RESEARCH REPORT

NOV. 2012

ROAD TRANSPORT: UNLOCKING FUEL-SAVING TECHNOLOGIES IN TRUCKING AND FLEETS

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Editors: Tessa Margaret Lee, Matthew Stanley Cullinen

Associate Editor: Benjamin Matek, Hilary McMahon

Contributing Authors:
Georgetown University McDonough School of Business:
Karthikeyan Ramachandran, Suneetha Kanchustambham, Van Wingerden, Olaolu Ladipo, Sachin Aggarwal, Andrew Rucker

Duke University: Fuqua School of Business and Nicholas School of the Environment: Adam Rigel

Report by:
The Carbon War Room Research & Intelligence Group

Design: **www.grahampeacedesign.com**

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EXECUTIVE SUMMARY

The Carbon War Room is considering the potential for achieving growth-positive and gigaton-scale greenhouse gas (GHG) emissions reductions in the operation of ground freight trucks and other commercial vehicles. At present, the global trucking and commercial vehicle sector is incredibly diverse in terms of the vehicles being used, as well as the purposes for which they are used and the conditions under which they are used. There is an almost equally wide range of proven technologies currently on the market that can increase the fuel efficiency of these vehicles. Confronted with a lack of globally-applicable hard data, the Carbon War Room has assessed a slice of the ground freight sector – long-haul Class 8 trucks operating in the United States – and a representative but narrow range of applicable efficiency technologies.

Notwithstanding our limited scope, our findings are substantial. If the tractor-trailer fleet of the United States alone were to adopt just seven efficiency technologies, the trucking sector would save 624 million tons of CO_2 emissions by 2022. Though the sector's diversity made the generation of more comprehensive figures difficult, the relative simplicity of the technologies in question allows us to confidently conclude that there is enormous potential for emissions reductions to be found in scaling the adoption of money-saving fuel efficiency technologies throughout the trucking and commercial vehicle sector worldwide.

Greenhouse gas emissions from all transportation sources will increase 80% by 2030

In the United States, over 26 million trucks of all classes hauled over nine billion tons of freight in 2010 alone

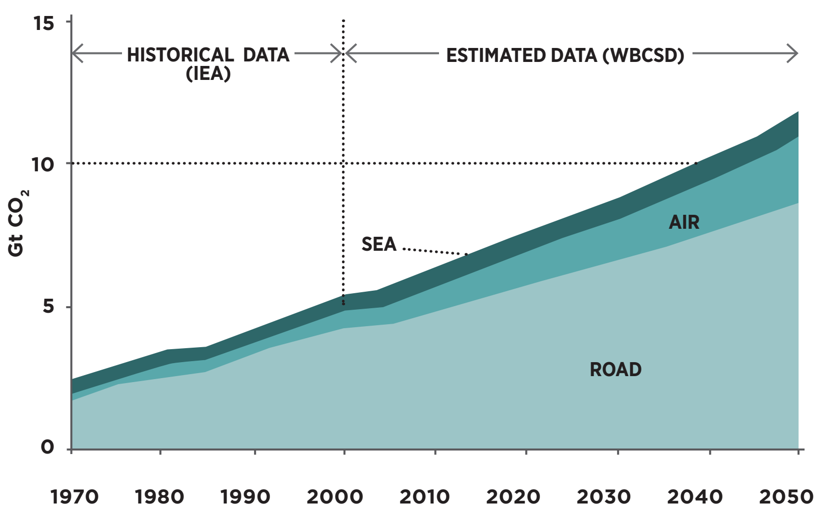
Key Findings

- The adoption of five physical technologies and two information and communication technologies (ICT)-based efficiency solutions by the Class 8 commercial vehicle fleet in the United States will prevent the emission of 624 million tons of CO_2 by 2022 under predicted industry growth rates.
- This suite of seven technologies represents average fuel savings of $26,400 per truck, with a payback period of just 18 months.
- The US is a key location for such savings, as the operation of heavy-duty vehicles consumed 50 billion gallons of fuel in 2010.
- Opportunities for fuel reductions fall into the two categories of physical technologies and ICT technologies; the adoption of a single physical technology could offer 3-15% emissions reductions and fuel savings over a ten-year timeframe.
- Key barriers to adoption include:
    - Access to capital and high upfront costs: though payback periods are short, truck owners struggle to finance these technologies upfront
    - Principal-agent problem: often the owner of the truck, who would pay for a technology upgrade, does not pay for the fuel costs of the truck and so would not see a benefit from investing in an upgrade – a split incentive that needs to be rectified
    - Information, education, trust and momentum: these four issues are interrelated and need to be addressed comprehensively by generating more and better data about the benefits of efficiency technologies and enhancing trust in them.
- In the United States and Europe the current policy climate is favourable to the adoption of these technologies.However, continued policy progress would provide greater incentives for efficiency technologies.

INTRODUCTION

Today, the movement of people and products from one place to another generates nearly one quarter of all anthropogenic GHG emissions. Road transport claims 75% of the transportation sector's total emissions, while the rest are generated by sea, air and rail (IPCC 2007). As the world economy recovers from the financial crisis, 2010 emissions for all sectors were nearly back to pre-crisis 2007 levels (US-EPA 2012; Green Car Congress 2012), and models predict that energy use for transportation will continue to rise by 2% overall each year, with even higher growth expected in developing countries (Figure 1). At this pace, GHG emissions from all transportation sources will increase 80% by 2030, with carbon dioxide-equivalent (CO_2e) emissions from trucking and other commercial operations predicted to grow even more rapidly than those of personal transportation (Ribeiro and Kobyashi 2007).

Figure 1: Historical and Projected CO_2 Emissions from Transport by Modes, 1970-2050



Assuming growth proceeds apace with no increase in the uptake of clean technologies. Source: IPCC 2007.

At present, road freight (the commercial operation of medium- and heavy-duty trucks) is responsible for 5.75% of total worldwide greenhouse gas emissions, pumping 1.6 billion metric tons, or gigatons (Gt), of CO_2e into the atmosphere each year (Box 1) (Ribeiro and Kobyashi 2007). If this sector enjoys growth as high as is predicted, the emissions from commercial trucking alone will jeopardise the world's chance of meeting key climate stabilisation targets. However, it is possible for strong growth in the road freight sector to take place without a correspondingly large increase in GHG emissions. The trucking industry's widespread adoption of a range of proven efficiency technologies could drive substantial emissions reductions in the road freight sector – and profitably so – by significantly reducing the fuel per freight-ton-mile ratio of commercial trucks.

The global road freight sector is hardly a homogenous one. A large number of factors vary substantially from region to region, including regulations, fuel costs, road quality, dominant freight transportation methods, truck makes and models, duty cycles, and the options available for financing efficiency investments. In light of the variation, the report focuses on the United States market, quantifying the potential for obtaining emissions reductions with cost-saving dividends via a range of proven fuel efficiency technologies currently available in that market. However, there is a need to reproduce the research presented here according to the specifics of each regional market, as the GHG emissions of the road freight sector are a global problem, and the chance to achieve emissions reductions through the adoption of efficiency technologies is a global opportunity.

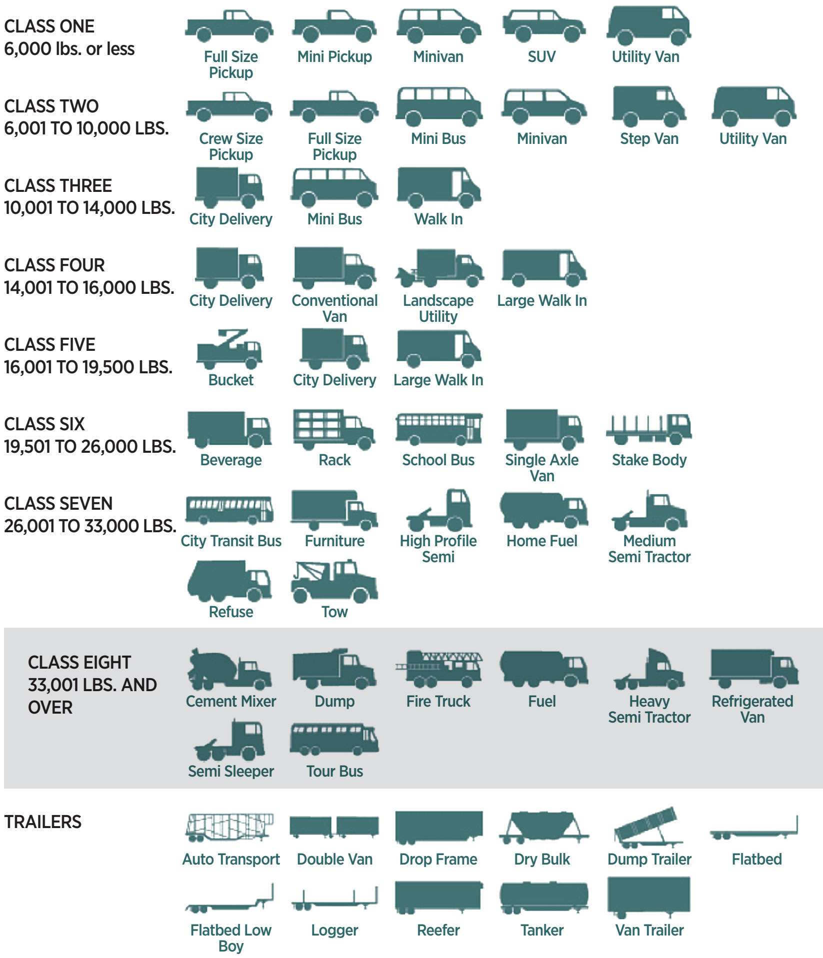
In the United States, over 26 million trucks of all classes hauled over nine billion tons of freight in 2010 alone, consuming nearly 50 billion gallons of fuel and producing more than 402 million tons of CO_2e emissions in the process (ATA 2011). Trucks deliver 70% of all freight tonnage in the United States, and 80% of US communities receive their goods exclusively by truck (ATA 2008b).

In 2010, 3.5 million Class 8 vehicles (Figure 2, overleaf) were registered in the United States, and 2.4 million of those were tractor-trailers (ATA 2011). An additional 4.9 million vehicles were registered in Classes 4-7 (Polk 2011). Though the majority of the technologies considered in this report are applicable to all trucks, and some are even applicable to light-duty commercial vehicle fleets, this report focuses on technologies particularly suited to long-haul heavy-duty truck applications. Improving fuel efficiency for Class 8 trucks is a high-impact area, as they account for over 75% of the fuel consumed by the road freight sector (NESCCAF 2009). Furthermore, while heavy-duty road freight vehicles only account for about 4% of all the vehicles currently on the road in the United States, they produce nearly 20% of the transportation sector's total emissions, which translates into a huge opportunity to achieve significant emissions reductions by targeting only a small slice of the overall American transportation sector (US-DOE 2009; US-EPA 2012).

Box 1: Definition of Truck Classes

"Medium-duty trucks" are commercial trucks of gross vehicle weight classes 4, 5 and 6, and "heavy-duty trucks" are of weight classes 7 and 8, while weight classes 1, 2, and 3 are "light-duty trucks". This report considers "light-duty vehicles" to be class 1-3 trucks as well as passenger cars operated within commercial fleets.

Figure 2: Examples of Different Vehicles Within All Truck Classes by Gross Vehicle Weight (GVW)



Note: GVW is the current standard for classification of vehicles in the United States.
This report considers trucks of GVW Class 8.
Source: Goodyear 2004.

In the United States, tractor-trailers remain on the road for an average of 19 years, transitioning from long-haul to local and regional duty cycles after about eight years. The market opportunity to retrofit the existing truck fleet is clear, as is the corresponding emissions reduction potential of such retrofit technologies (UCSUSA 2008). Additionally, with well over 100,000 new Class 8 vehicles sold each year, purchasers have a strong incentive to incorporate fuel efficiency improvement options into the design of the new trucks they order, and original equipment manufacturers have a strong incentive to offer these options (Polk 2012). This report considers five categories of physical efficiency technologies that are appropriate either for retrofitting or for factory installation. These technologies and their emissions reduction potential include: aerodynamic improvements (3-15%); anti-idling devices (5-9%); traction and rolling resistance upgrades (3-6%); transmission alterations (2.5-6%); and automatic cruise control devices (5-10%) (NAS 2010). These technologies all offer significant fuel-saving benefits for long-haul Class 8 freight trucks and the majority of them are applicable to a wider range of truck weights and duty cycles.

Further reductions in the emissions of the trucking sector may be profitably achieved through the implementation of a number of ICT solutions, such as GPS-assisted route optimisation services and other practices and services under the umbrella of Mobile Resource Management (MRM). These have the potential to achieve significant fuel savings for commercial trucks, as well as for the many other light-duty vehicles being used in commercial fleets (NAS 2010).

This report is limited to a ten-year timeframe. Nascent technologies, such as advances in electric vehicles or natural gas fuelling infrastructure, should provide additional opportunities for reducing fuel consumption in the trucking sector. Some companies have already started to operate a small number of fully electrified trucks for niche functions, but the payback periods are still too long for this technology to have been widely adopted. Further development in advanced battery technology is required before it will be economically feasible to fully electrify heavy-duty long-haul trucks. Contrary to electric vehicles, natural gas vehicles are a proven technology, but the necessary infrastructure for their refuelling is still weak in the US. With natural gas prices expected to remain quite low compared to diesel, the use of natural gas engines in long-haul trucking is expected to increase over the next decade as the infrastructure grows.

Regulation can play a major role in driving the wider adoption of efficiency technologies. Worldwide, most trucking emissions regulations currently concern the reduction of air pollutants. But the EPA recently adopted a set of GHG emissions regulations for heavy-duty trucks, which will come into effect for the 2014 model year (US-EPA 2011a). Additionally, the US, Canada and the European Union have all proposed increased fuel efficiency requirements for heavy vehicles that will have a direct impact on GHG emissions and will encourage the adoption of efficiency technologies.

Aside from regulatory requirements, there is an excellent wealth creation opportunity in the adoption of the efficiency technologies surveyed here. However, significant market barriers are currently preventing this growth. For example, there is little incentive for owners of leased fleets to invest in upgrades because they will not benefit from the savings derived from reduced fuel consumption – a significant principal-agent problem. Additionally, access to capital is a barrier to purchasing efficiency measures, especially within the current lending atmosphere. Lastly, some fleet owners are simply not aware of the benefits of efficiency measures. Fleet owners not only need education on efficiency measures, but also reasons to trust the validity of such information and therefore be motivated to act on it and alter their fleet's operations.

This report finds that the cost savings offered by these technologies are so substantial that, with a concerted effort to overcome the barriers of trust and education and with new financial mechanisms to overcome the barriers of upfront capital costs, the market alone could encourage the widespread adoption of efficiency technologies in the near term, resulting in a significant low-carbon wealth creation opportunity. Currently, under predicted 2% annual US industry growth rates, Class 8 road freight emissions will grow by 29% over the next decade, releasing nearly 4Gt of CO_2e greenhouse gases into the atmosphere. However, full adoption of the physical technologies considered in this report could reduce the growth of the GHG emissions of Class 8 trucks in the United States from 29% to just 2% within that same timeframe, preventing more than 404 million tons of CO_2e emissions while allowing the industry the same 2% annual growth rate. Adoption of proven ICT solutions will permit the sector to reduce its emissions even further as it continues to grow, with its emissions actually shrinking to 10% below today's levels.

Achieving this level of emissions avoidance with today's available technologies will be cost-effective for truck operators. A hypothetical tractor-trailer that is in good condition and driving 130,000 highway miles in a year getting the industry average of 6.5mpg, with 2,500 hours spent idling, will cost $88,000 annually to fuel at $4/gallon diesel prices. Were this truck to adopt the best available models of aerodynamic fairings, a battery-electric APU, wide-base tires, 6x2 transmission, advanced cruise control and GPS routing, the upfront capital outlay would be approximately $30,000. However, if these devices all achieved even an average degree of their fuel reduction potentials, the truck would increase its fuel efficiency by 30%, reducing its fuel costs in a single year by $26,400. The upgrades would pay for themselves in less than 18 months, while delivering the corollary benefit of significantly reduced greenhouse gas emissions. Further cost savings may be achieved by fleet operators through the implementation of other ICT solutions.

Class 8 road freight emissions will grow by 29% over the next decade, releasing nearly 4Gt of CO_2e greenhouse gases into the atmosphere

Methodologies

This report brings together industry data with insights from professionals gained during interviews conducted for the purpose of contributing to this research. Though a number of assumptions are inherent in the quantitative calculations presented here, the size of the opportunities highlighted is great enough that our conclusions hold, even if fuel costs, industry growth rates or the market penetration levels of these technologies vary from our predictions. Due to constraints in available road freight sector data, this report elected to calculate potential cost savings and emissions reductions only for Class 8 long-haul tractor-trailers in the United States. Not only do these types of vehicles burn the most fuel proportionally, but concentrating on this segment of the road freight sector also allowed for the analysis of a large number of trucks operating in fairly homogenous duty cycle conditions.

A number of criteria were employed in choosing which technologies to review. The technologies presented here are all out of the pilot stage and widely available on the market. Their potential for emissions reduction is well documented in laboratory and field testing. Furthermore, they all offer payback periods of less than two years for Class 8 trucks. While other industries may have the luxury of longer-term planning, industry experts observed that truck owners are not only operating at very slim margins, but that "a lot can happen to a truck in five years," according to a recent Carbon War Room discussion, so long-term equipment investments are less attractive options in this sector. With average diesel prices at $4/gallon and rising, and with increasing fuel price volatility, the economic impetus for improving fuel economy by adopting technologies such as these is clear.

Some of the technologies presented here, particularly the ICT solutions, will offer substantial cost and emissions savings to commercial vehicles of all weight classes and duty cycles. However, the five physical adaptations reviewed in this report will have a lower impact on fuel use for vehicles engaged in stop-and-go driving compared to their potential for generating fuel savings in long-haul heavy-duty trucks.

Emissions Reduction Pathways

There are significant efficiency and performance enhancements available for freight trucks. Current estimates of the potential for new technologies to reduce fuel consumption and emissions range considerably but are consistent in their suggestion that major savings are available. In spite of this potential, the large-scale implementation of available technologies and best practices faces a number of market barriers. But as petroleum fuel prices continue to rise and these technologies continue to improve, they become increasingly attractive opportunities – and even financially necessary ones.

Emissions reductions in the transport sector are primarily achieved by reducing fuel use, as over 95% of Class 8 truck GHG emissions are generated by diesel combustion (DieselNet 2011). Improving fuel efficiency is also what confers the cost-savings benefits of these technologies. The technologies for fuel reduction fall within two main pathways: individual trucks may be retrofitted or purchased new with physical technologies that work to reduce their fuel consumption; or truck owners may adopt certain ICT solutions that serve to save fuel, though many of these solutions must be implemented across a larger fleet. This report considers five categories of physical technologies that are appropriate for heavy-duty trucks, particularly those engaged in long-haul duty cycles. This report further considers ICT and logistics technologies that are appropriate for heavy- and medium-duty trucks, as well as for other light-duty commercial vehicles being employed in a wide range of duty cycles.

Physical Retrofit Technologies and Factory Efficiency Improvements

There are currently many vendors and entrepreneurs producing a wide range of promising technologies for improving commercial trucking efficiency via physical retrofits. This report surveys five technologies or technology categories that are well proven in their effectiveness and have short payback periods. These technologies provide excellent opportunities to reduce GHG emissions while yielding savings for truck operators. Ranges in efficiency estimates (Table 1) reflect the fact that these technologies will vary in their effectiveness depending on both the make and model of the truck and the duty cycle for which the technology is being implemented.

Table 1: Examples of Physical Technologies

TECHNOLOGY	ESTIMATED FUEL REDUCTION	MODELLED CO_2 REDUCTION
Aerodynamic Fairings	3-15%	6%
Anti-Idle Devices	5-9%	7%
Single Wide-Base Tires	3-6%	5%
6x2 Transmission	2.5-6%	4%
Predictive Cruise Control	5-10%	7%

Source: NAS 2010; IPCC 2007; NACFE 2010a, 2010b, 2011.
Note: Given that 95% of emissions are generated by fuel use, modelled figures are the approximate level of likely reductions that each technology will be able to achieve when installed on newer model Class 8 tractor-trailer trucks engaged in long-haul highway travel.

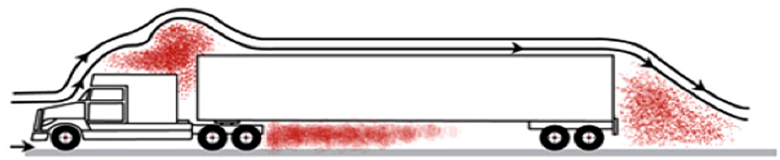
A combination of aerodynamic upgrades can increase fuel efficiency by as much as a 15% when applied to an early model combination tractor-trailer truck and 3-11% when applied to a newer truck

Improvements in Aerodynamics

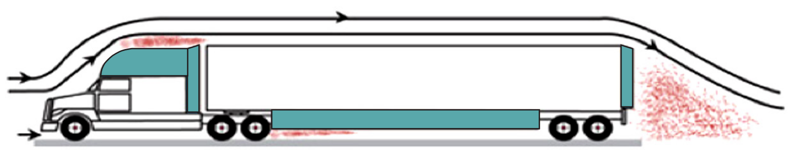
In recent years, truck manufacturers have begun designing and producing highly aerodynamic truck models, but the opportunities for improving aerodynamics even further with additional retrofit technologies are substantial, and owners of older trucks can also enjoy the benefits of these upgrades. Also called “fairings”, aerodynamic technologies are attached to the truck’s cabin or trailer and increase fuel efficiency by reducing drag. Common additions include roof deflectors, trailer skirts, cabin extenders, boat tails and other systems.

These aerodynamic surfaces vary in price and effectiveness according to the number of additions installed on a truck. Adopting one aerodynamic surface, such as a rounded air deflector, can increase fuel efficiency by more than 5% (EPA SmartWay 2010). However, a combination of these surfaces can increase fuel efficiency by as much as a 15% when applied to an early model combination tractor-trailer truck and 3-11% when applied to a newer truck (Figure 3) (EPA SmartWay 2010). One of these upgrades can cost as little as $300 while a comprehensive system can cost up to $10,000 (NAS 2010). Adopting aerodynamic surfaces will save approximately $21,000-95,000 over the lifetime of the truck.

Figure 3: Illustration of How Aerodynamic Retrofits Improve Fuel Efficiency



A: A tractor-trailer without aerodynamic devices installed produces a large amount of drag (shown as shaded area)



B: A tractor-trailer with aerodynamic devices installed produces less drag (shown as shaded area)

Source: Natural Resources Canada Office of Energy Efficiency 2011.

While aerodynamic improvements for tractors are already being widely adopted, aerodynamic devices for trailers are not as well utilised (Natural Resources Canada Office of Energy Efficiency 2011). It is common for tractors and trailers to have separate owners. If a company only owns trailers it is not financially responsible for the fuel consumption of the tractor and thus has no incentive to improve the aerodynamics of its trailers. However, applying a system of aerodynamic upgrade technologies to a trailer alone can provide up to a 9.3% reduction in fuel consumption (Natural Resources Canada Office of Energy Efficiency 2011). In the medium-duty truck market, few companies are adopting aerodynamic upgrades for tractors or trailers, even for those vehicles that spend the majority of their time on the highway (Roeth 2011). Medium-duty trucks engaged in long-distance duty cycles represent an additional untapped market for aerodynamic upgrades.

If such technologies were adopted at aggressive rates, improving aerodynamics on all Class 8 trucks to the maximum extent, there is the potential to reduce GHG emissions in the United States by a total of nearly 54 million t/CO_2e over the next ten years.

Anti-Idle Devices

Truckers idle engines in order to keep the engine block warm, to heat and cool the cabin, and to operate cabin appliances. Using the engine for these functions consumes almost a gallon of diesel fuel per hour and constitutes nearly 8% of total fuel use – 1.1 billion gallons of diesel fuel are spent on idling in the United States each year alone (Gereffi and Dubay 2009; ATA 2008a). But there are devices on the market today that reduce this waste by allowing drivers to remain comfortable in their trucks without idling their engines.

One such device is a direct-fired heater. This device warms the engine block and provides heat for the cabin, reducing the fuel used for idling by 75%. Such a system costs approximately $3,000-5,000 but does not completely remove the need to idle.

A more advanced device is an auxiliary power unit (APU). An APU is a generator that also replaces the need for idling for cabin heating and cooling, as well as for powering cabin appliances. These generators are powered either with diesel fuel or batteries. Diesel APUs reduce fuel consumption by 75% or more over idling. A battery-powered APU effectively removes all need for diesel fuel consumption when the truck is stopped.

Diesel APUs cost approximately $6,000-9,000, but their durability is an issue. These devices were originally developed for the recreational vehicle market and not for use in heavy-duty trucks. Thus, as currently manufactured, they may only function for 18-24 months in heavy trucks – a lifespan that nevertheless provides positive savings of $3,000-6,000 at current $4/gallon fuel prices (Roeth 2011).

Electric APUs cost $10,000-15,000, depending on the battery technology used. Lower-quality lead acid batteries will incur additional costs over time, as a lead-acid APU system battery only lasts 2-4 years, depending on annual usage levels, requiring 4-8 batteries over the lifetime of the truck at a replacement cost of approximately $350 per battery. Lithium-ion battery systems are more expensive upfront but they last up to three times longer than lead acid batteries and, as they have a lighter weight, they make a smaller impact on fuel costs once installed (Baumann 2011). Over the lifetime of a truck, an electric APU can save as much as $56,000-61,000, with a payback period of approximately 18-24 months.

Anti-idle technologies are installed in around 36% of sleeper cab trucks today; about one-third of these employ APUs (Gereffi and Dubay 2009). Although medium-duty trucks running certain duty cycles can also see savings with anti-idle devices, extremely few medium-duty trucks employ them, seemingly because these devices are mostly only being marketed to heavy-duty truck owners at the moment.

With laws restricting idling already in place in many US states, there is a significant incentive for truck operators to install these devices (ATRI 2012). By employing the best in lithium-ion battery anti-idle technologies, the US trucking sector could save more than 48.6 million tons of CO_2e emissions over the next ten years.

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Decreased Rolling Resistance

Overcoming rolling resistance – a measure of the force necessary to move the tire forward – consumes over 25% of the total energy required to keep a truck in motion (Consumer Energy Center 2012). Tire design plays a huge role in determining rolling resistance. Major innovations have already occurred in tire tread design to decrease this resistance and increase fuel efficiency. Although for certain rugged duty cycles these less resistant tread designs do not provide sufficient traction, most long-haul highway-based trucks have already adopted less resistant treading for their tires (Bridgestone Firestone North American Tire 2008).

Although today's heavy and medium trucks still most commonly employ double tires at each wheel site, major tire manufacturers have recently started to produce wide-base – or "super single" – tires for trucking applications (Figure 4). When using wide-base tires, only one tire is required per wheel site instead of two, a design improvement that can result in as much as a 6% increase in fuel efficiency through decreased rolling resistance, better aerodynamics and decreased weight (NACFE 2010a).

Figure 4: Two Traditional Tires (far left) Next to One Wide-base Tire (centre and right)

Source: NACFE 2010a.

Depending on the tire dealer, the cost of one wide-base tire is equal to or slightly less than a set of two regular tires, but there is a cost in switching from wheels that use double tires to ones that accept single wide-base tires. However, wide-base tire treads can survive slightly more mileage than double-wide tires, resulting in a slightly reduced maintenance cost (NACFE 2010a). Combined with the cost savings of increased efficiency, the switch from double tires to wide-base tires comes at little to no premium.

Currently, wide-base tires are used on about 10% of heavy-duty trucks and trailers, and close to 15% of new trucks are sold with them equipped (Roeth 2011). They have not been widely adopted by medium truck owners. Were US trucks to aggressively make the switch to wide-base tires, the sector could reduce its GHG emissions by 46.8 million tons CO_2e between now and 2021.

6x2 transmissions can see fuel savings of up to $44,000 over the lifetime of the truck when compared with trucks using 6x4 transmissions

New Transmission Systems

The trucking industry can reduce its fuel consumption by approximately 4% by adopting 6x2 transmission systems, also known as "dead axle" or "single-drive" tractors, into all new vehicles. These 6x2 transmissions use only two wheels to drive the truck instead of the more common 6x4 transmission systems, which use four wheels. An engine using a 6x2 transmission only has to power two wheels instead of four, which results in greater fuel efficiency, much like the difference between two-wheel and four-wheel drive transmissions in passenger vehicles. Additional savings are generated by the lower weight of the 6x2 system (NACFE 2010b).

The one disadvantage of a 6x2 transmission is that it creates less traction than a 6x4 one, which can be an issue for trucks travelling on routes with extreme weather or to delivery terminals that experience snow and ice. For trucks travelling in more moderate climates, vehicles using 6x2 transmissions can see fuel savings of up to $44,000 over the lifetime of the truck when compared with trucks using 6x4 transmissions. The cost of a new truck with a 6x2 transmission is around $300 less than one with a 6x4 one. Currently, 6x2 transmissions have only about 1% penetration in the heavy truck market (NACFE 2010b). Though this technology is not available as a retrofit onto existing trucks, implementing 6x2 technology onto just 32% of all new six-wheel Class 8 trucks (including tractor-trailer tractors, as well as other heavy-duty models, such as dump trucks), can save more than 13.5 million tons in CO_2e emissions in the United States by 2021.

Automatic Cruise Control

The speed at which trucks travel has implications for the amount of drag on the vehicle. As trucks move faster, aerodynamic drag increases by a power of three. When drag increases, the engine must work harder to overcome it. Trucks achieve the greatest fuel efficiency when traveling at around 55mph, though this speed is too slow for safe travel on many highways and interstates in the United States. Still, given that heavy trucks currently average peak fuel efficiencies of around 6.5mpg, and given that fuel efficiency declines approximately 0.1mpg for every 1mph increase in speed beyond 55mph, a speed reduction from 68mph to 63mph will lead to a 9% increase in fuel efficiency while still allowing drivers to travel at highway-safe speeds (NACFE 2011). A speed of 65mph is recognised in the United States as the most efficient speed for highway truck travel, down from a current average of closer to 75mph. Simply bringing the average highway speed of heavy-duty trucks down to 65mph would prevent 31.5 million tons of CO_2 emissions over the next ten years (ATA 2008a).

At current fuel prices, this modest speed adjustment can result in a fuel saving of $7,200 annually for an average vehicle. Lower speeds confer additional savings in tire replacement, as higher speeds adversely affect the life of tire tread – each decrease of 1mph at speeds above 55mph increases tire tread life by 1% (ATA 2008a).

In order to ensure that drivers travel at slower speeds, owner-operators can install "governors" – limiting devices that prevent drivers from exceeding a designated speed. However, such devices are criticised as safety hazards as they prevent drivers from accelerating if needed beyond the device-designated speed limit. Driver education about the value of limiting speeds is another option for lowering road freight speeds. Alternatively, the market now offers a variety of advanced adaptive and predictive cruise control devices. Such devices allow drivers to maintain a constant speed but do not prevent them from accelerating above that when needed (Cummins Engines 2012).

Adaptive cruise control employs a radar or laser sensor that augments conventional cruise controls by sensing the traffic ahead and adjusting vehicle speed accordingly to maintain safe driving distances. Predictive cruise control additionally employs a GPS receiver to gather data about the topography of the upcoming stretch of road and allowing for smooth uphill and downhill driving (NESCCAF 2009).

Along with lowering average speeds, achieving smoother acceleration and braking also increases fuel efficiency. Rapid acceleration requires more power and more fuel, while hard braking wears down brakes and requires more acceleration to get back up to speed. By sensing both changes in road grade and other vehicles in front of the truck, advanced cruise control can accelerate or brake as needed in a smooth profile. They also have the benefit of reducing collisions by allowing trucks to maintain a safe cruising distance from the vehicles ahead of them and ensuring adequate braking distance at various speeds, as well as providing lane departing warnings and blind spot monitoring (ETSI 2011).

Although there is concern that reduced speeds could lead to decreased productivity, such losses are minimal. According to a recent report, four major US fleets reported that 98% of their freight shipments were not affected by a 5mph decline in travel speeds, while the other 2% experienced delays of only several minutes per day (ETSI 2011).

Cruise control devices cost $800-1,500 for predictive cruise control or $1,100-3,000 for adaptive cruise control. These systems can reduce fuel consumption by 1-10%, depending on the prior behaviour of the driver, resulting in savings of approximately $800-8,000 per year (NAS 2010). Unfortunately, these cruise control options have not yet been widely adopted, despite their effectiveness. This report's model finds that if just over half of all highway-travelling Class 8 trucks in the United States were able to reduce their average speed by 5mph it would save over 54 million tons of CO_2e emissions over the next decade.

Information and Communication Technologies

In addition to the aforementioned five technology categories that provide trucking efficiency gains via physical modifications to the truck itself, the incorporation of customised suites of information and communication technologies (ICT) into current transport practices and processes can increase revenue and decrease GHG emissions. Such ICT solutions for the transportation and road freight sector are often also referred to as "intelligent transportation systems" (ITS) or "mobile resource management" (MRM). The ICT category of road freight efficiency options relies on the integration of telecommunications (including wireless signals) with information and logistics management systems. These ICT options therefore need to be implemented at the fleet or even societal level and require driver education and the changing of driver and fleet practices alongside the installation of the technology.

The hardware for ICT systems includes a GPS device or other wireless PDA-type device. By utilising ICT software with these devices fleet managers can monitor and optimise their workforce and their mobile (vehicle) operations. Such fleet management systems allow a fleet to travel fewer miles, saving fuel while increasing the number of jobs a driver can complete in a day.

Broadly, an ICT solution will reduce inefficiencies at all points along the road freight process by optimising a fleet's logistics and operations. Depending on the fleet's needs, an ICT solution can offer a variety of specific benefits within the pursuit of an overall goal of improving productivity and saving on fuel costs. ICT solutions can be generally broken down according to their impact on one of four areas of vehicle operations:

- Driver behaviour: solutions that monitor and improve key factors of driver behaviour that determine fuel economy: speed, shifting and idling
- Vehicle performance: solutions that monitor vehicle malfunctions and fault codes as well as maintenance intervals (usage vs time), and can also compare a vehicles' performance across benchmarked groups
- Fuel theft: ICT solutions prevent fuel theft by empowering the fleet manager to cross-reference fuel purchase data against dispatch information systems
- Fuel efficiency equipment: ICT solutions allow fleet managers to determine their actual payback period for retrofits, including for the physical technologies discussed in this report, as well as for alternative energy sources like biodiesel.

To elaborate further, ICT systems can monitor vehicle performance and handle vehicle maintenance scheduling, ensuring that all vehicles are being driven in good condition and reducing maintenance costs and vehicle breakdowns. They can allow for improved scheduling, real-time employee timesheet monitoring and in-the-field customer invoicing, all of which further reduce drive times. They can reduce unauthorised vehicle use, ensure correct fuel purchase and mileage data recording, speed load times, prevent cargo and vehicle theft, curb excessive speeding and drastically reduce driver idling. Along with traffic information, they can provide weather reports and other up-to-the-minute data, allowing drivers to optimise their routes. ICT systems also perform fleet analytics and record historical data, which help fleet managers to understand and address any outliers (US-DOT 2008; Prockl et al. 2011).

This last benefit of an ICT system can, in turn, facilitate the adoption of physical efficiency technologies. An ICT system that provides a fleet manager with a reliable and comprehensive set of data about their fleet can convince him that the physical adaptation he has installed onto a handful of trucks is in fact generating substantial savings and is a valuable upgrade to install across the fleet. This data can then be shared between fleets, further increasing sector confidence in clean technology.

Along with traditional road freight duty cycles, examples of commercial fleet duty cycles for which ICT solutions will be beneficial include many public municipal services, from snow ploughs to police patrols to mail routes. Other private applications include utility companies, home maintenance service providers, such as exterminators or renovation contractors, neighbourhood delivery trucks and many more.

As there are such broad possible applications of ICT systems to the road sector and other commercial vehicles it is impossible to quantify the fuel and emissions savings of ICT solutions – they are very substantial. Therefore, this report considers two practices within the wide spectrum of ICT solutions that specifically offer significant savings to long-haul heavy-duty truck operators.

GPS-Assisted Navigation and Routing

Improving navigation and routing has the potential to generate significant savings for the trucking industry. Individual truck drivers can use GPS devices with additional features, including up-to-the-minute traffic updates, left-turn minimisation and historical traffic data, all of which shorten their routes and reduce their fuel usage. Such a system is especially advantageous for intra-city trucking, reducing mileage by 5-10%; GPS systems may only provide a 1% mileage reduction for long-haul heavy-duty trucks. A GPS navigation device currently costs $400-800 with monthly service fees of $20-40, meaning that payback periods for GPS devices start at less than six months and can save up to $1,400 per truck per year.

Improved routing can also be managed by a central dispatch that tracks all the vehicles in a fleet with route optimisation software. Dispatch optimisation software starts at $10,000 (US-DOT 2008; Prockl et al. 2008). Fleet managers interested in doing more than simply managing driver routes often employ this type of software and also implement some of the other fleet-wide benefits described above.

The actual amount of fuel saved and emissions avoided from the use of GPS devices and optimised routing will vary considerably from one fleet to another. In any case, GPS-assisted navigation can confer significant cost savings and efficiency improvements to trucks engaged in ground freight operations and to light-duty commercial fleet vehicles engaged in a range of other duty cycles. For example, if an additional 10% of Class 8 long-haul fleets increased their efficiency by just 1% with GPS routing each year, the sector would avoid more than 20 million tons of CO_2e emissions in the next decade. If all commercial fleets, some of which would enjoy efficiency increases of closer to 10%, were to adopt GPS-enabled route optimisation, the fuel savings would be significant.

An ICT solution will reduce inefficiencies at all points along the road freight process, by optimising a fleet's logistics and operations

If an additional 10% of Class 8 long-haul fleets increased their efficiency by just 1% with GPS routing each year, the sector would avoid over 20 million tons of CO_2e emissions in the next decade

Logistics Management

Reducing the amount of deadhead (empty cargo) travel in truck operations is a cost-saving, revenue-generating and GHG-reducing opportunity. Deadhead trucks carry no cargo, presumably while making a return trip for the next shipment, meaning that deadhead trucks are generating costs but no revenue.

Up to 10% of driven truck miles are deadhead miles for leased freight carriers (EPA SmartWay 2010); private fleet trucks have, on average, an even higher proportion of deadhead legs, at 28% (Kilcarr 2008). For leased fleets these deadhead miles waste up to 1,500 gallons of diesel fuel per long-haul truck each year, resulting in approximately $6,000 per year in additional costs and even more in lost revenue. Meanwhile, private fleets are burning up to 5,600 gallons of diesel and wasting $22,000 per truck on deadhead travel annually.

Besides the increased fuel costs, deadhead miles represent a lost revenue opportunity. Freight shipments on trucks receive on average approximately $0.13 per ton-mile (BTS 2010). By shipping just one ton of freight on all current deadhead miles, truck operators could receive an extra $6,500-8,500 in annual revenues per truck.

Deadhead travel can be effectively reduced through logistics management. Several firms are active in the role of freight brokerage – essentially matching drivers with loads. These companies post available loads on information boards at truck stops for drivers to accept. Additionally, private companies can develop partnerships with other shippers to handle their loads on what would otherwise be their own deadhead legs. Lastly, shippers can improve delivery schedules and plan more efficient routes to reduce deadhead time and distance.

A reduction of deadhead miles would confer a significant reduction in carbon emissions by decreasing the number of truck miles driven annually. Reducing the number of deadhead miles driven by just 45% each year would prevent a total of 165 million tons of CO_2e GHG emissions over the next ten years. By eliminating all deadhead travel, the United States could avoid a total of over 706 million tons of CO_2e GHG emissions between now and 2021.

Furthermore, by optimising routes and by shipping the most freight possible per mile travelled, a fleet manager may be able to enjoy substantial savings in the form of fewer trucks purchased to ship the same amount of freight. The price of a new truck, largely in response to EPA emissions regulations that came into effect in 2007 and again in 2010, has risen by $20,000-25,000 since 2006 (Calpin and Plaza-Jennings 2012). A fleet operator can save the approximately $130,000 purchase price of an additional truck while still enjoying growth in their freight volume by utilising ICT solutions to optimise their operations.

GAME-CHANGING FUTURE TECHNOLOGY

Electric Vehicles

Worldwide, 95% of trucking operations currently rely on petroleum-based fuels, mostly diesel. The greenhouse gas products of fossil fuel combustion – Carbon Dioxide, Methane, Nitrous Oxide – contribute 90%, 0.1-0.3% and 2-2.8% to the GHG emissions of the trucking sector respectively (Ribeiro 2007).

Electric vehicles are the optimal technology for reducing the trucking sector's GHG emissions. These vehicles run on electricity stored in batteries that can be recharged by plugging into the electrical grid. Thus, the vehicles' only GHG emissions would be produced indirectly by the source of regional electrical generation. Although the majority of electricity comes from the burning of coal, a major GHG gas contributor, the GHG emissions from coal-fired electricity generation are still less than the GHG emissions from burning petroleum fuel to propel a vehicle (Hunt 2011). Furthermore, as grid power shifts towards more renewable sources, the operation of electric vehicles will produce fewer and fewer carbon emissions.

Currently, electric vehicles are only able to fill some niches of the trucking sector's operations, as today's battery technology only enables short-distance travel at below highway speeds. Even for these uses, the payback periods for electric trucks are relatively long – they cost about $30,000 more upfront than their diesel counterparts, and have an expected payback of approximately three years (Ramsey 2010).

Nevertheless, large fleet-owning companies such as Staples, Frito-Lay, FedEx and AT&T are already incorporating small numbers of electric vehicles into their fleets for intra-city product delivery. Electric trucks are well suited for this role, as they have a range of 50 miles and a top speed of 50mph. The above companies reported that, along with zero fuel costs, these trucks had significantly lower maintenance costs due to their simpler design of the electric motors and reduced braking wear and tear.

For leased fleets, deadhead miles waste up to 1,500 gallons of diesel per long-haul truck each year, resulting in around $6,000 per year in extra costs

Electric trucks could one day reduce trucking emissions to zero, although current technology only allows for their use in short-distance trucking operations

Electric trucks are also being piloted at the San Pedro Bay, California port complex. The Port and South Coast Air Quality Management District co-funded a demonstration project for electric drayage trucks that transport goods around the port complex. These drayage trucks have a top speed of 40mph, a range of 30-60 miles when charged and can carry 30-ton shipping containers, making them well suited for the short-distance, low-speed needs of the port. However, these trucks cost up to $200,000 and require an additional investment of $75,000 for a charging station, making them an unlikely candidate for widespread adoption in the near term (Port of Los Angeles 2007).

Although medium-duty electric trucks are starting to break into the freight market, heavy-duty electric tractor-trailers will not travel the highways until there is an improvement in battery technology. Batteries today do not come close to achieving the energy density of diesel fuel. Diesel fuel has an energy density of 46.2 Mega Joules per kilogram, while the best lithium-ion batteries have an energy density of 0.7MJ/kg, or 1.6% that of diesel fuel (Prakash et al. 2005). When the difference in efficiency between combustion engines and electric motors is factored in, this difference in energy density means that a battery must be about 30 times more massive than a full fuel tank of diesel. For a tractor-trailer carrying 100 gallons of fuel, an equivalent tractor-trailer would be required to haul a battery weighing 20,000 pounds or greater. Such a battery would cost more than one million dollars per truck (AllAboutBatteries.com 2011).

Although electric trucks could one day reduce trucking emissions to zero, current technology only allows for their limited use in the short-distance trucking market. Until there is a massive increase in battery energy density and a reduction in costs, there will be no electric tractor-trailers on the roads.

Natural Gas

Unlike electric trucks, natural gas-fuelled vehicles are a tested and proven technology. At the end of 2011 there were 15 million natural gas vehicles operating in 84 countries around the world (NGV Global 2012). Though currently small, the percentage of vehicles that are powered by natural gas will likely continue to grow, as natural gas fuel prices are predicted to remain quite low over the next decade compared to diesel fuel. This growth is positive from an emissions standpoint, as natural gas engines release 23% less GHG emissions than diesel fuel, making natural gas vehicles a good near-term solution (Clean Energy Fuels 2012).

Natural gas trucking is divided into two categories of vehicles: liquefied natural gas (LNG) and compressed natural gas (CNG). CNG vehicles are more commonplace than LNG vehicles at the moment. In the United States, the Energy Policy Act of 1992 (EPAct) required many municipalities and government agencies to purchase significant quantities of light-duty alternative vehicles for their fleets, and many agencies purchased CNG vehicles. This fuel source is best suited to high-fuel-use vehicles, such as public transit vehicles, refuse trucks and delivery fleets. Modest growth of CNG fuelling stations in the last decade is also a consequence of the EPAct and demand is expected to rise further (TIAX 2012a).

LNG has a much higher energy density than CNG, making it a well-suited fuel for heavy-duty trucks working long-haul routes. Large vehicles are necessary to accommodate the tanks needed to store LNG, which are 70% larger by volume than a comparable diesel tank. In addition, LNG must be kept at cold temperatures to keep the fuel in its liquid state, which thus requires bulk-cooling apparatuses. Though this technology is proven to save money, until LNG infrastructure – such as liquefaction facilities, distribution trucks and LNG fuelling stations – is commonplace, LNG trucking is unlikely to become a widespread technology (TIAX 2012b).

Along with a lack of infrastructure, two regulatory hurdles are hindering the adoption of CNG or LNG vehicles. The EPA and other state agencies closely monitor vehicle emissions by certifying the vehicles and engines that automakers produce. If a fleet operator chooses to retrofit vehicles for CNG or LNG operation, it is often considered tampering and is punishable with fines. In addition, retrofitting vehicles for natural gas sometimes can violate a vehicle's warranty. Only recently have auto manufactures begun to sanction such retrofits (Garthwaite 2011).

Despite the hurdles, adoption of natural gas vehicles is expected to increase, largely due to the low prices of natural gas, in addition to the other benefits discussed above. Some of the largest trucks on the road, like UPS long-haul trucks, are already powered by liquefied natural gas, while AT&T has converted a large section of their light-duty fleet to run on compressed natural gas (Garthwaite 2011). Global natural gas vehicle sales are predicted to grow by more than 9% annually in coming years, and infrastructure will scale as regulations change to meet demand (Garthwaite 2011). Natural gas trucks can benefit from the ICT and physical retrofit technologies discussed in this report as well – the combination of which offers the largest GHG emissions reduction opportunity.

Investment Opportunities

Adopting any of the aforementioned proven road freight efficiency technologies provides significant opportunities for cost reduction, especially at today's prices of just over $4 per gallon of diesel. The volatility of crude oil prices in recent years, which can jump by as much as 9.4% in a single day, adds an additional level of economic incentive for road freight fleet operators to invest in technologies that will reduce their fuel consumption (Biers 2012).

Investing in efficiency upgrades on a new truck can cost over $30,000 per heavy truck. This figure includes: a top-of-the-line lithium-ion battery APU, which costs $15,000; additional aerodynamic surfaces on both the cabin and the trailer, which can cost up to $10,000-15,000 on new truck models; $1,500 for advanced cruise control; and $1,000 for ICT solutions, such as GPS routing. Other technologies, such as wide-base tires and 6x2 transmissions, must be installed onto new trucks during their production but will cost about $500 less than their conventional counterparts. Installing all of these upgrades onto a new tractor-trailer may add more than 30% to the approximately $130,000 price tag (NAS 2010).

However, this full suite of technologies will optimally save $26,400 in fuel costs per year – over 30% of current annual fuel costs for a long-haul tractor-trailer. For a truck adopting all five of the physical retrofit technologies alone, the present value of the savings could be up to $167,000 for a tractor-trailer over a ten-year period, assuming fuel prices rise about 4% each year. Every 1% of diesel fuel saved at current prices yields more than $800 of reduced costs annually. Fleet-wide investment in ICT solutions to increase efficiency can yield even greater savings. And although there may be a large upfront cost, the payback period of these technologies is 12-24 months for a heavy-duty truck owner, which is considerably less than the 19-year average lifetime of a Class 8 truck.

In the United States, sales of new Class 8 trucks have been growing, from 104,600 new registrations in 2009 to 161,200 in 2011, with predictions on track for over 190,000 new Class 8 trucks to hit the road in 2012 (Polk 2012). Even a $15,000 investment in new technology for the new Class 8 trucks of 2012 represents a $2.85 billion market. Many of the technologies discussed in this report are also appropriate for retrofitting onto existing vehicles, expanding the market exponentially. The clean technology upgrades discussed in this report generate a minimum of five times their upfront investment cost in capital savings over the lifetime of a truck, while reducing greenhouse gas emissions. Such rates of return represent a massive climate wealth opportunity.

Globally, manufacturers produced approximately 4.2 million new heavy-duty commercial vehicles in 2010 – the majority of them came online without the five physical efficiency technologies covered in this report (OICA 2010). Though an efficiency technology solutions suite would have to be customised for each truck operator, scaling the adoption of fuel-saving clean technology by heavy-duty commercial truck fleets offers a clear potential to achieve a significant reduction in global greenhouse gas emissions while generating substantial economic growth for the road freight sector.

This full suite of technologies will optimally save $26,400 in fuel costs per year – over 30% of current annual fuel costs for a long-haul tractor-trailer

Market Barriers

The industry will need a strong understanding of the costs and benefits of efficiency technologies in order to be willing to make the necessary investments of time and money

Access to Capital and High Upfront Costs

The current lending atmosphere for the trucking sector is very difficult. In the United States, a significant proportion of the tractor-trailers on the road are part of owner-operated fleets of fewer than five trucks (US-DOT 2008). Truckers operate on thin margins, leaving very little capital to finance major upgrades out of pocket (US-DOE 2009). These efficiency technologies have high upfront costs, so without easy access to capital many truck owners cannot afford them, even those upgrades that offer extremely attractive payback periods. For the ICT options in particular, many of the benefits of implementing them occur on an economy of scale. For owner-operators of small fleets with only a few trucks, these solutions will not be feasible.

Principal-Agent Problem

The trucking industry is highly fragmented and there are multiple stakeholders involved in trucking transactions. Freight companies do not pay for fuel – the owners of the trucks do – so they have no incentive to make their trucks more efficient. Thus, while owner-operators and private fleets may be encouraged to upgrade their fleets, leased fleets will be less likely to incorporate upgrades since they will not see the benefits.

Education and Awareness/Trust and Momentum

In order for efficiency technologies and practices to be adopted on a wide scale, stakeholders in the trucking sector first need to have an awareness of these still relatively unknown opportunities. Once an awareness of these technologies and practices is generated, trust must be fostered for the trucking industry to be convinced to adopt them. Until truck owners experience the benefits of the technology themselves or witness other trusted members of the trucking industry enjoying them, they may be slow to change. The industry will need a strong understanding of the costs and benefits associated with each option in order to be willing to make the necessary investments of time and money to adopt these efficiency methods.

In order to achieve a substantial degree of understanding and trust of new technologies, a significant amount of new information needs to be gathered, as well as disseminated. The technologies reviewed in this report were chosen in part because they have a greater amount of reliable data about their effectiveness available than many other technologies. However, even these technologies need further testing to show their potential for fuel savings in other vehicle classes and duty cycles besides heavy-duty long-haul tractor-trailers. Such testing needs to be performed by independent third parties to verify producer claims, and the results of such testing need to be publically accessible.

For ICT solutions in particular, overcoming the barrier of trust and education is significant, for the results of the technologies in question will vary much more widely from fleet to fleet than the benefits of a physical retrofit. Even the technologies themselves will involve a package of options that will be different according to each user's specific needs. Though current research demonstrates positive effects from the implementation of ICT solutions, it has struggled to tease apart interdependent variables and identify the exact mechanisms by which these efficiency gains are being achieved, and it has furthermore failed to empirically quantify the potentials of the technologies (Prockl et al. 2011).

Current Policy Landscape

The policy landscape in developed nations is favourable to the adoption of these trucking technologies and practices. Governments in the developed world have already implemented many new regulations and programmes designed to improve air quality and reduce greenhouse gases. The developing world has not yet implemented the same level of regulation, so there is less pressure to adopt these technologies and the trucking sector will more than likely continue with business-as-usual practices.

In the United States, the EPA established the SmartWay programme in 2004. Much like the familiar ENERGY STAR efficiency ratings system for appliances, SmartWay certifies trucking technologies that increase fuel efficiency and reduce transport-related emissions (US- EPA 2011b). SmartWay additionally provides education for truck operators on the best methods to reduce GHG emissions and on their potential cost savings. The EPA also proposed new standards for fuel efficiency and GHG emissions for heavy vehicles in 2010. Known as The Heavy-Duty National Program and adopted in 2011, this regulation establishes a national programme for tractor-trailer, heavy pickup, box and vocational trucks, and encourages truck manufacturers and truck operators to adopt efficiency technology on existing trucks while mandating a variety of emissions reductions for new trucks beginning with the 2014 production model year (US-EPA 2011a). The California Air Resources Board (CARB) has even more stringent restrictions and demands for the reduction of diesel fuel consumption. Since California has some of the largest population centres and ports in the country, most US truck fleets involved in interstate shipping conform to the CARB standard and retrofit their trucks as needed (CARB 2012).

In Europe, trucks are not included within the EU's emissions trading market and there is currently no regulation restricting GHG emissions (Environmental Agency 2010). However, in 2009 the EU introduced GHG emissions regulations for passenger vehicles, stating that by 2015 the fleet-wide average emissions must be less than 130g/km CO_2 (Smokers et al. 2010). Considering the trend towards more aggressive restrictions on carbon emissions across all sectors, it is likely that trucks will be targeted for such regulations in the near future (Prockly et al. 2011).

Though not a fuel-saving technology and not considered in this report, policy is having an impact on approximately 5% of the GHG emissions of the trucking sector generated by leaking or improperly disposed refrigerant gases used in the air conditioning systems of trucks. As of 2011, Europe has a regulation holding that new models of passenger cars must be manufactured with refrigerants with a global warming potential (GWP) of 150 or less, with a complete phase out of older refrigerants by 2017 (European Parliament and the Council of the European Union 2006). As a result, car manufacturers there have rapidly replaced HFC-134a, a common refrigerant, with its lowest-cost substitute, HFO-1234yf, which has a 99.7% lower global warming potential (Spatz and Minor 2008). In the US, General Motors announced that they would be using HFO-1234yf in all of its 2013 models (General Motors 2010). As production of this refrigerant scales up to accommodate demand in the passenger vehicle production market, lowering its price compared to HFC-134a, it is likely that truck manufacturers will also begin to adopt this refrigerant in response to similar regulations.

In the developing world, the BRIC countries (Brazil, Russia, India and China) have all adopted emissions controls similar to the EU for pollutants, but they do not have vehicle efficiency standards, nor do they have explicit GHG regulations (GSGnet.net 2012). Other developing countries have little or no regulation of pollutant emissions and do not have efficiency standards or GHG restrictions.

Although GHG regulations are not widely applied to the heavy- and medium-duty freight trucking sector, the adoption of air pollutant, fuel efficiency and refrigerant standards are indirect methods of regulating GHG emissions, as truck manufacturers and operators adopt efficiency technology to be in compliance with these regulations, thereby reducing GHG emissions. Furthermore, as the GHG emissions of passenger vehicles face increasing regulations, it is likely that similar regulation of the trucking industry will follow.

The US EPA established the SmartWay programme in 2004, which certifies trucking technologies that increase fuel efficiency and reduce transport-related emissions

Conclusions

Aggressive adoption of these technologies allows for annual emissions from heavy-duty long-haul trucks to fall to 10% *below* current levels

Proven Efficiency Technologies Present a Significant Climate Wealth Opportunity

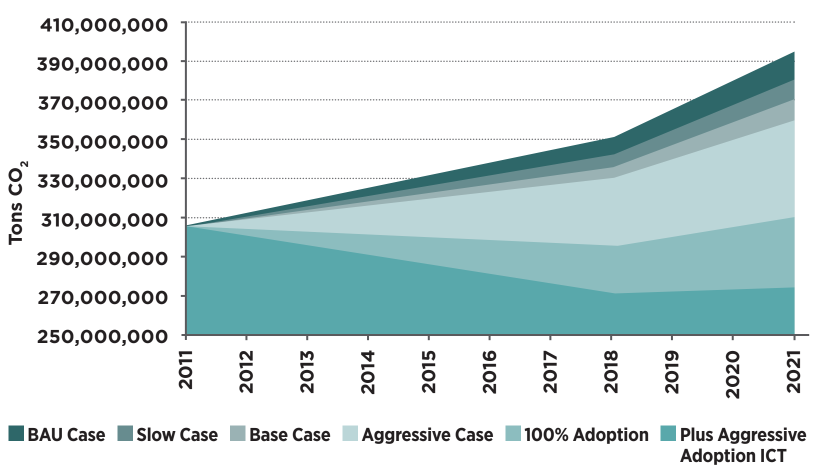
The technologies considered in this report reduce emissions by reducing fuel use – thereby saving truck operators substantial amounts of money. The climate wealth creation opportunity to be had from improving the fuel efficiency of the road freight sector is substantial.

This report considered five physical efficiency technologies and two ICT solutions for increasing the fuel efficiency of Class 8 trucks operating in long-haul duty cycles in the United States. The physical technologies considered were improved aerodynamics, anti-idle devices, 6x2 transmissions, single wide-base tires and advanced cruise control, all of which are among the upgrades required to achieve EPA SmartWay certification. The ICT solutions most applicable to and easily adopted by heavy-duty fleets were the reduction of deadhead legs and the implementation of GPS-assisted route optimisation. For both physical and ICT efficiency upgrades, hundreds of other technologies and options exist, many of which are also proven to reduce fuel consumption and to offer relatively short payback periods (NAS 2010, NACFE 2011, NESCCAF 2009).

The aggressive implementation of only five types of physical efficiency technologies would allow the United States' Class 8 trucks to reduce their greenhouse gas emissions by up to 404 million tons of CO_2e over the next ten years, while still enjoying strong annual growth. If business continues as usual, the annual emissions of long-haul trucking will increase by 29% by 2021. The lowest rates of adoption for these five technologies alone allow for the same levels of growth in the sector to occur but with only a 25% increase in emissions, equivalent to avoiding 67 million tons of CO_2e emissions, while aggressive rates of adoption will allow the annual GHG emissions of the heavy-duty trucking sector to grow by only 2% even as the number of trucks on the roads increases greatly – a difference of nearly 439 million tons of GHG emissions. Some of these technologies are appropriate and cost-effective for adoption by commercial vehicles of other gross vehicle weights and engaged in a variety of other duty cycles, further increasing the potential of the road freight sector to reduce its greenhouse gas emissions.

In addition to the five types of physical technologies quantified here, truck fleets can implement a range of ICT solutions to profitably reduce emissions. If Class 8 trucks in the United States aggressively adopted just two of those solutions, eliminating deadhead legs and optimising their routing with GPS, the sector would avoid an additional 185 million tons of CO_2e over the next ten years. These ICT solutions are not only appropriate for heavy-duty long-haul tracks but can increase efficiency and profitably reduce emissions for all commercial vehicle fleets, from trucks to light-duty vehicles.

Figure 5: The Emission Reductions Potentials Modeled by this Report



These seven technologies have the potential to prevent a total of 624 million tons of greenhouse gas emissions by 2021 in the United States alone (Figure 5). Their aggressive adoption allows for annual emissions from the operation of heavy-duty long-haul trucks to fall to 10% *below* current levels, even while the sector enjoys 2% annual growth rates. Those avoided emissions translate into reduced fuel consumption and therefore cost savings.

This report finds that the savings potential of efficiency technologies is such that the market alone provides sufficient incentive for their adoption, though a favourable regulatory climate will positively contribute. However, certain market barriers, particularly relating to trust, education and a lack of innovative financing tools to address the upfront capital cost of adoption, need to be overcome. The quantity of emissions from the road freight sector is such that taking serious, collaborative steps towards overcoming these barriers will have a substantial effect on the ability of the US to address climate change without hampering market growth.

The technologies reviewed by this report were chosen based on their payback periods, efficiency improvement potentials and relative simplicity to adopt, but the market offers a myriad of proven efficiency technologies from an even wider variety of vendors. The first step towards overcoming the barrier of trust and education includes gathering data about the true results achieved by the different technology options when employed in a variety of vehicle models and duty cycles. More research is required, including laboratory and field tests, as well as better financial data, which should then be made affordably accessible for fleet operators. Another step towards overcoming the trust barrier would be to highlight the experience of early adopters and other respected industry players who have implemented efficiency technologies. A few recent reports (NACFE 2011; NAS 2010; NESCCAF 2009) have begun these processes of information gathering and sharing, but a larger effort is needed.

Though this report considers the United States road freight sector, the opportunities to increase trucking efficiency are global. Worldwide, total ground freight (including rail) energy usage in OECD countries stayed stable between 2000 and 2005, but non-OECD countries increased their consumption by 25% over that same period. Growth of ground freight in non-OECD countries will continue to be the major source for the growth of GHG emissions for the next few decades (see the reports listed above). An assessment of the potential for achieving profitable reductions through the adoption of fuel efficiency technologies, as well as of the market barriers currently preventing the adoption of them, is also necessary in light of this global growth.

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Thanks you,

Carbon War Room
1150 Connecticut Ave., NW, Suite 620
Washington, DC 20036

P / 202.717.8448
F / 202.318.4770

Web: www.carbonwarroom.com

Twitter: www.twitter.com/cwarroom

Carbon War Room – LinkedIn Group: http://linkd.in/f3Zu1G