-idling).
2. Formalize ongoing collaboration.
3. Create a regional mitigation strategy.

This dual responsibility for transportation and the environment is reflected in the *Kansas City Regional Freight Outlook Strategic Plan*, which includes three core objectives: improve goods movement system performance, support business attraction and retention, and ensure the region's quality environment. Critical strategies identified in association with the last objective include encouraging the freight community to take a proactive stance by joining the dialog on regional air quality standards; measurement and regulation (through involvement in the Air Quality Committee); and promoting sustainability by encouraging a balanced approach between growth in goods movement and promoting environmental standards (MARC and Kansas City SmartPort, 2009).

The "2009 KC Regional Freight Outlook Report" includes a section on freight and the environment. This component considered national GHG emissions from freight activity, as well as the likelihood that the region will move into nonattainment status for ground-level ozone in the future. Nonattainment would require a new regulatory plan to reduce emissions in

Kansas City, along with new and tighter regulatory requirements (e.g., anti-idling, vehicle inspection, reduced speeds) and will also likely require extensive air quality and transportation coordination as well as modeling to ensure that future projects do not undermine the ability of the region to regain/maintain attainment.

In parallel with freight planning initiatives, MARC is taking voluntary action to maintain air quality through the "Clean Air Action Plan." This plan claims to be the first to set out a strategy for clean air, outside of a regulatory requirement enacted by a region, promoting retrofits for on-road diesel engines (although no funding is currently available), truck-stop electrification, idling reduction, switching locomotive emissions control technologies, and land-use policies in support of air quality.

Use of Technology to Improve Environmental and Economic Performance of the Freight Sector: C-TIP

C-TIP is focused on improving intermodal goods movement within the Kansas City region. Typically, multiple "rubber tire" truck movements are required when the intermodal facilities of the various railroads are not in close proximity or not equipped for a direct rail-to-rail transfer. These multiple truck moves frequently result in empty moves where there is no backhaul associated with the original move. This adversely affects the overall efficiency of the transportation network and transportation safety, adds to congestion, escalates carriers' fuel use, increases air emissions, and undermines quality of life in adjacent communities. C-TIP aims to coordinate information between the terminals to improve efficiencies and eliminate empty moves, thus reducing the overall number of moves, saving time and money, and reducing emissions.

C-TIP is a collaborative project between government and industry. The initiative is supported by the FHWA Office of Freight Management and Operations as well as the Intermodal Freight Technology Working Group, a partnership of public- and private-sector interests, focused on the identification and evaluation of technology-based options for improving the efficiency, safety, and security of intermodal freight movement). It has involved Kansas DOT (KDOT), Missouri DOT (MODOT), as well as MARC, the railroads, and trucking companies.

C-TIP is based on the concept of an intermodal moves database for coordinating cross-town traffic, tracking intermodal assets, distributing information to truckers wirelessly, allowing the railroads, facility operators, and truckers to share information about available loads, delivery information, traffic, and scheduling. The results of the initial testing proved the concept to be viable. However, since this reporting, C-TIP has not yet progressed further.

Kansas City Climate Protection Plan

In 2006, the Kansas City Council adopted a resolution supporting a climate protection planning process. The Kansas City (2008) Climate Protection Plan was published in July of 2008 and has been supported since that time. The Council has adopted a goal of a 30 percent reduction in greenhouse gas emissions over 2000 level by the year 2020 with a recommended a target of 80 percent reduction by 2050 and attaining a climate-neutral Kansas City. The Climate Protection Plan supports three primary initiatives: reduction in vehicle GHG emissions; conservation of electrical energy; and understanding the impact of buildings. (Note that this latter initiative is also supported in the Regional Freight Outlook Strategic Plan, which promotes the use of Leadership in Environmental Design, or LEED, for warehousing and distribution centers.)

The plan sets out two strategies to address these initiatives: a strong reliance on community involvement (not only as a planning tool, but as a building block for the future), and building on existing initiatives within in the region. Working groups were established to tackle target areas for improvement.

Although communities and businesses were included in the work groups and encouraged to drive the initiative forward, the freight community was not invited to participate because it was believed that this segment would be unresponsive both to inquires regarding actual emissions data and to setting improvement goals. Some information was included from the results of traffic studies relative to truck emissions, but the reduction goals that were set did not include initiatives developed with the freight transportation sector.

Key Metrics

Both the Climate Protection Plan and C-TIP each apply one primary metric to their work. In the case of the Climate Protection Plan, the metric is greenhouse gas emissions (measured as metric tons of CO_2 equivalent). C-TIP measured effectiveness based on a reduction in truck trips with the understanding that fewer truck trips over certain distances would reduce emissions.

Both of these metrics are simple and effective and can be employed in jurisdictions of varying size. Although other metrics are employed in different regions and under different conditions for application, these two are easy to understand, employ, and measure for maintenance and improvement against standards.

Gardner Intermodal Facility

Air quality issues came to the fore following the U.S. Army Corps of Engineers' approval of the Burlington Northern Santa Fe (BNSF) Railway intermodal facility at Gardner/Edgerton,

30 miles southwest of Kansas City. The intermodal railyard will enable the transfer of cargo between trains and trucks, and is expected to generate an estimated 33,500 daily vehicle trips and 110 daily train movements by 2030. The facility will generate significant employment and revenue for the State of Kansas. The Corps found that there were no significant adverse environmental effects from the project, and that the maximum predicted concentrations of criteria pollutants from the facility are below both the applicable National Ambient Air Quality Standards and the U.S. EPA's reference concentrations for protection of human health.

Nevertheless, a lawsuit filed by the Natural Resources Defense Council (together with a similar suit filed by local environmental and community groups and private citizens) claimed that the approval does not address human health impacts from increased diesel pollution as a result of truck traffic (Natural Resources Defense Council, 2010). Residents of the nearby town of Gardner objected to the project, leading the neighboring town of Edgerton to annex the land so that the project could proceed in the chosen location.

The lawsuit found in favor of BNSF Railway and the U.S. Army Corp of Engineers, and the project is proceeding. The project was found to be necessary to meet policy objectives at federal and state levels aimed at making the intermodal network more efficient and competitive with trucking. It will help to alleviate capacity issues and bottlenecks on BNSF's mainline, which cause train delays of up to 36 hours. These delays are forecast to increase as the number of intermodal units shipped through Kansas City rises.

Design elements such as an automated gate system, larger container storage, and trailer parking areas are intended to minimize truck idling emissions per trip. The use of electric gantry cranes (rather than diesel cranes at the existing facilities) also is expected to reduce emissions from handling equipment. Locomotive idling control is to be implemented (but there is no indication that alternative-fuel/electric yard hostlers or hybrid locomotives will be used). To accommodate traffic, KDOT and the county are invested in a new interchange and upgrade of the roads linked to it (U.S. Army Corps of Engineers Kansas City District, 2009; Natural Resources Defense Council, 2010).

Chicago: Chicago Region Environmental and Transportation Efficiency (CREATE)

Overview

This case study considers the CREATE Program, which is a public-private partnership approach to addressing the issues of freight transportation efficiency, air emissions, and congestion in the Chicago region.

Context

Chicago is a major freight crossroads and the only U.S. city where all six major U.S. and Canadian Class I railroads come together to interchange freight. Seventeen intermodal terminals are located in the region and almost half of all intermodal containers in the nation are interchanged here. In addition to two transnational interstates, the region also has two major airports, a seaport on Lake Michigan, and canal access to the Mississippi River.

Rail constitutes 36 percent of total intercity freight tonnage passing through the city, while 60 percent of commodity flows occur by truck (FHWA, 2005). It has been estimated that Chicago-area railroads operate 1,200 daily trains and generate more than 3,200 daily truck trips to transfer cargo between yards (FHWA, 2005). This problem is compounded by increasing volumes of intermodal freight, and is expected to worsen with the forecast 200 percent growth in intermodal rail freight by the year 2035 (AASHTO, 2003). Commuter train traffic makes Chicago's rail system even more complex.

Chicago has the highest overall rail freight emissions of all regions in the United States, approximately twice the rail freight emissions of the Los Angeles region (with the exception of carbon monoxide emissions) (AASHTO, 2003). Trucking is also a significant source of on-road PM emissions because of the high proportion of pass-through traffic that is predominantly composed of Class 8b (diesel-powered) large combination vehicles used for long-haul trips (FHWA, 2005). The Chicago metropolitan area is a designated nonattainment area for PM and ozone.

Impetus

Severe snowstorms during the winter of 1998–1999 made railyards and highways impassable and created delays that rippled across the North American rail system for weeks. That event, coupled with public concerns about merger discussions among the railroads, led railroad officials and civic leaders to join forces to develop a regional operations and infrastructure strategy that would avoid a future transportation service breakdown.

In 2003, the State of Illinois and the City of Chicago joined with six of the nation's freight railroads together with Chicago's commuter railroad (Metra) to formalize a partnership to reduce rail bottlenecks. This led to the establishment of CREATE.

The program goals are to (CREATE, 2010)

- Reduce freight rail congestion to boost regional and national economic competitiveness,
- Reduce motorist delay due to rail conflict at grade crossings,
- Enhance public safety,

- Promote economic development,
- Create and retain jobs,
- Improve air quality,
- Reduce noise from idling or slow-moving trains, and
- Improve passenger rail service.

Organization

CREATE is a public-private partnership established to implement 70 rail infrastructure projects consisting of (CREATE, 2010) the following:

- Twenty-five road/rail grade separations,
- Six passenger/freight rail grade separations,
- Railroad projects to improve rail infrastructure and upgrade technologies,
- A viaduct improvement program,
- Grade crossing safety enhancements, and
- Rail operations and visibility improvements.

The $3.2 billion program is currently funded to $952 million, of which $116 million is from the railroad partners and the remainder is from public funds. The partners are seeking additional funds for completion of the program. Progress to date includes (CREATE, 2010) 14 completed projects, 12 projects under construction, 4 projects in final design, and 15 projects in environmental review.

Air Emissions Reductions and Benefits

Although the impetus for the program was to reduce several rail bottlenecks and inefficiencies, the projects also have air quality benefits for the region. It is estimated upon full project completion, the program will result in (CREATE, 2011) the following pollution reduction from locomotive emissions:

- Nitrogen oxides (NO_x)—1,453 tons per year,
- Carbon monoxide (CO)—225 tons per year,
- Volatile organic compounds (VOCs)—80 tons per year, and
- Particulate matter—51 tons per year.

This is coupled with the following pollution reduction from highway vehicle delay:

- NO_x—6 tons per year,
- CO—213 tons per year, and
- VOC—24 tons per year.

Once CREATE is in full operation, NO_x emissions reductions are forecast to reach the equivalent of seven NO_x-free summer days per year. Moving freight by rail instead of trucks also reduces gas emissions by 75 percent, on average.

With the projects completed thus far, rail simulation showed that passenger delay has been reduced by 33 percent and freight delay reduced by 28 percent. If all of the projects are completed in 20 years, passenger delay is expected to be reduced by 66 percent, freight delay by 50 percent, and motorist delay by 25 percent (CREATE, 2011)

Partnering and Collaboration

Collaboration is key to program implementation. Projects were identified for implementation via "owner-neutral" rail modeling, which identified areas of the most significant bottlenecks and delay. From the modeling, it was clear that neither commuter nor freight operations could grow without significant infrastructure improvements.

Given the complexity of the program, whereby improvements can impact and benefit multiple parties, the partners developed a sophisticated management structure to oversee the required collaboration. CREATE is unique in that it is governed by unanimous agreement, with the Association of American Railroads (AAR) representing the six freight railroads and Metra, together with representation from the state, the city, and FHWA, as a nonvoting member responsible for overseeing the federal aspects of the program.

Governance

To manage the collaboration and construction for this program, the partners created a clear governance structure to oversee all the program's needed operational, financial, permitting, construction, and outreach responsibilities consisting of the following:

- FHWA CREATE program manager based in Chicago serving as the onsite full-time federal officer responsible for the federal interests for the project.
- Stakeholder Committee consisting of three members (AAR president and CEO, Chicago DOT [CDOT] commissioner, and Illinois DOT [IDOT] secretary) that makes decisions unanimously.
- Management Committee made up of one member each from Chicago Transportation Coordinating Office, AAR, the six Class 1 railroads, CDOT, and IDOT. Nonvoting members to this committee include Amtrak, FHWA, and two short-line railroads. The committee must decide matters unanimously, and any member may elevate an issue to the Stakeholder Committee for resolution. Reporting to the Management Committee are the
  - Implementation Team, comprised of one member from Chicago Transportation Coordinating Office, AAR, Metra, the six Class 1 railroads, CDOT, and IDOT, tracks budget and construction, recommends project changes, and meets monthly.

  - Finance and Budge Committee, which is comprised of one member from each of the organizations above. This group works with the Advocacy Committee to identify sources of public funds worth pursuing. It also monitors project costs versus actual expenditures.
  - Advocacy Committee, comprised of government affairs officers from each partner. They are responsible for addressing community concerns, conducting public outreach, and advocating for CREATE.

This governance structure enabled numerous projects to proceed concurrently while minimizing impacts to rail operations as well as the surrounding roadways and communities. The unique requirement for unanimous decision making, rather than the more common majority decision-making protocol, ensured that minority issues were addressed and that no partner would drop out if their concerns were not met directly. Given that decisions for the CREATE Program are made unanimously by the partners, there are no unintended consequences to report to date.

Also, to ensure meetings are productive, members are to make decisions when the group meets. It is expected that all members are empowered to speak and render decisions for their organizations to avoid delay to the program.

Environmental Process

The other innovation brought about by CREATE is in its environmental process. There was considerable concern that if each individual project required its own federal National Environmental Policy Act of 1969 (NEPA) review, given the federal funding and regulatory involvement, the overall program would never be implemented. A project-by-project approach would also have been vulnerable to legal segmentation challenges. A tiered or programmatic Environmental Impact Statement for CREATE as a whole would reduce the segmentation risk but would result in delay for low risk/low impact projects.

To address this issue, FHWA, together with IDOT and CDOT, created a strategy termed Systematic, Project Expediting, Environmental Decision-Making, or "SPEED." This process looks at proportional impacts so projects that are low/no risk can be granted categorical exclusions or can be assessed in an environmental assessment and granted a Finding of No Significant Impact, enabling them to proceed on a more expedited basis than those undergoing full Environmental Impact Statement review. This methodical process allowed the multimodal program to proceed with risk-appropriate environmental reviews for individual projects without holding up small projects with the more complex ones, while limiting the risk of legal segmentation challenges to the NEPA process.

Replicability

Despite the grand scale of the CREATE program, the partners take the view that other communities can replicate their lessons learned. They advise

- **Look beyond the highway perspective.** Metropolitan planning organizations ought to look at investments intermodally, examining rail, truck, landside, waterside, and air opportunities equally for projects that can reduce air pollutants.
- **Engage consistently and keep stakeholders informed.** Start from the top and look at problems from a macro perspective. Engage with the railroads to review a list of potential projects. Make them aware of what transportation projects are being considered and obtain early feedback.
- **Require project agreements between partners.** These should describe clear roles and responsibilities for a series of projects and become the road map on how to get the projects done.

Lessons from this Case Study Cluster

Interagency coordination—Kansas City's strong history of interagency cooperation in freight planning has been instrumental in the region's success. The integration of environmental and transportation functions within MARC was essential to a balanced approach to economic development and environmental protection.

Engagement—Engaging the community has been effective in mitigating impacts and pre-empting issues and public objections that often arise in response to freight infrastructure development projects. However, in the case of the Gardner facility, a lack of communication and information led to legal challenge and delay.

Forums such as Kansas City SmartPort and MARC's Goods Movement Committee provided a forum for public-private cooperation, and a joint approach to economic development and environmental mitigation in Kansas City. Public investment in future projects is a key aspect of keeping the private sector engaged in Chicago. These case studies illustrate how the public and private sectors can cooperate and find consensus on economic development and environmental issues when time is taken to identify common goals. Freight transportation companies and private fleets benefit financially from infrastructure-investment programs that reduce operating costs or produce service improvements. These also can have environmental benefits. Encouraging the freight community to take a proactive stance by joining the dialog on regional air quality standards, measurement, and regulation ensures they remain aware of, and consider, the impacts of their actions.

Organization and governance—Groups working together, for example among FHWA, IDOT, and CDOT, enabled the streamlining of the environmental process in the case of CREATE, allowing the multimodal program to proceed with risk-appropriate environmental reviews for individual projects ensuring that small projects were not held up by more complex ones. CREATE's clear program governance is a key element of the project's success. This reduces conflict regarding roles and responsibilities. The governance model included public outreach as part of planning and project development. The organization of the responsible parties under this framework is one way to streamline decision making.

Integration of plans and initiatives—Integrated and parallel plan development (e.g., Kansas City Regional Freight Outlook Strategic Plan, and the Clean Air Action Plan) enable common goals and performance measurements to be applied. The C-TIP initiative in Kansas City provided a means to engage the private sector in an emissions-reduction effort that has potential business benefits.

Metrics—The projects demonstrate success with performance measures from the simplest—reduction in truck trips in Kansas City—to more complex measures as shown in CREATE. For small and potentially less sophisticated communities, the simple measurements may give the best starting point with the opportunity to become more detailed as experience grows.

APPENDIX E

Corporate Programs

Introduction

This case study cluster aims to showcase several compelling voluntary programs put in place by industry. These include multi-company initiatives and programs launched by individual shippers and carriers. In particular, the companies whose efforts are profiled range from large, well-known corporations to small, ordinary firms with few available resources and limited capacity—yet are also developing and executing sustainability projects.

The purpose is to illustrate the significant strides that have been taken by the private sector, often without any direct regulatory pressure; to characterize what sorts of results are being achieved; and to make suggestions for ways in which regulatory agencies can encourage shippers and carriers to advance supply-chain sustainability even further.

Industry Initiatives

This section focuses on two specific industry initiatives. The first of these draws together shippers and carriers, with a primary focus on ocean container transport; the second is a consortium of apparel and outdoor companies concerned with the environmental aspects of their end-to-end supply chains. These efforts are selected because of their significant work to promote sustainable supply chains and transportation. In particular, both initiatives demonstrate the ability of the private sector to tackle complex issues of environmental impact measurement on a purely voluntary basis. As such, they demonstrate a possible alternative or complementary approach to public-sector regulations in addressing complex, multi-party issues.

BSR's Clean Cargo Working Group

Founded in 1992 and headquartered in San Francisco, CA, Business for Social Responsibility (BSR) is a global network of over 250 companies that work together to develop sustainable business strategies and solutions through consulting, research, and cross-sector collaboration. Along with public and private companies, nongovernment organizations, sector associations, sustainability groups, and educational institutions are all involved with collaboration.

In addition to strategy and reporting work with companies, BSR facilitates and provides expertise for the transportation and maritime industry through their Clean Cargo Working Group (CCWG). The BSR CCWG is a business-to-business collaboration committed to integrating sustainable business principles into transportation management. The group was established in 2003 in response to the growing complexity of global supply chains and increasing regulations and customer demands. Shippers began to need standardized, credible information about the environmental performance of carriers, while carriers were receiving requests for sustainability measures and metrics. The CCWG consists of 29 shippers, including American Eagle Outfitters, IKEA, Nike, Heineken, Wal-Mart, and some carriers such as APL, Maersk, OOCL, and Kuehne + Nagel. Sixty percent of the global containership fleet by volume is represented by ocean carriers in the CCWG. CCWG members develop and use practical tools for measuring, evaluating, and reporting the environmental impacts of global shipping. These tools, along with dialog and collaboration, help members track and benchmark their environmental performance and easily report to customers in a standardized format.

CCWG has compiled a comprehensive database of the shipping industry and, from that, has been able to develop baselines and measurement tools. One of the benefits of the CCWG calculation method is that it provides an industry standard for assessments and sharing of information in respect to the air emissions impacts of shipping. CCWG assembled emissions data (CO_2, SO_x, and NO_x) from some of the largest transportation carriers, thereby enabling the creation of measurement tools that did not exist previously.

These are tools that carriers are unlikely to be in a position to assemble on their own. It provides carriers with an efficient, standardized, and transparent tool by which to calculate environmental impacts and to relay this information to shippers and stakeholders who can make decisions based on reliable information about the environmental performance of transportation service providers (BSR, 2012).

CCWG's Performance Metric Tool is a valuable Excel-based tool for ocean carrier environmental performance. The vessel-by-vessel data collection method assesses the environmental performance of a carrier in six key areas, including CO_2, SO_x, NO_x, waste/water/chemicals management, environmental management systems, and transparency. Detailed inputs are required. Total scores are then placed into the output scorecard. Additionally, for CO_2 performance, a score is provided for each trade lane and compared to performance from an indexed CCWG average.

CCWG also has created a carrier "scorecard" to quantify performance and benchmark individual carriers against industry performance. The organization asserts that through its actions it has realized an average 8 percent decrease in aggregated CO_2 emission rates across trade lanes from 2007 to 2008, and a 17 percent decrease compared to 2006 (BSR, 2012).

Additionally, CCWG has both an Intermodal Calculator Tool and an Environmental Performance Survey (EPS). The Intermodal Calculator Tool helps carriers calculate their CO_2 emissions and footprint for intermodal shipments. The EPS is a qualitative survey meant to supplement the quantitative performance metrics. It collects best practices in areas where quantitative metrics are less suitable at the present time (e.g., pilot projects) (CCWG, 2012).

Outdoor Industry Association's Sustainability Working Group

Founded in 1989 and headquartered in Boulder, Colorado, the Outdoor Industry Association (OIA) is a trade organization for companies in the outdoor apparel, footwear, and equipment industry. In 2000, several key players, such as REI and Timberland, started the Sustainability Working Group within the OIA in an attempt to begin to create a clear basis for evaluating sustainability of outdoor industry product (OIA 2012, pers. comm., June 1).

The Sustainability Working Group now has over 250 member companies and has developed one of the most collaborative, innovative programs yet, the Eco Index. Based on members' own previous research and tool development, the Eco Index was developed to address the environmental impacts of the supply chain. By 2011, the OIA had adopted the full Eco Index and, in conjunction with the Sustainable Apparel Coalition, began to develop a second version of the Eco Index that would be broader and applicable to all apparel and footwear products, not just those in the outdoor industry. The Eco Framework is the foundation for the original index. The new index is driven more by lifecycle data and digs further into specific areas of impact, such as energy and GHG, carbon emissions, and air emissions. Version 2, to be released in July 2012, will have a transportation component and indicators will be reorganized. Although OIA created the initial Eco Index, the Sustainable Apparel Coalition brought the scale and knowledge of supply chain to be able to leverage the index to a broader level, beyond what the OIA could have done with the outdoor industry (OIA 2012, pers. comm., June 1).

Since the Eco Index tool is still under development, it remains an internal-use-only tool for companies. Because of this unique positioning of the index as an internal learning tool, it has allowed companies to collaborate and work toward the greater good for the industry. This fully voluntary, collaborative effort and development of a tool by the companies actually using it is groundbreaking. The Eco Index was not developed by the government or consultants but by competitors who shared the common goal of creating a single, shared, global tool for measuring the environmental impact of apparel and footwear (OIA 2012, pers. comm., 1 June).

Lessons from Industry Collaborations

The voluntary industry initiatives studied have made great strides in promoting greener supply chains and transportation practices. Among their accomplishments, they contribute by

- Sharing best practices in sustainability across companies. Industry consortiums are an ideal forum for advanced firms to share their experience with others.
- Developing common methodologies and metrics. In the absence of comprehensive definitions, methodologies and metrics for supply-chain sustainability emanating from a public agency with a sufficiently broad perspective, it is useful for industry groups to advance a common understanding of what constitutes sustainability and how it should be measured. Both CCWG and the OIA have made significant progress in this regard.
- Experimenting with different methods (advanced by different groups) that can serve as a laboratory for how to address sustainability. Since the standards are voluntary, industry groups can essentially compete to see which approaches resonate best with shippers and carriers. Regulators can benefit from studying the results flowing from these initiatives.

On the other hand, voluntary groups face certain limitations inherent in their role, as follows:

- They have no power to require any shipper or carrier to adhere to the norms and metrics developed. These groups

therefore tend to attract progressive companies interested in improving their sustainability performance and may not directly influence those who are less interested and therefore do not join the group.
- They are fragmented in their membership. Some are more European, others more U.S.-oriented; some are focused exclusively on issues affecting a single industry vertical; and others are united around a specific mode of transportation. This means that while each group advances some aspect of sustainability, there is no clear, cohesive solution developing at this time from the many sustainability organizations.

Shipper Initiatives

Shippers active in the United States (especially large companies) are without exception paying attention to supply-chain sustainability. Each of the shippers studied was able to recite an impressive list of supply-chain sustainability objectives and achievements. The questions that raise concern (1) which types of companies are most actively involved in sustainability efforts and (2) what can small companies reasonably be expected to do, even if they can devote only limited resources to green efforts? These points are addressed by analyzing Nike and Stonyfield Farm. These two companies are at two very different points on the size spectrum and are both consumer goods companies.

Nike

Nike is a footwear and apparel giant, with revenues of $25 billion. As a leading consumer brand associated with athletics and healthy living, the company is naturally focused on sustainability. Nike's supply-chain sustainability program is evolving to encompass a more complete, end-to-end supply-chain view that is transparent to consumers. The company has developed a list of supply-chain expectations that includes environmental footprint analysis, publishing a corporate responsibility report on a consistent basis, proactively investing in research and development of alternative materials, understanding their supplier footprint, ensuring traceability of materials throughout the supply chain, and integrating environmental standards, certifications, and traceability systems to ensure integrity throughout the supply chain (Nike, 2012).

Each segment of the supply chain is measured via a common denominator (grams of CO_2 per unit processed). This allows Nike to conveniently roll up the impact along each leg of the product's journey. With the company's continued double-digit annual growth, many opportunities to simply "do things more efficiently" have been exhausted. This means that Nike must work on doing things differently, such as shifting transport modes (Nike 2012, pers. comm., May 18).

These transportation initiatives complement manufacturing process improvements (e.g., Nike Flyknit's manufacturing process changes to reduce waste in knitting together the upper part of a shoe) and exploring new materials and manufacturing processes through the company's Sustainable Business & Innovation Lab. A Manufacturing Index was introduced in 2012 to evaluate sustainability and other performance elements in Nike supplier factories as well. Each plant is rated on quality, delivery precision, cost competitiveness, and sustainability (lean implementation, environment/energy and labor, health and safety), with 25 points going to each of the four factors. Overall scores are then compiled leading to red, yellow, bronze, silver, or gold performance and corresponding action requirements.

Nike recently refreshed all of its environmental targets to FY15 (baseline FY11) as follows:

- Achieve 20 percent reduction in CO_2 emissions per unit from FY11 levels through FY15.
- Source all products from factories that have achieved bronze or better on Nike's Sourcing and Manufacturing Sustainability Index by the end of FY20.
- Accelerate the adoption of cleaner fuels and vehicle technologies by transport and logistics partners (Nike, 2012a).

Nike also promotes its Nike Better World image by creating products with low environmental impacts. The company recently launched sports apparel made from recycled PET plastic bottles. For example, the U.S. men's and women's soccer teams are outfitted with complete kits made of 13 recycled plastic bottles each. The shorts are made of 100% recycled polyester and the shirts are made of a minimum of 96% recycled polyester (Nike Inc., 2012).

Stonyfield Farm

This New Hampshire-based organic yogurt maker places significant emphasis on sustainability and on educating consumers about its environmental efforts. Sustainability was one of the founding principles of the company and is central to its brand as the consumer understands it. Over time, Stonyfield has concentrated its sustainability efforts on the hot spots of its supply chain: milk (largest and most difficult impact area to fix), transportation, packaging, and facilities.

Although sustainability is central to the Stonyfield brand, the company has found that most consumers rate price, nutrition/health, and taste above sustainability. The company's research has shown that consumers do not necessarily wish to pay for sustainability. Thus, a sustainable brand is not a guarantee of consumer demand or loyalty. Stonyfield therefore aims to meet its own sustainability goals while also fulfilling consumer needs. The company is focused on

educating consumers about why they should choose a sustainable brand. Stonyfield expects the level of consumer green awareness to rise in coming years, thanks to the company's own efforts and those of its competitors (Stonyfield Farm, 2012, pers. comm., June 15).

Stonyfield's main sustainability target is to achieve a 5 percent annual reduction in CO_2 emissions per ton of product delivered. Reaching this goal implies a 75 percent decrease by 2015 (from a 2006 baseline). A 50 percent reduction was already achieved by 2010. All the company's individual sustainability projects tie into this 5 percent annual reduction in GHG (the company does not directly address CAP).

On the transportation side, Stonyfield looks at miles in network, vehicle utilization, and mode to reduce the CO_2 footprint. The company became a certified EPA SmartWay transport shipper and measures its GHG impact using EPA SmartWay's FLEET performance model. Stonyfield also requires that all trucking companies moving its products be SmartWay-certified carriers. A transportation mission action program (MAP) was created, under the direction of Stonyfield's director of logistics, to craft cross-functional environmental goals covering shipments from the main plant and distribution center in Londonderry, New Hampshire, where 99 percent of the company's outbound volume originates.

Significant progress has been achieved. Between 2006 and 2008, for example, Stonyfield reduced transportation CO_2 emissions by more than 40 percent while also growing the business. This is equivalent to taking 1,700 automobiles off the road for a year (Stonyfield Farm, 2012, pers. comm., June 14; Stonyfield Farm, 2012; Cooke, 2009).

In terms of advice to other small companies seeking to make sustainability a core part of both the company's image and its operations, Stonyfield's director of logistics advises, "the biggest thing is getting [sustainability] into the day-to-day. It's not top to bottom, it is at the employee level" (Stonyfield Farm, 2012, pers. comm., June 14).

Lessons from Shipper Initiatives

Nike and Stonyfield Farm are examples of a large and small consumer products company, each with a progressive record in supply-chain sustainability. Many other shippers are active as well—companies like Wal-Mart, Home Depot, REI, Staples, Timberland, and ConAgra Foods. The findings from interviews and secondary research suggest that shippers are devoting significant efforts to improve the sustainability of their supply chains, often driven by consumer and competitive pressures more than by specific regulations. These efforts typically include the following:

- Naming a senior executive to lead sustainability efforts, often chairing an internal sustainability council;
- Joining one or more of the voluntary industry sustainability groups;
- Working with suppliers and carriers to ensure sustainable practices at all stages of the supply chain;
- Establishing teams focused on supply chain or transportation sustainability;
- Setting annual and medium-term goals for sustainability, focused primarily on CO_2 reduction; CAP emissions are rarely the explicit subject of shipper sustainability objectives; and
- Publishing an annual report on sustainability, based on the format and metrics developed by one of the leading sustainability councils.

Shippers most focused on supply-chain sustainability appear to be those making or selling consumer products. Although all companies are required to meet regulatory standards, companies in industries such as apparel and food are particularly sensitive to their sustainable brands and make special efforts to reduce their emissions and communicate their efforts. In other cases, corporations report that having an active sustainability program is essential to winning competitive procurements in a business-to-business environment.

Small companies face special challenges in mounting an effective supply-chain sustainability effort. There are steps that all firms can take, however, even though the benefit-cost equation will vary from case to case. These include

- Naming an internal champion for sustainability;
- Analyzing the environmental footprint of the company's end-to-end supply chain, including activities by suppliers, carriers, distributors, and retailers; and
- Joining an appropriate industry consortium to learn more about the issues and solutions.

These are practical steps that manufacturers and retailers can take to become more informed and proactive in driving their supply-chain sustainability.

Carrier Initiatives

Carriers are the most directly impacted by air emissions regulations. Although shippers are interested in their overall supply chains, as part of their corporate sustainability efforts, carriers are required by local, state, federal, and international regulations to implement new technologies and operations in order to limit their GHG and CAP emissions. As such, carriers were found to be highly attuned to air emissions issues (primarily in respect of GHGs but, in some cases, focused on CAP emissions as well). This section highlights the efforts of two leading parcel carriers, UPS and FedEx.

UPS

UPS has paid great attention to its sustainability programs and made these efforts a part of its brand. The company is highly focused on helping its customers reduce the carbon footprint of their supply chains. UPS set some impressive overall objectives for sustainability in its transportation activities, as follows:

- Increase average in-service MPG for package cars in the U.S. domestic package segment by 20 percent (from 2000 to 2020).
- Reduce global CO_2 emissions by 20 percent (from 2005 to 2020). Supporting initiatives include reduced aircraft flight speeds; computer-optimized flight plans; computer-managed aircraft gate departure, arrival, and taxi times; bio-diesel in ground support equipment; environmentally friendly paint that reduces drag; and cleaner engines ("Sustainability at UPS," 2010).

For the U.S. line-haul trucking operation (UPS Freight), the company has emphasized optimizing its network operations and fleet using technology, as well as shifting to lower-emissions modes and experimenting with alternative-fuel vehicles (UPS Freight, 2012, pers. comm., June 27) as follows:

- UPS Freight created a package plan/routing system and database that allows customers to view package details, data, and options. The basis for the delivery route is the service commitment or requirement. Planning technology is then used to build a route that requires the least number of miles. This approach has been the basis for the reduction of the carbon footprint, using many fewer miles to deliver freight than in the past.
- The other part of the package plan system is reduction in idle time. For each driver, UPS Freight has been able to reduce idle time by 50 minutes per day.
- These efforts have driven a 28 percent reduction in fuel use to move a ton of freight (2006-2011). The savings equate to 400,000 gallons of fuel and a corresponding tonnage of CO_2.
- The next aspect of reducing emissions is the rolling laboratory approach, focusing on vehicles, fuel, telematics, and differences between rural, urban, and long-haul heavy freight movement.
- Shifting freight from truck to intermodal rail is a key element of UPS Freight's plan for long-haul lanes. The company enjoys strong relationships with all of the major railroads. UPS is currently working to develop an intermodal solution for 2-day delivery work, which currently can only be met by road solutions. Intermodal rail reliability is at an all-time high, as the railroads focus less on coal and more on their intermodal product.

UPS has actively experimented with alternative-fuel vehicles—it has 2,600 in its global fleet today. These vehicles have traveled over 200 million miles since implementation. UPS' first alternative vehicle was an electric one in the 1930s. Current alternatives in use include LNG, CNG, propane, hybrid electric, electric, hydraulic hybrid, biomethane, and composite vehicles (that yield 40 percent fuel savings). UPS recently took a decision to add 150 of the composite vehicles to the fleet (UPS Freight, 2012, pers. comm., June 27).

One of the ways UPS has extended its sustainability brand is to offer customers a carbon-neutral shipping option (using carbon offsets) and eco-friendly packaging. This is offered in many countries and is widely available, though actual volumes are still low. The carbon-neutral product has been third-party validated. UPS expects demand to grow as consumers become more aware of the sustainability advantages. To encourage demand, UPS initially matched customer cost (up to $1 million, by 2011). The carbon offsets are viewed as a cost-effective way to address carbon in the supply chain. (UPS 2012, pers. comm., May 11; UPS, 2012).

FedEx

FedEx presents its sustainability efforts to customers and partners in an annual Citizenship Report. This emphasizes the "simple goal" of connecting "the world in responsible and resourceful ways." Environmental and efficiency goals are highlighted, such as aircraft emissions, alternative energy vehicles, recycling, and electricity generated by solar facilities.

Ambitious targets have been set, such as improving fuel efficiency and CO_2 emissions of the FedEx fleet by 20 percent by 2020 (from a 2005 baseline). One of the main levers to achieve this goal is to increase the electric and hybrid fleets by 20 percent. By the end of FY2011, FedEx had 408 electric and hybrid vehicles in operation, saving substantial fuel and reducing CO_2 emissions. FedEx Express vehicles' fuel efficiency has improved by more than 10 percent annually for the past 3 years. FedEx Express and FedEx Freight have each received an EPA SmartWay score of 1.25, rated outstanding (FedEx, 2011).

FedEx expanded its sustainability brand by launching, in April 2012, a worldwide carbon-neutral envelope-shipping program. FedEx purchases the equivalent amount of CO_2 offsets from BP Target Neutral for all global FedEx envelopes shipped, at no extra charge to customers (a first in the industry, according to FedEx). As of April 10, 2012, every Express envelope that moves through the system is being offset. FedEx is currently exploring opportunities to offer a similar program for non-envelope packages. Customers like the idea of carbon-neutral shipping and are asking FedEx, "What is our carbon footprint?" With the new program, FedEx can show customers

that their carbon emissions are now effectively zero for envelope shipping (FedEx, 2012, pers. comm., May 21).

Lessons from Carrier Initiatives

Carriers in all modes are highly focused on sustainability in their equipment and operations. This is partly due to the direct correlation between GHG and fuel consumption, providing a strong environmental co-benefit to measures essentially aimed at fuel savings. Sustainability practices by carriers are driven by regulations in a more clear fashion, since regulators have required carriers to introduce cleaner engines, other equipment upgrades, and operational changes to improve air quality and address global warming concerns.

Why do some carriers go above and beyond the existing environmental regulatory requirements? This appears to stem, as it does for progressive shippers, from a desire to differentiate the company and its service in the eyes of its customers, whether consumers or corporate users. Parcel carriers, in particular, are highly sensitive to sustainability issues, which can be attributed in part to the nature of their business, involving daily contact with many thousands of consumers, often in busy urban and suburban areas. Other carriers (Maersk or Con-Way, for example) appear to believe that proactive environmental practices will help qualify them for the business of shippers who are sensitive to sustainability, or that they will in some indirect fashion gain favor with the public by their actions.

The main issues from carriers involved situations in which, reputedly, regulators did not sufficiently solicit or heed the advice of the private sector. Carriers can become frustrated when (in their eyes) ill-considered rules are imposed. The practical solution appears to be the involvement in policy discussions and rulemaking, early on and in a meaningful way, of carrier representatives. Carriers are often eager to be consulted. They bring a wealth of knowledge based on their own experimentation with different solutions, which can be leveraged by regulators to hone in on the best win-win alternatives.

APPENDIX F

Supply-Chain Sustainability Metrics

Introduction

This appendix presents the broad range of existing metrics for supply-chain performance (as these relate to air quality and GHG emissions) that are in use by shippers and carriers and required or proposed by public agencies.

In reviewing the metrics commonly employed to assess transportation supply chains, it was found that different agencies in the public and private sectors focus on very different sets of metrics, that ends and means are commonly confused in discussions of sustainability metrics, and that the distinction between outputs and outcomes is not always made. Therefore, the team developed a supply-chain sustainability metrics map that attempts to address the relationships between the regulatory drivers, shipper/carrier considerations, impacts, outputs, and outcomes. It is intended to enable a better understanding of the effects of decision making on impacts (such as mode share), outputs (such as air emissions), and outcomes (for example ambient air quality, health, energy security).

Sustainable Supply-Chain Definition

To direct and refine the metrics that are of relevance to supply-chain sustainability, a definition of supply-chain sustainability was developed. This was based on findings of the literature review and discussions with public- and private-sector interviewees. It is considered that the metrics employed should reflect, as far as possible, the components of the following definition of sustainable transportation supply chains:

Sustainable supply chains connect a competitive economy in an efficient manner, consistent with human and ecosystem health, at the same time reducing reliance on fossil fuels. Specifically, they

- Enable efficient, safe, reliable, and cost-effective freight distribution by a choice of transport modes;
- Reduce unnecessary freight movements, minimize distance traveled, and maximize loads with effective planning; and
- Are supported by public policy, regulation, infrastructure, and financial incentives that optimize land-use configurations, promote promising technologies, and minimize the impacts of harmful air and noise emissions on communities.

Types of Sustainable Supply-Chain Performance Metrics

The Task 1 literature review and Task 2 stakeholder interviews identified a range of different types of performance metrics as these pertain to the sustainability impacts of supply chains. These include those metrics reported by private companies under voluntary reporting frameworks, metrics that are monitored and developed by the public sector as part of their regulatory role, and supply-chain metrics that are commonly deployed by supply-chain participants themselves. These are discussed in more detail in the rest of this appendix.

Voluntary Reporting Frameworks

A review of voluntary corporate sustainability reporting programs found that GHG emissions are more commonly reported than CAP emissions and that shippers do not commonly report on transportation emissions (although carriers are more likely to do so). The exception to this is the EPA SmartWay Program, which is specifically focused on logistics emissions.

Commonly used corporate sustainability protocols (such as the Carbon Disclosure Project, the Greenhouse Gas Protocol, the Carbon Trust, and EPA's Climate Leaders Program) are focused on climate change and hence GHG emissions. Note, however, that under these reporting regimes at present, *shippers* are not obligated to and do not typically include freight transportation emissions in their reporting unless these occur

from fleet vehicles. These reporting regimes do not currently encourage shippers to consider their lifecycle emissions. Nevertheless, several reporting protocols (such as the Carbon Disclosure Project Supply Chain Program and the Carbon Trust PAS 2050 carbon footprinting standard) are pushing beyond such boundaries, motivating shippers to address the issue of carrier emissions in their reporting, and requiring the measurement of GHG emissions from goods and services throughout their entire lifecycle, from sourcing raw materials, through to manufacture, distribution, use, and disposal.

Another widely used program is the Global Reporting Initiative (GRI) protocol, which, in addition to Scope 1 and 2 carbon emissions and CAP emissions reporting, includes a protocol for reporting the significant environmental impacts of transporting products and other goods and materials used for the organization's operations. These impacts include energy (or fuel) use, GHG and CAP emissions, and noise.

The Clean Cargo Working Group (CCWG) has developed a calculator that provides an industry standard for assessments and sharing of information in respect of the air emissions impacts of container shipping. The CCWG has assembled emissions data (CO_2, SO_x, NO_x) from some of the largest transportation carriers as part of the creation of measurement tools that did not exist previously. Carriers report on vessel capacity, distance sailed, fuel consumed, and number of reefer plugs. The CCWG Performance Metrics Tool uses this information to calculate vessel CO_2 emissions (the general formula for this calculation is total kg fuel consumed for containers, multiplied by 3114.4 gCO_2/kg fuel, divided by the product of [maximum nominal TEU capacity * total distance sailed]; see http://www.bsr.org/en/our-work/working-groups/clean-cargo). Other data reported includes average sulfur content of fuel, and engine NO_x performance (BSR, 2011).

National Ambient Air Quality Standards

Under the requirements of the Clean Air Act, the EPA sets National Ambient Air Quality Standards for the six principal pollutants. The primary standards, which are the limits set to protect public health, set levels (in parts per million or mg/m^3) for pollutants such as nitrogen dioxide, PM, ozone, and sulfur dioxide. Areas where air pollution levels persistently exceed the National Ambient Air Quality standards may be designated nonattainment areas by the EPA. In areas that do not comply with the National Ambient Air Quality Standards (NAAQS), the Clean Air Act (CAA) requires the preparation of a state implementation plan (SIP) to demonstrate how the area will come into compliance with NAAQS. Part of the process of developing a SIP involves the creation of an emissions inventory. These emission inventories also are used to demonstrate "rate of progress" toward NAAQS attainment. Further, where infrastructure (e.g., port or railyard) expansion will affect an area's attainment status or rate of progress, emission inventories may be prepared for environmental impact statements (EIS) as part of the NEPA requirements.

State and local air pollution control agencies are responsible for developing CAP emissions inventories (by year, pollutant, county, and air basin) as part of the development of the states' air pollution control programs. Various agencies contribute data to these inventories including the Air Resources Boards, air pollution control and air quality management districts, state departments of transportation, and regional transportation agencies. Port authorities (such as POLA, the Port Authority of New York and New Jersey, South Carolina State Port Authority) also produce their own air emissions inventories. In the case of the Californian ports and the Port Authority of New York and New Jersey, these include GHG emissions as well as pollutant emissions, by source.

There are compelling non-regulatory reasons for ports to develop and maintain an accurate assessment of port-related emissions. These inventories enable ports to be engaged in national and regional discussions about environmental issues. Inventory data also ensures that they have sufficient understanding of the sources of their emissions such that they are well prepared to participate in discussions and respond to new regulations and initiatives, particularly where ports are growing or where they are located in regions that may be designated as a air quality nonattainment area in future (Ang-Olson, 2004).

Health Risk Assessment

Regulatory agencies (such as CARB) also may undertake health risk assessments for particular sites, based on the exposure of populations to emissions. Typically, these include metrics such as risk of deaths attributed to respiratory illness as a result of freight emissions, cancer risk, risk of non-cancer chronic health effects from diesel PM, school days lost due to respiratory illness, and health costs associated with respiratory illness.

GHG Emissions

Presently, there are no federal-level performance measures for freight-related greenhouse gas emissions. However, there are estimates of emissions that can be monitored as general measures of the trends related to GHGs generated by the freight sector. Typically, the EPA generates these estimates by multiplying fuel-use data by the emission factors generated from several sources.

In California (following the enactment of the California Global Warming Solutions Act of 2006, AB 32), CARB has been tasked with helping to address global warming and thus has responsibilities to develop and maintain a greenhouse gas emissions inventory and oversee mandatory reporting of

GHG emissions by large private-sector emitters. Transportation emissions from heavy-duty trucks, shipping, aviation, and rail are reported (in total tonnes of CO_2e) as part of the greenhouse gas inventory.

EPA SmartWay Metrics

EPA SmartWay reports on a range of metrics associated with the program including the following:

- Number of partners;
- CO_2, PM, and NO_x reductions (tonnes) achieved;
- Fuel savings ($ and gallons)—relative to a base case without the SmartWay Program initiatives;
- Oil savings (barrels)—relative to a base case without the SmartWay Program initiatives;
- Absolute reductions in emissions achieved as a result of the SmartWay Program; and
- Environmental justice—number of susceptible populations (poor, minorities, children, the elderly) affected by pollution.

State Departments of Transportation Metrics

State DOTs tend to be concerned with the performance of transportation infrastructure and the benefits derived from infrastructure investments. Typical measures include

- Velocity,
- Throughput,
- Reliability,
- Congestion,
- Environmental impacts, and
- Security.

The literature review and stakeholder interviews confirmed that the impacts of specific infrastructure projects may be measured in terms of the following:

- Reductions in traffic delays,
- Improvements to safety,
- Economic benefits from decreased congestion,
- Energy/fuel benefits, and
- Reductions in community severance.

The railroads involved in this project assess benefits in terms of improvements to rail running time.

EPA Regulatory Impacts Analysis (RIA)

As part of their rulemaking in respect of air emissions, the EPA undertakes regulatory impact analysis and reports on the costs and benefits of regulations. Metrics include, for example, the following:

- Forecast emissions reductions (by pollutant in tonnes per year),
- Forecast premature deaths averted (lives saved per year),
- Forecast relief from respiratory symptoms (number of people per year),
- Monetized health-related benefits (in $),
- Costs of reduction of pollutants ($/tonne by pollutant—$NO_x$, SO_x, PM), and
- Impacts on carrier operating costs (% and in $ per ton or TEU).

The RIA approach is not only independent, but it also combines the three cornerstones of sustainability (environment, society, and economy) into a single approach. It includes composite metrics, such as cost per tonne of pollutant reduced, which enable a more integrated assessment of environmental benefits relative to economic costs. It also potentially enables comparison of the relative costs and benefits of different approaches to emissions mitigation.

Complexity of Monitoring Supply-Chain Performance

The review of the literature pertaining to supply-chain performance indicates that even without the inclusion of environmental and social sustainability performance considerations, the monitoring of supply-chain performance on the part of the private sector is extremely complex.

Cai et al. contend that it is often difficult for supply-chain managers to figure out the intricate relationship between different key performance indicators (KPIs) in the supply chain, and the order of priority of these KPIs. Their analysis shows that traditional measures of supply-chain performance are usually classified into four categories: quality, time, cost, and flexibility. However, the cause and effect relationships between KPIs are not always clear.

Shepherd and Gunter (2006) claim that within the private sector there is a disproportionate emphasis on cost in most supply-chain performance assessments, while other aspects (such as quality, time, flexibility, innovation) tend to receive significantly less attention. Their analysis highlights the paucity of environmental performance measures in traditional approaches.

Quariguasi Frota Neto (2008) asserts that win-win solutions for the environment and business are elusive in practice and that initiatives on the part of private companies, which are both profitable and environmentally friendly, are the exception rather than the rule. He points to the "family" of activities influencing the environment and costs in supply-chain networks, of

which transportation is just one aspect. He contends that the multitude of trade-offs and decisionmakers affecting environmental and financial performance obscures causal relationships and makes informed decision making (as well as monitoring) extremely difficult.

Cottrell (2008) investigates freight transportation performance metrics used by carriers. He notes that freight transport providers are typically concerned with financial performance measures and customer service metrics, which generally are not consistent with those used in, or of interest to, the public sector. His research also draws attention to the lack of uniformity in performance measurement across freight transportation mode. Cottrell's analysis reveals that the measures of interest depend on the role of the agency (i.e., users, shippers, carriers, regulatory authorities) and the geographic scale of their interest (local, regional, and national). Further, he notes that the critical distinction between the performance measures suggested in literature, and those actually applied in practice, is the availability of data to compute the measure (Cottrell, 2008).

Use and Availability of Freight Transportation Metrics

The result of stakeholder consultation undertaken as part of *NCFRP Report 10: Performance Measures for Freight Transportation* is useful to this research insofar as it reveals the relative availability and utility of different metrics to various stakeholders. Public-sector stakeholders are typically interested in less frequently updated measures to assist with policy, planning, and infrastructure-investment decisions. Private-sector stakeholders are more interested in continuously available measures to make daily operational decisions including reliability and travel time measures.

The research found that within the public sector, the minority of states that have freight performance measures use only a handful (up to 5 and 10 measures in "mature" states), that no two states had the same measures, and there are wide differences in the metrics. The most commonly reported metrics relate to the performance of infrastructure including level of services (LOS), traffic volume, vehicle-miles traveled (VMT), travel time, speed, incidents, duration of congestion, and percentage of system congested.

The research found that the cost of logistics ranked lowest on the list of state DOT's preferred performance metrics. Performance regarding the emissions, pollution, and energy impacts of freight also ranked very low. Local congestion and reliability were the highest rated.

Environmental performance metrics rated second highest overall for federal agencies, after estimates of future demand. For truckers, the use of performance measures to make business practices more efficient was by far the strongest motivator. Rationales included improving bottom line return, increasing operational efficiency, increase productivity, controlling costs, or improving and measuring productivity. Specific measures included

- On-time pickup and delivery,
- Revenue yield by shipment or mile,
- Fuel economy,
- Equipment utilization, and
- Out-of-route and loaded miles.

The freight transportation system is a mixture of public and private infrastructure, private carriers and shippers, public planning and regulatory bodies, and other players interacting at global, national, regional, and local scales. The researchers assert that the challenges presented by growing demand for freight movements in the face of physical, economic, and environmental constraints are beyond the capabilities of any one private entity, level of government, or community of interest. Collaboration among diverse public and private parties is required to meet the challenges effectively. Programs need to be developed in partnership, with metrics based on balancing considerations.

The research suggests the creation of a freight system report card that relies upon existing sources and reports freight performance measures across the following six categories:

1. Freight demand (volumes);
2. Freight efficiency (speeds, reliability, cost as a % of GDP);
3. Freight system condition (bridge and road condition);
4. Freight environmental impacts (total GHG and CAP emissions by mode);
5. Freight safety; and
6. Adequacy of investment in the freight system.

Metrics Map

The literature review, stakeholder interviews, and research in respect of supply-chain performance metrics indicate that for supply-chain participants the range and complexity of supply-chain issues and the relationships between them is daunting even without the additional overlay of environmental and social sustainability considerations.

The research highlights that a range of data relevant to supply-chain sustainability is collected by various different agencies, depending upon their mandates or areas of concern. Although various data are available, these data are in the hands of a range of organizations. Further, the parameters of these data vary and they relate to various aspects of the supply chain. Some relate to inputs or means (e.g., vehicle fuel efficiency, freight miles), while other parameters relate to ends or outputs (e.g., GHG emissions or CAP emissions) and still other data relate to outcomes (e.g., ambient air quality, health,

and noise impacts). Recognition of the relationships between these parameters is critical to understanding the drivers, causal relationships, and linkages in sustainable supply chains.

Based on Singh et al., the research team concluded that ideally a useful set of sustainability indicators is transparent; clearly distinguishes between ends and means; enables balanced consideration of social, economic, and environmental considerations; and should reflect the priorities of the communities of interest.

Thus, the researchers developed a sustainable supply-chain metrics map that attempts to identify the influences and relationships between the different types of sustainability metrics. The categories identified incorporate critical freight performance measures as well as sustainability considerations and builds upon what is currently being measured and where data is most likely to be readily available. The sustainable supply-chain metrics map shown in Exhibit F-1 is intended as a guide to potential metrics that might be employed in assessing sustainability impacts, allowing a range of data to be captured depending on availability. It is also intended to allow for the use of data from both public- and private-sector data sources and, for example, to permit the development of composite metrics such as cost (to carriers or shippers) per tonne of emissions reduced.

Proposed Metrics

Regulatory Drivers

The regulatory driver metrics (Exhibit F-2) set the context for actions on the part of the supply-chain actors. They directly affect shipper and carrier behavior as well as impacts, and hence, outputs. They may be influenced by outcomes. These metrics are generally inputs into the sustainable supply-chain

Exhibit F-1. Supply-chain sustainability metrics map.

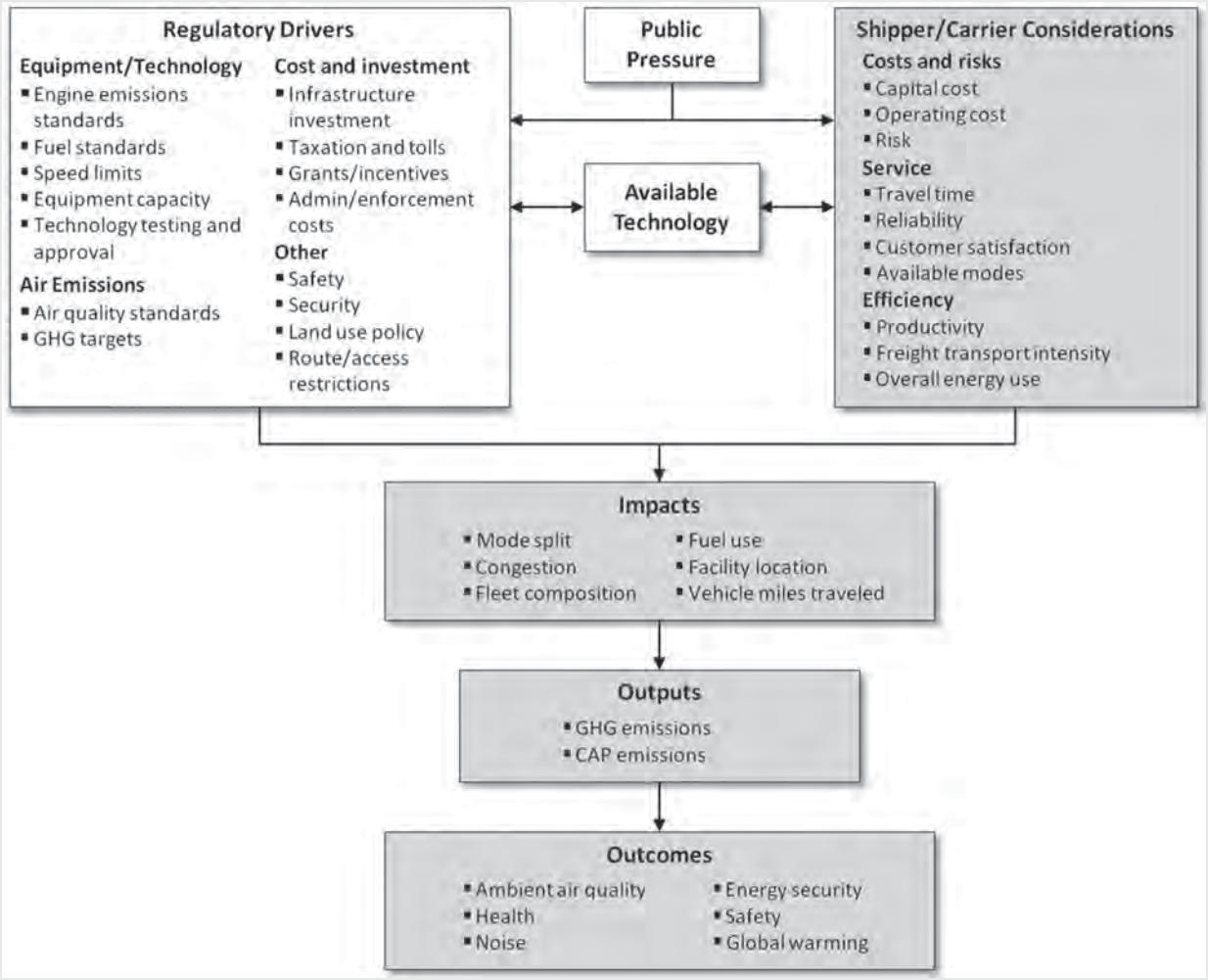

Exhibit F-2. Regulatory drivers metrics.

Consideration	Measure	Applicability
Engine emissions standards	Standards for CAP emissions (usually expressed as g/bhp·hr)	Applicable to all modes, including • Standards for heavy trucks • Locomotives • Off-road engines • Category 3 marine engines • Harbor craft
Vehicle fuel economy standards	Average fuel consumption (gallons per 1,000 ton-miles)	Applies to trucking. Standards are currently proposed at the federal and state (California) levels.
Fuel standards	Permitted level of sulfur in fuel (ppm)	Applies to all modes.
	Fuel carbon intensity	Federal low carbon fuel standard proposed
Speed limits	Expressed in mph	Applies to trucking only.
	knots	Applies to shipping.
Truck weight and length	Gross vehicle weight (in pounds) length (in feet)	Applies to trucking only. Typically improved efficiencies can be achieved as weight and length increases. (This can impact mode shift to trucking.)
Ambient Air Quality Standards	Standards for pollutants (typically expressed in ppm or µg/m^3)	Typically set as the federal level. Nonattainment invokes a requirement for a state implementation plan (SIP), which may include measures to reduce emissions from freight.
GHG targets	% reduction over a base year	Currently applied at the state level in more than 20 states.
Land use controls	Policy, zoning, and permitting for DCs	Impacts locational options and vehicle miles.
Route and access restrictions	Limits on truck access	Impacts locational options and vehicle miles.
Infrastructure investment	$ invested	Includes all modes. May include public-private partnerships.
Taxation	Vehicle taxes	Typically affects truck carriers.
	$ per gallon (fuel)	Typically affects truck carriers.
Grants/incentives	Total $ value by type	Usually levied to encourage uptake of cleaner/greener technologies.
Admin/enforcement costs	Cost in $ to the public sector	Utility of regulation is in part driven by the ease/cost of implementation and enforcement.

system. The exception to this is Administration and Enforcement Costs associated with regulation or financial incentives. These, for example, may be considered together with Shipper or Carrier Costs to develop an understanding of the overall costs of emissions-reduction efforts.

Shipper/Carrier Considerations

These metrics (Exhibit F-3) are the main issues that private-sector shippers and carriers need to balance. They are subject to external forces including the availability of technology (such as vehicle technology, marine vessel design, ITS) as well as public pressure and expectations. The latter encompasses community action, public sustainability expectations, and industry sustainability reporting norms. Individual shipper/carrier considerations may assume different levels of importance under various circumstances. Decisions relating to the balance of these considerations affect freight transportation impacts (such as freight mode split, fleet composition, fuel use). There is a degree of reverse interaction between impacts and shipper/carrier considerations, too. For example, congestion levels and distances to distribution centers will impact travel time and operating costs.

Freight Transportation Impacts

Freight transportation impacts (Exhibit F-4) occur as a result of the interaction between regulatory drivers and shipper/carrier considerations. They are key determinants of emissions.

Outputs

Outputs refer to the air emissions from freight transportation and logistics operations. These are typically those associated

Exhibit F-3. Shipper/carrier considerations metrics.

Consideration	Measure	Applicability
Capital costs	Investment ($)	Applies to cost of investment in sustainability made by shippers/ carriers either as a result of regulation or of voluntary initiatives
	Payback period (years) or return on investment (ROI)	Return on investment
Operating costs	$ per tonne mile	Changes in shipper/carrier operating costs as a result of regulatory or voluntary initiatives
	Change in operating cost (%)	
Transit time	Average speed (mph)	Relevant across modes for shippers and carriers; includes slow steaming considerations for marine vessels
	Length of time in transit	Typically by route; applies across modes for shippers and carriers
Reliability	On-time deliveries as a % of total number of shipments	Applies to shippers and carriers
Customer satisfaction	Change in customer satisfaction ratings	Applies to shippers and carriers
Productivity	Ratio of vehicle-miles to ton-miles	Applies to truck carriers
	Miles traveled empty as a proportion of total miles	Applies to truck and rail carriers, as well as to fleets
	Average capacity utilization (average actual load as a proportion of full load capacity)	Applies to carriers of all modes as well as to fleets
Total energy use	Warehouse energy use intensity (total source energy use/by the gross floor area) measured in kBtu/sq ft (based on Energy Star performance rating methods)	Warehouse energy use impacts GHG emissions
	Direct energy consumption by source/energy type measured in GJ	This is a GRI reporting requirement; consideration of total supply-chain energy use is relevant to shippers in developing a lifecycle approach to emissions
Freight transport intensity	Total freight miles	Applies to shippers and carriers
	The ratio of freight movement to economic output expressed as ton-miles/revenue $	Applies to shippers and carriers

with vehicle emissions, but may also include secondary emissions associated with energy provision to warehouse operations. Where shippers are in a position to consider lifecycle energy use, lifecycle GHG emissions associated with the entire supply chain (and the proportion of these which are logistics related) may also be considered. However, it is considered that this is likely to be the exception rather than the rule for shippers at present.

There are various measures for reporting CAP and GHG emissions, depending on which agency is reporting. See Exhibit F-5.

Outcomes

Outcomes refer to the effects of air emissions from freight transportation and logistics operations. These relate primarily to CAP emissions in respect of ambient air quality and health impacts on affected populations. Noise has been included here, although the study tasks to date have not indicated that this metric is widely employed (other than in the EU). Data on noise impacts may need to be more qualitative for the purposes of case study assessments. See Exhibit F-6.

Conclusion

Various metrics are used by different agencies in the public and private sectors, with little commonality between agencies. Further, there are issues associated with data availability and compatibility (e.g., with different measures applied across modes and between agencies). For supply-chain participants (and for shippers in particular) the range and complexity of supply-chain issues, and the

Exhibit F-4. Freight transportation impacts metrics.

Consideration	Measure	Applicability
Mode split	Total freight ton-miles by mode	Mode choice impacts emissions, journey length, route, fuel consumption and emissions Frequently reported by carriers (e.g., Wal-Mart, Stonyfield Farm)
	Amount (%) of cargo shifted to "cleaner" modes	
Congestion	Standard deviation from mean travel time	Applies to road and rail carriers
	Average delay in hours	Route-based measure
	Relative congestion—the ratio of average delay over total transport time (measured as hours/ton-km)	
	Congestion costs (measured in $ terms based on value of time of total hours lost)	Financial measure often employed by DOTs
Fleet composition	Composition of fleet by model year, emissions standard (tier), and additional vehicle equipment specification	Applies to road and rail carriers; this is an indicator of potential emissions
	Composition of off-road equipment fleet by emission standard	Applies to port and rail facilities
Fuel use	Total fuel consumed by type (gallons)	EPA SmartWay measure; also reported as part of corporate reporting
	Average fuel consumption (gallons/ton-mile or TEU miles)	
	Fuel savings (%)	
Location of facilities	Average distance from distribution center to outlet	Applies to shippers and carriers
	Average trip length	
Vehicle-miles traveled	Total miles, by mode	Impacts overall emissions in interaction with other impacts (not a useful measure on its own)

Exhibit F-5. Freight transportation impacts metrics.

Consideration	Measures	Applicability
CAP emissions	Total CAP emissions (tonnes by pollutant)	Usually applicable to a facility such as a port or railyard; currently reported by agencies such as CARB and ports; applicable to carriers and shippers
	Total annual average CAP emissions (lbs per day)	
	Average CAP emissions (tonnes) per ton-mile and per ton	Applies primarily to carriers and shippers
	CAP emissions reductions (tonnes, %, and per ton-mile)	Applies to facilities, carriers, and shippers
GHG emissions	Total GHG emissions (tonnes of CO_2e)	Applicable to facilities such as a ports or railyards; currently reported by agencies such as CARB and (some) ports facilities; applicable to carriers and shippers
	Total GHG emissions (tonnes of CO_2e) from transportation and distribution by private-sector companies	Applies to shippers and carriers; required by Carbon Disclosure Project
	Tons of GHG by volume of units shipped	Measures of intensity typically reported by shippers and carriers, for example by Wal-Mart
	GHGs (in metric tons) emitted per million $s in sales GHG emissions	
	Total annual average GHG emissions (lbs of CO_2e per day) from freight transportation as a proportion of all GHG emissions	Frequently reported by the federal government
	Average GHG emissions per ton-mile and per ton	Applies primarily to carriers and shippers
	GHG emissions reductions (tonnes, %, and per ton-mile)	Applies to facilities, regions, shippers, and carriers

Exhibit F-6. Freight transportation impacts metrics.

Consideration	Measures	Applicability
Ambient air quality	Ambient concentrations of pollutants (measured in PPM)	Applied to a particular location affected by emissions
	Improvements in ambient air quality	Based on facility/mobile source emissions added to background levels
		Part of Air Emissions Inventory data
Health risks	Diesel exhaust concentration (24-hour average in ppm) and human intake estimates	Usually part of health risk assessments—linked to emissions inventories
	Risk of premature deaths due to cardiovascular disease and non-cancer health effects such as asthma and chronic obstructive pulmonary disease	Usually part of health risk assessments—linked to emissions inventories
	Estimated number of acres where cancer risk is higher than 10 in 1 million and population that resides therein	
	Non-cancer chronic health effects from diesel PM	
	School days lost due to respiratory illness	
	Health costs associated with respiratory illness ($)	
	Deaths attributed to respiratory illness as a result of freight emissions	
GHG targets	Contribution to emissions target	Where reduction targets exist
Noise	Total distance exposed to noise levels above 50 dB or 55 dB for rail	Not commonly reported; metrics employed in EU Super Green Project; noise has recently been added to GRI reporting for airports
	Qualitative assessments may be required (e.g., based on time of exposure and relative level of noise from vehicles and equipment	
Energy security	Oil savings (barrels)	EPA SmartWay measure
Safety	Incidence of crashes, accidents, injuries, and fatalities by mode and ton-miles	Relevant to all supply-chain participants

relationships between them, is daunting even without the additional overlay of environmental and social sustainability considerations.

The supply-chain sustainability metrics map is intended to provide an initial framework to better expose the relationships between different supply-chain parameters that ultimately affect air emissions and the associated sustainability outcomes of supply-chain activity (including, for example, ambient air quality, health, safety, energy security, and noise). The framework also can enable causal relationships and linkages to be imputed using qualitative assumptions in the absence of quantitative data.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
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
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
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