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DRAFT FOR REVIEW

Air Quality Impacts of Freight Sector Innovations

Prepared by the Texas A&M Transportation Institute

Prepared for the Texas Department of Transportation

August 2014

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AIR QUALITY IMPACTS OF FREIGHT SECTOR INNOVATIONS

Air Quality and Conformity Inter-Agency Contract

Subtask 2.2 Air Quality Impacts of Alternative Modes and Fuels - FY2014

Prepared for

Texas Department of Transportation

By

Texas A&M Transportation Institute

August 2014

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INTRODUCTION

This report summarizes findings from the Air Quality and Conformity Inter-Agency Contract (IAC), Subtask 2.2 (Air Quality Impacts of Alternative Modes and Fuels), focused on the future of freight and implications for air quality. The aim of this task was to study the current landscape in terms of freight sector innovations and changes, and discuss potential impacts in terms of air quality and conformity for Texas. This report lists various strategies and technologies (both currently available and future technologies) and discusses them in the context of air quality impacts.

This report builds on the previous work completed in past years under the Air Quality and Conformity Interagency Contract, including a study of the impact of emissions associated with different freight modes (*1*), and another report that looked at fuel and engine technologies available to agencies to assist in compliance with emissions reduction programs (*2*). By addressing the information in the aforementioned reports, as well as additional available data, this report outlines the findings and describes what the findings mean in terms of future outlook. The following sections of this report provide an overview of the freight sector, assess current and future technologies to assist in reducing emissions in the freight sector, and discuss the findings and how they affect air quality and conformity including the modeling or gaining credit from a mobile source/transportation budget standpoint.

FREIGHT SECTOR OVERVIEW

Freight moves throughout the U.S. on 164,000 miles of the National Highway System, 138,500 miles of railroads, 11,000 miles of inland waterways, and over 1.7 million miles of pipelines. It is expected that by 2035, freight volume will double within the U.S. while international freight volume will triple. As the industry expands to sustain a burgeoning economy, on the flipside it is associated with problems of corridor congestion and delays, which have direct environmental and health consequences as well as a loss in both time and money (*1*,*3).*

Freight movement is linked to an economy’s growth and productive capacity, and is seen as a crucial factor in facilitating domestic and international trade. Efficient and reliable movement of freight keeping in mind changing needs is therefore of increasing focus in Texas as well as around the world. The Texas Department of Transportation (TxDOT), for example, is in the process of developing its first comprehensive Freight Mobility Plan (*4*). The US Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) are also working on several initiatives to address freight transportation concerns, including the establishment of a National Freight Advisory Committee (*5*). There are also several global research efforts underway discussing freight in the context of changing global needs and urbanization (*6*).

Freight Volumes

In the U.S., over 19 billion tons of goods, valued at over $17 trillion, were moved in 2012 according to the FHWA. These numbers are both represent the highest numbers seen, passing the previous record numbers reached in 2007. By 2040, the U.S. transportation system is expected to handle approximately 29 billion tons of cargo valued at nearly $40 trillion (*3*). The growing nature of the freight industry demands the support of a robust transportation network that best serves the ever-expanding pattern of trade and population.

Surface freight, specifically heavy duty trucks, make up the bulk of freight transportation in the U.S. In 2012 trucks accounted for 67% of the total tonnage and 64% of the total value of freight transportation in the US. This is by far the biggest segment of the freight movement, as the next highest contributor, railroads, accounted for only 10% of the tonnage and 3% of the value of fright moved in the US. The numbers in Texas are similar to the national numbers, with trucks making up 57% of the total freight tonnage in Texas and 59% of the total value of goods transported. Rail freight made up 11% of the total tonnage and 6% of the total value of goods transported by freight in Texas (*7*).

Freight Related Emissions

Trucks and locomotives, the main modes for freight transportation in the U.S. and Texas, are major sources of greenhouse gases (GHG) emissions as well as other emissions that are directly or indirectly harmful to human health, including oxides of nitrogen (NOx), volatile organic compounds (VOC), and particulate matter (PM). Thus, the air quality impact of freight movement is a significant issue, both in terms of climate change/GHG emissions and the emissions of other harmful pollutants. Diesel exhaust from freight trucks is a primary source of PM2.5, air toxic contaminants, and NOx emissions. Transportation sources account for nearly 30% of total GHG emissions in the U.S., one-third of which is emitted from freight transportation (*8,9*). Freight emissions have grown by more than 50% since 1990. Approximately half of mobile source NOx emissions and 27% of all NOx emissions at the national level are emitted from freight sources. Additionally, 36% of mobile PM10 emissions come from freight modes of transport.

There are existing engine emissions standards/regulations for criteria pollutants for heavy-duty vehicles and trucks. The United States Environmental Protection Agency (EPA), in collaboration with the National Highway Traffic Safety Administration (NHTSA) and the California Air Resources Board (ARB) are similarly working on extending GHG emissions standards to medium and heavy duty vehicles for Model Year (MY) 2018 onwards (*10*). Currently, GHG reduction efforts from the freight sector derive from the adoption of fuel-efficiency technologies, which have often faced several barriers to more widespread deployment (*11*).

EMSSIONS REDUCTION TECHNOLOGIES AND STRATEGIES

There is a wide variety of options available to transportation agencies and freight operators to reduce emissions from freight operations. In this report, we divide them into two categories:

- technological strategies; and
- operational, policy, and regulatory strategies.

Technological strategies include using cleaner fuels, increasing engine efficiency, and installing idle-reduction equipment. Operational improvements such as mandatory idling restrictions and using fiscal instruments to bring about economic efficiency, are other strategies to indirectly reduce freight transport emissions. Modal shifts (from truck to rail or barge or other modes) could also help reduce GHG and pollutant emissions. The following sections describe both technological and operational strategies that are currently available to reduce the emissions impacts of freight transportation. Also discussed are some technologies and operational strategies that are currently not available or implemented, but have a potential to have an impact in the future as their deployment becomes widespread.

Technological Strategies

There are many technological strategies available that could reduce the emissions impacts that freight transportation has on air quality. Many of these technologies are already available and being implemented today, where others are looking more at future possibilities that may one day be implemented. This section looks at these technologies and their possible emissions reduction benefits.

Exhaust Aftertreatments

Exhaust aftertreatment technologies, or retrofit devices, are those that remove emissions from the engine exhaust. In some cases, retrofits can eliminate up to 90% of pollutant emissions. Many of the effective after-treatment devices require the use of ultra-low sulfur diesel (ULSD). Some of the better-known diesel retrofitting, after-treatment devices are Diesel Oxidation Catalysts (DOC), Diesel particulate filters (DPF), and Selective Catalytic Reduction (SCR) Technologies. Diesel pollution consists primarily of PM and NOx, and, in this aspect, these devices can cause substantial reduction in those emissions (*1*).

Diesel Particulate Filter

DPFs are designed to collect PM in the exhaust stream and can be installed in both new and used vehicles. One mandate is that the filters must be used in conjunction with low sulfur diesel fuel because the sulfur in the diesel fuels can interfere with the regeneration process of a DPF. The high temperature of the exhaust heats the ceramic structure and allows the particles inside to break down into less harmful components. DPFs can reduce PM emissions by 50% to 90%, but do not affect NOx emissions. DPFs are particularly suited to be used on trucks, due to the sulfur requirement, but have been used on rail installations as well. DPFs are impractical for marine applications due to the high sulfur content of bunker fuels.

Diesel Oxidation Catalyst

Diesel Oxidation Catalysts use a chemical process to break down the pollutants found in diesel exhaust, converting them into less harmful compounds. A DOC device can achieve 20% reduction in PM emissions and up to 40% reduction in CO. Unlike DPFs, DOCs do not require the use of low-sulfur fuel. DOC technology only works on the soluble organic fraction of diesel PM emissions, which is why the overall emissions reduction is limited. DOCs are best for truck and rail applications, but may also be used in some marine applications.

Flow-Through Filter (FTF)

Flow-through filters push the exhaust through a filter which introduces turbulence in the exhaust flow. A catalyst is then used on the filter material which reduces the PM and CO emissions. Typically FTFs are less effective as DPFs, reducing PM by around 30%, but have fewer maintenance issues and do not require low sulfur fuel. This makes FTFs options for engines that may not be candidates for DPFs, such as locomotives or marine engines.

Selective Catalytic Reduction
Selective Catalytic Reduction technologies utilize a catalyst to convert NO_x to water and nitrogen. A SCR uses diesel exhaust fluid, urea, and injects it into the exhaust stream. The exhaust and the urea then travel through a catalyst where they are converted to nitrogen and water and are exhausted through the tailpipe. SCRs are typically installed downstream of a DPF to reduce both NO_x and PM. SCR systems rely on the exhaust being hot in order for the conversion to take place. This makes the SCR operate better for engines with predictable cycles, as engines that operating cycles are varying may not operate at the optimal temperature for the SCR to work efficiently. A SCR that is operating efficiently can reduce up to 80% of the NO_x emissions of a diesel engine.

Exhaust Gas Recirculation (EGR)
Exhaust gas recirculation is a NO_x emissions reduction technique used by gasoline and diesel engines, wherein the exhaust gases are injected back into the combustion chamber. This process results in a reduction in the net amount of NO_x released through tailpipe emissions. EGRs can reduce NO_x emissions by up to 50%.

Repowering

Repowering involves replacing an existing engine with a new engine. Repowering is a useful strategy to reduce emissions usually when the equipment has a longer life than the existing engine. It enables the vehicle to comply with newer and more stringent emission standards, often also improving fuel economy and lowering maintenance costs. Repowering can also include converting diesel-powered equipment (such as port cranes) to alternative fuels, such as propane or electrical power. When an engine is replaced in order to have the full emissions benefit the engine being replaced must be scrapped and not be reentered into service.

The emissions benefits of retrofits depend on many different factors. These factors include, but are not limited to:

- The age of the engine/vehicle being replaced
- The type of technology being used to replace the old engine
- The annual miles/hours of operation of the engine being replaced
- The number of engines being replaced
- The remaining life of the vehicle that a new engine is being installed on

Alternative Fuels

Clean fuels are becoming more widely accepted as alternatives to fossil fuels. They can be used in freight transport with little or no modification to the equipment. Compressed Natural Gas (CNG), Ethanol, Emulsified diesel, fuel additives, and the use of catalysts contribute to lesser vehicular emissions. The following discusses a few of the strategies.

Bio Fuels
Biodiesel is a renewable alternative fuel that is clean burning and can be produced from a wide range of vegetable oils and animal fats. It contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend. With little or no modifications, it can be used

in compression-ignition engines. A popular blend of biodiesel that also has commercial applications is the B20 biodiesel. It contains 20% pure biodiesel and 80% petroleum. Though the tailpipe emissions from B20 biodiesel are similar to its standard petroleum derived diesel counterpart, it has a lower life-cycle carbon foot print.

Natural Gas

Natural gas, in the form of CNG or liquefied natural gas (LNG), can be used to power on and off-road engines. Existing diesel engines can sometimes be converted to run on natural gas, or the existing engine can be replaced with a natural gas engine. Though CNG and LNG have a fossil fuel base, an advantage is that it can be processed from renewable sources such as landfill gas. CNG emits 70% to 90% less PM than conventional diesel.

Emulsified Diesel

Emulsified diesel mixes diesel, water, and other additives that can contribute to a reduction of PM and NO_x emissions. Any diesel engine can be run using emulsified fuel. However, the water content in the fuel reduces the energy content and therefore the power and fuel economy of the diesel engine running on emulsified diesel. Caution must be taken to ensure emulsified diesel does not sit for an extended amount of time as the water may settle out of the mixture and potentially cause problems. EPA data shows a potential reduction of 5 to 30% of NO_x and 20 to 50% of PM (*12*).

Propane

Propane engines use spark-ignition similar to a gasoline engine, or use either vapor injection or liquid injection. Propane is a clean burning fuel low in carbon. Using a propane engine instead of a diesel engine would result in lower hydrocarbon, CO, NOx, and other GHGs (*13*).

Fuel Cells

Fuel cells are an emerging technology that could have many uses in the transportation field in the future. Fuel cells use a chemical reaction with hydrogen and oxygen to create their energy. There is no need to store energy from an external source, which is required of hybrid electric vehicles. Fuel cell vehicles can either use pure hydrogen, or hydrogen rich fuels such as methanol, natural gas, or gasoline. Those that do not use pure hydrogen produce small amounts of CO_2, while fuel cell vehicles that use pure hydrogen produce no emissions, as the only byproduct of the chemical reaction is water and heat. Currently fuel cell vehicles are not mass produced, and freight vehicles powered by fuel cells are not a near-term solution. However, the emissions reduction possibilities from the vehicles make them an attractive alternative to conventional fuels (*8*).

Fuel Additives

Fuel additives, also known as fuel-borne catalysts (FBC), are additives that are added to the fuel to improve the combustion of the fuel which leads to a reduction in PM. While fuel additives can help with PM reduction they can also increase emissions of fine metal oxide particles if they are dosed above certain levels. Because of this, additives have been slow to gain traction from the EPA. To reduce this problem, additives can be used in conjunction with a DPF, or other retrofits (*8*).

Idle Reduction Technologies

The EPA estimates that idling long-haul trucks consume 960 million gallons of diesel fuel and emit 10.9 million tons of CO2, 180,000 tons of NOx, and 5000 tons of PM annually (*14*). Idling is most extensive when trucks are parked at truck stops or other roadside rest areas, often to allow the driver to sleep. Drivers tend to idle for extended periods to heat or cool the cab, to run vehicle electrical appliances, to keep the engine warm during winters, or simply out of habit. Using a heavy-duty truck engine to provide temperature control or electricity is grossly inefficient and causes unnecessary fuel consumption and pollutant emissions. Idle reduction (IR) technologies can be used to reduce emissions caused by extended idling. Following are the available IR technologies (*1*).

Internal Combustion Auxiliary Power Units

Auxiliary power units (APUs) are portable, truck-mounted systems that can provide climate control and power for trucks without idling. These systems generally consist of a small internal combustion engine equipped with a generator and heat-recovery system to provide electricity and heat. An electrically powered air-conditioner unit is normally installed in the sleeper for air-conditioning, although some systems use the truck's air-conditioning system. Because of the engine's smaller size, operating a diesel-fueled auxiliary power system uses only a fraction of the fuel that would be used by idling the vehicle's primary engine.

Fuel Operated Heaters

Direct-fired heaters (DFHs) are small, lightweight devices usually installed in the tool or luggage compartment. DFHs produce heat from the combustion of a small amount of diesel fuel in an auxiliary burner. DFH is the simplest of APUs. These systems can be used to heat up both the cab and the engine. DFHs do not provide air conditioning, power for appliances, or charge for the truck’s batteries

Thermal Storage Systems

A Thermal Storage Cooling (TSC) unit consists of a phase-changing material that stores cooling energy transferred from the vehicle air conditioning system while the vehicle is operating. TSCs can only provide cooling to the cab. A small amount of electrical power is required to operate the fans. A TSC system stores energy in cold storage as the truck is driven, and then provides air conditioning when the truck is not running. The stored energy can be used later for cab or sleeper berth cooling during periods of rest. Such systems only provide cooling, but can be paired with a fuel-fired heater for a complete heating and cooling package.

Stationary Idle Reduction Options

Truck stop electrification (TSE) can be installed at truck stops, service plazas, or rest areas to provide electric power, cooling and heating, and other services to a truck parking area. Truckers park, connect their trucks to a convenient power source, and use electricity. TSE allows truckers, without idling their engines, to operate on-board systems – sleeper cab heating and cooling, microwave ovens, refrigerators, televisions, telephones, personal computers, and other small appliances – while parked. Different from other idle reduction technologies, TSE provides “plug-in” power to operate accessory loads in the truck cab without running the engine at idle.

Aerodynamic Devices

Aerodynamic devices, used mainly on heavy duty trucks and tractors, improve fuel economy and therefore reduce emissions, by improving the aerodynamics of a vehicle. Aerodynamic devices can be used on the truck, trailer, or both. Aerodynamic devices can improve the fuel economy by 5% or more, depending on the technology. Many of the technologies can be used in combination to further improve the fuel economy. The U.S. EPA keeps a list of verified aerodynamic technologies through the SmartWay program (*15*).

There are five main types of aerodynamic devices that are on the SmartWay approval list. The types, and their estimated fuel savings, are as follows:

- Trailer Gap Reducers (1+ %)
- Trailer Boat Tails (1+ %)
- Trailer Side Skirts (4+ %)
- Advanced Trailer End Fairings (5%)
- Advanced Trailer Skirt (5%)

The EPA verifies each technology, but both the trailer gap reducer and the trailer boat tails are approved in combination with a trailer side skirt.

Low Rolling Resistance Tires

Like aerodynamic devices the EPA SmartWay program keeps a list of verified low rolling resistance tires. The rolling resistance of tires account for as much as 13% of the energy a truck consumes. Low rolling resistance tires are often called single wide tires, can improve fuel economy by up to 3% when installed and used properly. This can save up to 4 metric tons of CO_2 annually on a typical long haul truck (*8*).

Operational Strategies

Unlike technology strategies, operational strategies can be viewed as those that affect a larger number of vehicles (i.e. have a broader based deployment). Operational strategies are generally accomplished by public agencies or other entities implementing a mandate for the operational strategy to be adopted by each end user. The following section describes different operational strategies that are currently being enforced in order to reduce the emissions impacts of freight.

Idling Restrictions

Idling laws or restrictions vary by location, but follow a similar concept - whenever a vehicle is to be parked in a location for a certain amount of time they must shut off their engine in order to reduce emissions during extended idling periods. Violating the restrictions usually results in a warning or a fine, depending on the location. The amount of time a truck is allowed to idle before having to turn off the engine varies. The amount of emission reductions that can be achieved will depend on many factors, including the amount of idle time reduced and the number of engine on-engine off cycles due to the restrictions. The restrictions can reduce all gaseous as well as PM emissions due to the zero emissions when the engine is off.

Rail locomotives emissions can also be lowered through reduced idling if restrictions are implemented. Locomotives are idled for as much as 8 hours at a time while they are either waiting for cars to be loaded or while they what for other locomotives to pass. While there are times, such as in cold weather, when the engine needs to idle to keep the engine warm, locomotives are often idled when there is no operational reason to keep them running.

Port Access and Border Crossing Improvements

Freight traffic at both ports and border crossings can be very congested. Trucks can often experience significant wait times at both locations due to the access to the ports as well as security measures that are necessary at border crossings. These instances can lead to lengthy delays where trucks are "creep idling", with periods of idling followed by short bursts of movement. These types of activities can greatly increase the amount of emissions that are attributed to freight traffic at these locations.

While some solutions are long term in nature, whether it is better designed ports or more efficient scheduling, other solutions can be implemented sooner to reduce the emissions. At border crossings, for example, higher rates of pre-clearance participation can reduce the congestion at truck border crossings, leading to fewer emissions. Ports, as well as other locations, can provide climate controlled comfort stations to the truck drivers can get out of the trucks while they wait for their scheduled pick-up or delivery. The amount of potential emissions and fuel savings for these strategies depends on many different factors, including the amount of wasted idling that is removed as well as the efficiency of the newly designed ports (*2*).

Reduced Speed Limits

While congested roadways can lead to increased emissions from truck traffic, higher speeds also could contribute more to emissions than lower speeds. The emissions rates per mile of NO_x are nearly twice the emissions rates at 65 mph than they are at 20 mph. In order to save emissions, as well as reduce fuel consumption, lower speeds can be implemented. These changes can be driven by either local or state agencies, or can also be driven by truck fleets which implement lower maximum speeds for their drivers in order to save fuel and reduce costs. These changes are simple to make and can have large impacts on the air quality in regions with large percentages of truck traffic (*16*). This strategy can also apply to rail traffic, and some rail lines have experimented with it in the past.

Driver Behavior Training ("Eco-Driving")

Driver behavior has been found to have a fairly significant impact on emissions and fuel consumption. Driver behavior, such as accelerations, shifting techniques, route selection, accessory use, amount of stops, etc. can all affect the emissions of a truck. One way to improve this, especially for large truck fleets, is to have drivers take part in training courses offered by training organizations or vocational schools. In addition to the training, data from post training monitoring of the behavior, through engine data loggers and other technologies, can be used to review driving habits of the drivers and continuously improving the behavior of drivers (*16*). Incentive programs can also be used to entice the drivers to participate more readily in these activities.

Reduced Empty Mileage

An efficiency improvement that reduces empty mileage, from both rail cars as well as trucks, can have a large emissions benefit. Long haul trucking can have as much as 20% of their mileage be empty loads, when return shipments cannot be scheduled. This is also true for loads that are not empty, but also do not have a full load. By improving the operational logistics of both truck and rail freight the emissions impacts they have on the overall air quality can be reduced.

Future Emissions Reduction Technologies and Strategies

While the strategies and technologies discussed so far are currently available and being used, there are also ideas that are currently not ready for implementation but may have future impacts on the freight sector. The following section describes some of those technologies and strategies that may be implemented in the future.

Modal Shift

As discussed earlier currently over 65% of the freight transportation in the U.S. is handled by trucks. It is also known that trucks are much higher emitters than other modes of freight transportation, such as rail. On a ton-mile basis rail traffic is 2-4 times more fuel efficient than trucks and emit 1/3 of the total GHGs. Rail can also cut NO_x emissions by 2-3 times that of trucks (*17*). While the technology currently exists, there are other obstacles to quickly implement a modal shift. A shift from truck to rail freight can be led by either the individual choices of shipping companies or can be driven by government policies and regulations. However, in order to take advantage of the potential savings, there are long-term changes that must be implemented, such as the capacity of the rail system. If a large amount of freight is shifted from trucks to rail the rail system must have enough capacity to handle the increased load. If the shift is made and the rail system is not ready to handle the increased traffic the potential savings in emissions will be lost due to increased congestion on the rail system. This congestion could lead to increase rail idling, leading to higher rail emissions and reducing the benefits. In addition if the rail system cannot handle the increased loads in a timely manner, shippers are not going to be as willing to participate in the shift, for economic and practical reasons.

Truck Platooning

Truck platooning, or caravanning, has been shown to increase the fuel economy of trucks by as much as 15% (*18*). The concept behind platooning is simple: by reducing the amount of space between trucks to a short distance the aerodynamic drag on the truck is reduced. This reduction in drag leads to the increased fuel economy of both the lead truck and any other trucks in the platoon.

While this concept can be achieved today by drivers employing the same tactic, it can also be a safety hazard to both the truck drivers and others on the road. This leads to the need for technology to be developed and tested that will automate the platooning process and make it a safe and valuable technique. One technology that would be used is adaptive cruise control (ACC), which is based on radar. This technology is available today, and used in many high end luxury cars, where the vehicle uses radar to increase/decrease the speed of the vehicle when the cruise is set. By using the radar ACC can slow down a vehicle when approaching a slower moving vehicle in front, instead of running into the slower moving vehicle. ACC is a very important component to truck platooning, but even if each truck has ACC more technologies are needed. To safely implement the strategy each truck in the platoon must also communicate with each other. This will allow the vehicles to all respond to different situations simultaneously, and safer, that if each reacted independently.

Studies have already started using the technology, and have even been demonstrated in different conditions (*18,19*). As technologies continue to improve the viability of truck platooning will increase, and lead to a large potential reduction in freight emissions from trucks.

Freight Shuttle System

The Freight Shuttle System (FSS), currently being developed at TTI, is a new freight transportation system that could greatly reduce the emissions of truck freight by taking a large amount of the truck traffic off the roadways. The concept of this system is to use automated transporters on an elevated track. The FSS would transport trailers over short distances on the guided track from one point to another. The trailers would be dropped off and picked up from the end points by conventional trucks to be delivered to the final destination. The system is purported to reduce emissions from freight in two ways – through the use of electrically powered motors instead of diesel engines on the system itself, as well as through the reduction of conventional truck use (*20*). The FSS is only one example of various paradigm-shifting concepts that are being discussed that could potentially change freight transportation systems in the future.

DISCUSSION

As seen in this report, there are many different strategies that are available for reducing the freight impact on air quality. These strategies vary widely, from those already being implemented to those being in the early stages of the development and testing of technologies that will continue to improve the freight emissions performance.

Table 1 summarizes the strategies that are covered in this report. The likely practicality of enforcement of the strategies varies, and may depend on potential regulation, the need for training (in the case of driver behavior strategies) and other factors. In the case of strategies that are not viable in the near-term, future factors including the broader economic and policy context may affect how they are implemented. Some of the strategies outlined in the report are more viable than others. They may be easier to implement, more cost-effective, more economic benefits to users, more easily enforceable, and have more user buy-in than some of the other strategies. These more viable strategies are better candidates to be used to achieve SIP and conformity credits. Some of the strategies, such as reducing empty mileage, have large potential benefits in terms of fuel and emissions reductions, but are not easily enforceable or feasible.

Almost all of the strategies discussed would have to be implemented at the owner/operator level with owner /operator commitment and support. Some could reasonably be made enforceable and therefore be used in the Texas SIP and also be counted for conformity credits. Those likely to be impractical to enforce would not have much benefit to SIPs or conformity in Texas.

Table 1: Freight Emission Reduction Strategies Discussed

Strategy Name	Category
Exhaust Aftertreatments	Technological Strategy
Repowering	Technological Strategy
Alternative Fuels	Technological Strategy
Aerodynamic Devices	Technological Strategy
Idle Reduction Technologies	Technological Strategy
Idle Restrictions	Operational Strategy
Port Access and Border Crossing Improvements	Operational Strategy
Reduced Speed Limits	Operational Strategy
Driver Behavior Training	Operational Strategy
Reduced Empty Mileage	Operational Strategy
Mode Shift	Technological Strategy
Truck Platooning	Technological and Operational Strategy
Freight Shuttle System	Technological Strategy

However, there are strategies that are being implemented in other places. For example, the California Air Resources Board (CARB) recently enacted requirements that any trailer passing through California must have SmartWay verified aerodynamic devices installed. Violators can face fines of up to $1,000, for both the owner and driver, per day they violate the requirement. Other strategies, such as idle reduction technologies, are also good candidates for SIP and conformity inclusion, as they are easily enforceable, all that is required is a visible check, and can produce significant savings.

Many of the strategies will be difficult to implement, requiring either large fundamental changes to the freight sector, large investments into new or expanded infrastructure, or additional research in order to prove their viability as options for reducing the freight contribution to air quality problems. The freight shuttle is an extreme example. These strategies, while they should not be ignored as being potentially beneficial, should not be considered short term solutions to the problems of today. These strategies will require large investments into new infrastructure that will house the new technology and allow it to operate. Others, such as the truck platooning, require additional research and the development of new technologies that will allow the strategy to be safely deployed. Until these issues are resolved these and other strategies will continue to be long term possibilities, not near term solutions. Any future application of these strategies for SIPs and conformity would require the involvement of stakeholders, including TxDOT, TCEQ, and TTI about the strategies listed and how to move forward. Additional testing or modeling may be required to determine how effective the strategies would be if implemented in certain situations or areas. Once these steps have been completed a more thorough evaluation can be made about which strategies TxDOT, TCEQ, or local agencies want to implement for SIP and conformity credits.

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