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Chapter 12:

Technologies and Policies for Improving Truck Fuel Efficiency & Reducing CO_2

by Anthony Greszler

Most of the focus on transportation efficiency and carbon dioxide (CO_2) mitigation has been on light duty cars and trucks used primarily for personal transport. This segment has a 66 percent share of transport petroleum consumption in the United States (U.S.) and a proportional share of CO_2 emissions. Nonetheless, the 21 percent share of U.S. transport petroleum consumption by heavy trucks and buses is significant and growing. Furthermore, when transport is viewed globally or if trends are projected out to mid-century, commercial road transport could well become the largest user of petroleum and emitter of CO_2 within the transport sector. Hence, increased focus, particularly on road freight transport, is essential for an effective program for mitigating transport CO_2 and petroleum consumption.

This chapter investigates the reasons for the increasing petroleum consumption, potential technologies for improved efficiency and greenhouse gas (GHG) mitigation, and policy options to promote these technologies. It will look at both vehicle and freight systems, since each offers significant potential for improvement.

Freight Segment Projections

Freight movement, measured in ton-miles, is closely correlated with economic activity in the U.S. The *Annual Energy Outlook 2009* (*AEO*), published by the Energy Information Administration projects annual truck vehicle miles traveled (VMT) to grow by 2.5 percent per year over the next 20 years (EIA 2009), while the Federal Highway Administration pegs the growth rate for tons hauled at 2.0 percent annually (FHWA 2009). This difference is primarily due to *AEO*'s projection that the average length of haul will increase, in addition to a growth in tonnage moved.

The impact is that, by 2030, truck VMT is projected to increase by 62 percent, barring improvement in freight transport, distribution, manufacturing, or other systems that drive freight demand. Interestingly, many “green” developments can also increase freight demand. For example, reduction in sulfur dioxide output from coal-fired power plants has greatly driven up coal transport from the Powder River Basin to eastern power plants, although primarily by rail. Moreover, mandates for renewable fuels, particularly ethanol and biodiesel, drive up transport of feedstock and finished product, since neither of these can be transported through existing oil pipelines.

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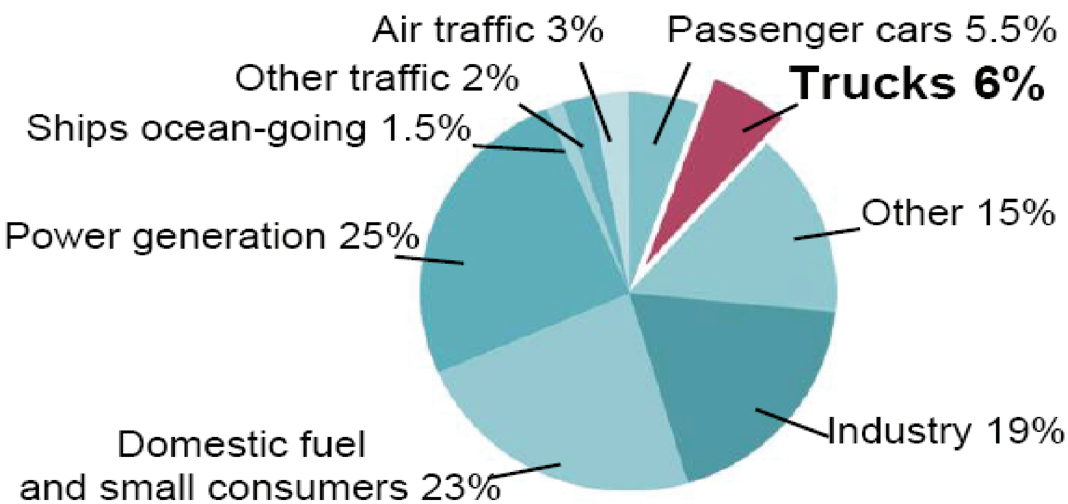
When the freight projections are combined with the historical rate of truck efficiency improvement of around 0.6 percent per year, the result is a dramatic growth in diesel consumption and CO_2 emissions by 44 percent by 2030, barring significant availability of lower carbon fuel alternatives. A recent U.S. Department of Energy (DOE) projection showed truck petroleum consumption exceeding light duty car and truck consumption by 2040, assuming a variety of aggressive policies to reduce light duty fuel consumption and VMT (DOE 2009). On a global basis, the impact of trucks is even greater, since developing countries have much lower reliance on personal cars (although use may now be increasing rapidly), but still depend heavily on road freight transport. As shown in Figure 12-1, data from the United Nations Environment Program show that truck CO_2 emissions exceeded emissions from the much more numerous cars on the road in 2002 (UNEP 2002).

Figure 12-1: Global anthropogenic carbon dioxide



Source: UNEP 2002

The demands for road freight have accumulated over time as primary modes have shifted from animal-drawn carts, to rivers and canals, to rail, and finally to roads. This last transition has been driven by dramatic improvements in highways, trucks, and logistic systems. According to the American Trucking Association (ATA), "Economic deregulation of the trucking industry, with its resulting low cost and high service levels, combined with the completion of the interstate highway system, gave rise to what is known as just-in-time delivery, allowing manufacturers to shift inventories from the warehouse to the highway" (ATA 2008). U.S. manufacturing and distribution systems are now critically dependent on the cost-effective delivery precision that trucks provide. Improvement in freight movement efficiency will do nothing to lower the demand for goods movement and may even tend to increase demand if efficiency translates into lower freight cost.

In dealing with light duty vehicle CO_2 mitigation, it has long been recognized that we need a "three-legged stool" approach combining actions to improve vehicle efficiency, to de-carbonize fuel, and to reduce VMT. The same approach needs to be applied to freight transport, but very little public sector attention has gone into this area. In fact, public policy related to freight has been almost entirely focused on safety or mitigation of criteria emissions, primarily nitrogen oxides and particulate matter, from diesel combustion. With the final phase-in of the 2007 and 2010 on-highway diesel emissions regulations, even the U.S. Environmental Protection Agency (EPA) refers to trucks as "clean diesel" (EPA 2001). Further reductions in criteria emission levels are not envisioned. Except for the introduction of low sulfur fuel, criteria emissions improvements have otherwise been accomplished almost entirely through vehicle technology improvements. These emission cuts have also reduced engine efficiency below what it might otherwise be, primarily due to combustion modifications to reduce nitrogen oxide emissions. Concerns are now shifting to global warming impact, which considerably broadens the scope of potential improvement, encompassing the entire freight and distribution system.

Truck Fuel Efficiency

Trucks haul a wide variety of goods in urban, regional, and long-haul operations. They also perform a broad range of vocational work such as garbage collection, concrete mixing, and utility repair. Commercial trucks cover a broad size range, rated by gross weight capacity, and generally include class 3 trucks weighing up to 10,000 pounds to class 8 trucks weighing as much as 80,000 pounds. Eighty-three percent of fuel burned in medium to heavy duty trucks is in the heavy truck segment, and most of this is in combination tractor-trailer trucks (ORNL 2009).

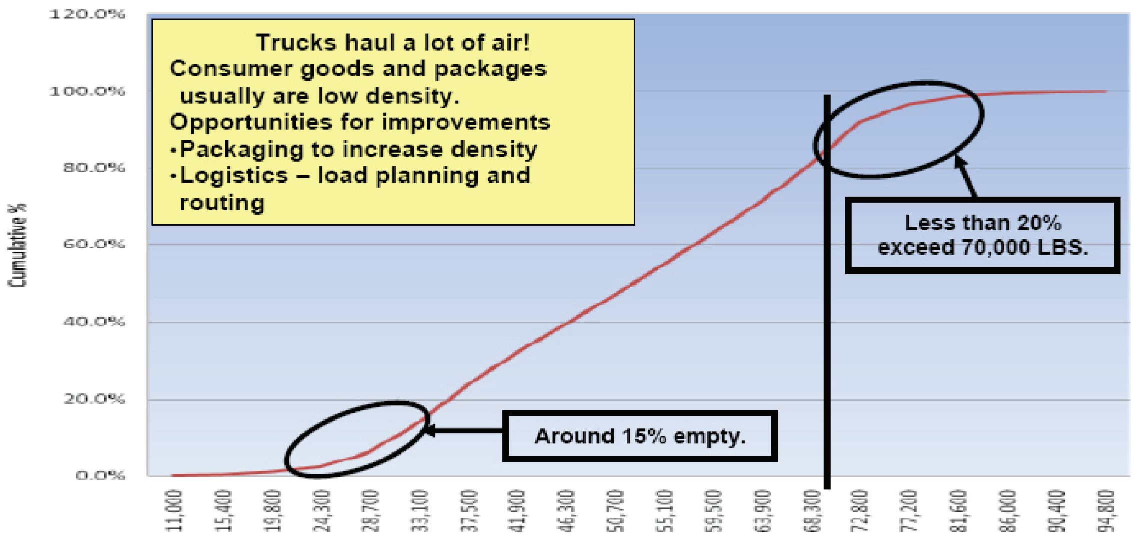
For light duty vehicles, fuel efficiency is usually measured in miles per gallon (mpg), but this is not an appropriate measure for heavy trucks. In the broadest sense, truck fuel efficiency could be defined as work performed per amount of fuel burned, an easy concept to envision, but nearly impossible to measure unless the scope is confined to a subset of the many functions trucks perform. If the vocational functions of trucks are ignored, attention focuses on freight delivery. Here, fuel efficiency can be measured in terms of freight-miles per gallon of fuel. Figure 12-2 below helps to show the big differences between mpg, ton-mpg, and volume-mpg. It shows why an mpg measure, which would be maximized by use of very small trucks, is a poor measure for efficient freight transport.

Figure 12-2: MPG is not an appropriate efficiency measure of global anthropogenic carbon dioxide

Source: Volvo Powertrain Division of AB Volvo

The majority of combination trucks in the United States are hauling 53-foot long box vans, simply because this is the longest trailer permitted in most states. There is no data on how often these vans are filled to capacity, but anecdotal data from carriers indicates that most loads are volume limited to well below the maximum gross combination weight (GCW) of 80,000 pounds, the limit set by federal regulation. Weigh station data, noted below in Figure 12-3, show that the 50th percentile load is around 53,000 pounds, and less than 20 percent of trucks carry over 70,000 pounds (US DOT VTRIS 2008). The major reason for this is that trucks usually haul high value, but lower density consumer goods, while heavier bulk and liquid commodities usually go by train, especially over longer distances. Regardless of the reasons, being aware of what trucks haul is important in driving technologies and establishing policies to improve truck freight efficiency and freight system efficiency. From a vehicle design standpoint, the goal is to haul the greatest volume of freight with the least fuel. From an operation standpoint, the goal is to maximize the amount of freight in each load, while minimizing VMT and fuel consumed. From a total system standpoint, the goal should be to minimize fuel burned by minimizing the amount and cost of freight movement required to support economic activity and by moving to lower carbon fuels.

Figure 12-3: Cumulative percentage weights of 5-axle truck combinations in 15 U.S. states in 2008



Source: U.S. Department of Transportation, Vehicle Travel Information System, 2008

Until recently, heavy truck design and manufacturing in the U.S. has been primarily a process of purchasing and assembling major components developed somewhat independently by the component manufacturers. Most engines, transmissions, axles, drivelines, and other systems were supplied by nonintegrated manufacturers. Customers were given wide latitude in specifying their desired components. Original equipment manufacturers (OEMs) of trucks focused on frame and cab features and also developed modeling tools to help integrate the components to meet the expected service requirements, including efficiency. This system drove a focus within the industry on component efficiency, but not necessarily on complete vehicle efficiency. Even government research funding tended to be funneled into specific component areas, particularly diesel engines. While this has reduced criteria emissions and improved fuel efficiency, it has also resulted in designs that could demonstrate very high efficiency in laboratory testing, but could not be reasonably deployed on a working truck due to packaging, weight, cooling requirements, or excessive in-use criteria emissions (NAS 2008).

During the past decade, largely driven by very demanding criteria emissions requirements, there has been a need for much closer integration of major truck components, particularly diesel engines. Of the three former non-integrated engine suppliers, only Cummins remains independent, with Caterpillar dropping out of the on-road diesel engine market and Detroit Diesel fully owned by Daimler. Meanwhile, all of the major U.S. heavy truck manufacturers (Daimler/Freightliner, Navistar, Paccar, Volvo/Mack) now have integrated diesel engine design and manufacturing capacity. These developments reflect the need for vehicle design integration while continuing efforts at component improvement, as noted in Congressional testimony by the industry members of the 21st Century Truck Partnership (HSTC 2009). The U.S. DOE has recognized this need as well and made funding available through the SuperTruck program to demonstrate a long-haul combination truck with a target of 50 percent freight efficiency improvement, including 20 percent improvement in engine efficiency at average road load.

Diesel Engine Efficiency

Diesel engine efficiency has long been driven by competitive demands in the trucking industry. From 1980 until 1999, diesel engines reduced fuel consumption by approximately 10 percent, but since then much of this improvement has been given up as increasingly stringent nitrogen oxide (NO_x) emission requirements led to combustion optimization for least NO_x emissions, rather than maximum efficiency. With most engine manufacturers adding selective catalytic reduction NO_x exhaust aftertreatment in 2010, efficiency will start to improve again. Trucks have seen steady improvements in available fuel efficiency features, particularly for long-haul tractors. The high fuel prices of 2008 forced many operators of "classic" shaped trucks with large frontal area and external air cleaner and mufflers out of business since they could not compete with more fuel-efficient trucks. Even as fuel prices have dropped, most fleets are now purchasing only aero-shaped trucks. It is very difficult to extract truck fleet fuel efficiency from available public data, but what data are available indicate very little change in combination truck mpg since 1980 (US DOT VTRIS 2008). Confounding issues are increasing speed limits since the gradual repeal of the federal 55 mph limit between 1987 and 1995 and truck load factors.

A major focus continues on diesel engine in-cylinder efficiency, including fuel injection, air induction, and combustion chamber design. New fuel system designs allow for injection pressures over 35,000 pounds per square inch with multiple injections per combustion event and rate shaping during each carefully timed injection event. Air induction is accomplished with variable geometry turbochargers and exhaust gas recirculation. Unfortunately, all this technology has been required to achieve nitrogen oxide and particulate matter reductions, while minimizing efficiency losses, rather than making efficiency gains, which would translate to GHG emission reductions. In fact, the most efficient truck engines were produced in 1998, before increasingly tight nitrogen oxide emissions requirements resulted in an approximately 10 percent loss in engine efficiency.

A recent development in diesel combustion is premixing fuel and air prior to start of combustion, commonly referred to as homogenous charge compression ignition (HCCI) or partial HCCI (PHCCI). Conventional diesel diffusion combustion relies on injection of fuel to time the start of combustion. Fuel is injected when the heat and pressure of compression are sufficient to initiate combustion as the atomized fuel spray plume evaporates and mixes with air. This process results in relatively slow combustion and generates nitrogen oxides and particulate matter. In premixed combustion, fuel is injected prior to achieving sufficient in-cylinder conditions to promote combustion, allowing for the fuel and air to be better mixed when combustion begins, eliminating most criteria emissions and increasing the rate of combustion. If in-cylinder conditions can be managed to perfectly time the start of combustion, the result is both very clean and very efficient combustion. Unfortunately, it is very difficult to control the variables that impact start of combustion, which include temperature, pressure, oxygen concentration, and fuel properties. An early start of combustion (SOC) reduces efficiency and can cause major damage, due to high cylinder pressure. Late combustion reduces efficiency and could also cause misfire. To date, PHCCI has been successfully deployed only at light loads, primarily for criteria emissions control. Deployment at higher loads will require systems to sense SOC and real-time management of in-cylinder conditions. This remains an elusive goal.

A requirement to meet recent on-highway diesel engine criteria emission levels has been the addition of exhaust aftertreatment systems (EATS). In 2007, all manufacturers added diesel particulate filters (DPF). In 2010, most will add selective catalytic reduction (SCR) to remove nitrogen oxides from the exhaust. Both these systems raise exhaust back pressure, which reduces engine efficiency. The DPF may also require active regeneration, accomplished by combusting fuel in the exhaust system to raise the temperature high enough to burn carbon accumulated in the DPF. Conversely, EATS allows for higher in-cylinder nitrogen oxide formation. As a result, manufacturers using SCR are expected to deliver a fuel efficiency improvement of around 4 percent. Fuel cost savings are partially offset by the need to use diesel exhaust fluid (DEF) to facilitate nitrogen oxide catalysis, but most of the CO_2 benefit is retained since DEF has very low net CO_2 impact. Further efficiency gains can be expected as better combustion optimization is facilitated by increased EATS effectiveness.

Engine efficiencies are also improving through efforts to reduce parasitic losses from pumping coolant, oil, and fuel and from friction. Efforts include reducing fluid pressure requirements, electrical or mechanical variable displacement pumps, low friction oil, active management of oil and coolant temperature, reduced friction power cylinder units, and reduced friction bearings.

Probably the single biggest engine efficiency gain could potentially come from waste heat recovery. Current diesel trucks average about 42 peak percent thermal efficiency, due to limits of the diesel cycle, emissions, and materials. The majority of the remaining 58 percent of fuel energy is rejected to coolant or exhaust heat. There are multiple approaches to convert some of this wasted heat energy into usable mechanical or electrical energy. The three primary methods are:

- Turbo-compounding, which uses a power turbine in the exhaust stream to drive power back into the crankshaft or to generate electricity
- Thermo-electricity, which uses thermo-electric materials capable of generating an electric current from a thermal gradient
- Rankine bottoming cycles, which involves boiling a fluid using the waste heat and driving a turbine or rotary expander to generate mechanical power or electricity

Turbo-compounding has seen limited deployment in production application, but has already been shown to deliver around 3 percent better fuel economy in a highly loaded application. However, at light load, it may harm fuel efficiency. Thermo-electricity, with current materials, can deliver an efficiency improvement of only 1 percent, due to very low conversion efficiency. Rankine bottoming cycles offer the greatest potential, with estimates of efficiency improvement of up to 10 percent in a highly loaded application. Rankine systems require multiple heat exchangers, an expander to generate the power with near-zero leakage of working fluid, low temperature heat rejection in the condenser, and a working fluid that can survive high exhaust temperatures, provide appropriate thermodynamic properties, and avoid freezing. All this has to be done with minimal additional weight and space claim and without adding aerodynamic drag for cooling.

All of these engine technologies combined might deliver a 15 to 20 percent improvement in efficiency, considering that not all can be combined and some are only applicable to highly loaded applications. A tremendous amount of development and expense is required to bring the best technologies into production. Given this, diesel engine efficiency might be expected to improve at a rate of about 1 percent per year over the next 20 years.

Heavy Truck Efficiency

Key areas for truck efficiency gain, beyond the fuel and engine, involve changes to the powertrain, hybridization, wheel and tires, aerodynamics, weight reduction, auxiliary systems, idle managements, driver management, and navigational aids.

In the powertrain, small losses occur in the transmission and axles. Although some friction reduction is possible, the biggest gains are available by deploying smart, advanced transmissions carefully matched to the engine and truck. A growing number of current trucks are sold with automated manual transmissions (AMT) that use a conventional gearbox and clutch, but deploy mechatronic controls to automate the clutching and shifting. This retains the very high mechanical efficiency of a conventional gearbox, while providing the convenience of fully automatic operation. More importantly, a computer controls the shift schedule to maintain the optimal gearing for efficiency. The most advanced AMT's have the ability to sense load and grade to optimize the shifting based on the engine efficiency map. Future transmissions may offer power-shifting capability that can avoid transient torque loss during each shift due to turbocharger lag and improve the acceleration capability from a smaller engine. In turn, use of a smaller engine will drive the average engine load into a more efficient zone, enhancing engine cycle efficiency.

Most long-haul trucks use tandem drive axles, due to the need for traction in slippery conditions or on uneven surfaces. Since each drive axle requires a differential and drive shafts, using only one drive axle reduces friction and lowers weight. This can be accomplished with minimal loss of traction by transferring weight to the drive axle when wheel slip is detected, although this system may temporarily exceed allowable axle weight limits.

Hybridization offers huge potential for efficiency gains in certain vocational applications, most notably urban refuse collection, due to stop-and-go operation, and utility trucks where engine idling can be avoided during extensive periods when the vehicle is parked, but power is needed for utility functions. In these applications, 30 percent or greater efficiency improvements are possible. However, in long-haul operations, where most truck fuel is burned, there are few braking cycles, and braking energy recovery, possible with hybridized drivetrains, is not a major source of energy. Long-haul hybrid systems can be effective in rolling hills or to avoid idling and light load diesel operation, however, and they can provide electrical power for auxiliary functions. A long-haul hybrid system is estimated to provide between 6 and 8 percent improved efficiency, but much of this is due to elimination of idling during sleeper truck hotel mode, which can be achieved with lower-cost systems. It remains unclear if the fuel and GHG savings of a long-haul hybrid system are adequate to cover the extra weight and cost of the system for typical long-haul applications.

Significant progress has been made recently in advancing low rolling resistance and single-wide truck tires. Since about 30 percent of a truck's energy demand is due to rolling resistance, every 3 percent reduction in rolling resistance translates into 1 percent vehicle fuel savings. The lowest rolling resistance is accomplished by replacing dual wheels on the rear tractor axles and trailer axles with wide single wheels and tires. This can reduce fuel consumption by approximately 3 percent compared to a typical dual wheel and tire system. Further gains are expected, but care must be taken to avoid loss of tire safety, durability, and traction.

Aerodynamic losses are the biggest power demand in a long-haul truck, typically accounting for about half of all losses at 65 miles per hour (mph). Truck manufacturers all offer aerodynamic cabs, which now comprise the vast majority of tractors sold. Still there are small aerodynamic improvements in tractor design that offer about 2 percent vehicle efficiency gain, but the biggest gains are possible by matching the tractor to the trailer and in streamlining the trailer. Significant trailer improvements have been demonstrated, including side skirts, bogie covers, and rear aerodynamic devices known as boat tails, that offer a total fuel efficiency gain of around 10 percent, but very few trailers are so equipped. A primary reason for this is that there are more than three trailers for every tractor, tripling the cost side of the cost/benefit ratio. Also, these devices may be subject to damage on uneven surfaces or may interfere with loading and unloading operations. Greater standardization of trailers could allow for better airflow design between tractor and trailer.

Since aerodynamic losses increase dramatically with speed, the simplest efficiency gain is to slow down. All modern long-haul trucks come with road speed governors that are used by most fleets to restrict maximum speed. In most countries, a maximum governed road speed is legally mandated and restricted by factory engine settings. Europe, for example, sets the maximum governed speed at 90 kilometers per hour, or 56 mph, which is programmed into the truck control system at the factory. The ATA is in favor of setting a road speed governor limit at 65 mph to increase fuel efficiency and safety (ATA 2009).

Heavy trucks are much less sensitive to weight impact on fuel efficiency than light duty vehicles. Fuel efficiency improves around 0.5 percent per 1,000 pounds of weight reduction, so the cost of weight reduction is hard to recover in fuel savings. However, weight is particularly important in the 20 percent or so of trucks that are hauling maximum weight, since less weight means increased freight capacity and fewer trucks to haul the same freight.

Truck auxiliary systems include the air compressor, air conditioner compressor, power steering pump, electrical alternator, cooling fan, engine oil pump, and engine coolant pump. Collectively, these can account for around 8 percent of the total vehicle power demand. All except the oil and coolant pump are typically operated either as an on/off function or modulated by demand, although most incur frictional losses even in the off mode. By converting these from mechanically driven to electrically driven, it is possible to eliminate the friction when off and to fully modulate the operation to meet demand. If the electricity is generated by an engine-powered alternator, much of the benefit is lost due to inefficiencies incurred in converting mechanical energy to electric and then back again. However, if the electricity can be generated by a hybrid motor using braking energy or by a waste heat recovery system, total system efficiency can be improved. Furthermore, an electric air conditioning system could be deployed while the truck is parked either by plugging in at an electrified truck stop or by using battery power to eliminate engine idling for cab cooling demand.

Truck idling while parked can account for a significant portion of fuel burned. Drivers are required by federal rules to rest for at least 10 consecutive hours. Drivers may not drive more than 11 hours per day. These rules mean a long-haul truck with a single driver must spend 13 hours per day stopped, much of it with the driver in the vehicle. If the diesel engine is idled to maintain cab comfort and electric supply, it consumes approximately 0.7 gallons per hour or 6 to 10 gallons in a day, depending on the total amount of idle time. The same truck might consume 100 gallons while driving, assuming 600 miles per day and 6 mpg. In this mode, 6 to 9 percent of fuel consumed is due to idling. There are many idle reduction systems on the market, for example diesel fired heaters, diesel auxiliary power units, battery powered systems, diesel start/stop systems that monitor cab temperature and battery, and truck stops with air conditioning, heating, and electricity supply. None of these is fully optimum, but all offer improvement over continuous idle and more improvement is possible.

The most important influence on the fuel economy of trucks is the driver. Unfortunately, there is a huge annual turnover of long-haul drivers, typically exceeding 100 percent in most fleets. Driver training is expensive, so fleets need to balance training against expected turnover. Fleets also must compete vigorously to attract and retain drivers. This might pressure them to acquire higher-power, less-efficient trucks because drivers generally like these trucks. Significant vehicle technology is available to help manage drivers, including road speed governors with maximum speed set by the fleet, reduced power in lower gears to encourage early up-shifting for better efficiency, smart transmissions to control gearing, driver feedback, and driver efficiency rewards. Future systems might deploy GPS with terrain and route maps to advise or even control vehicle speed when cresting hills to minimize brake application on the downhill segment or to adjust the road speed governor based on posted speed limits. The objective is to control the truck in the most fuel efficient way.

Additional navigational aid can be providing via intelligent transportation systems that rely on vehicle-to-vehicle communication and infrastructure communication to convey information on congestion, truck stop availability, or other data to help drivers adjust speed, schedule breaks and stops, and to modify routes to minimize time, distance, and fuel consumption.

Freight System Efficiency

Freight is moved by road, rail, pipeline, water, and air. Quite often, multiple modes are deployed. For example, an overseas shipment usually arrives by water. From the port, it may go by truck to a rail terminal, be transported some distance by rail, be moved to a warehouse by truck, and then be distributed to a retail store by truck, transported to a home by a consumer's automobile, and ultimately transported to a landfill or recycled by truck, maybe even being shipped back overseas for reuse. Typically, a domestically-manufactured product moves by truck six times during production and distribution, while imported products move four times after landing at a port (ATA 2009).

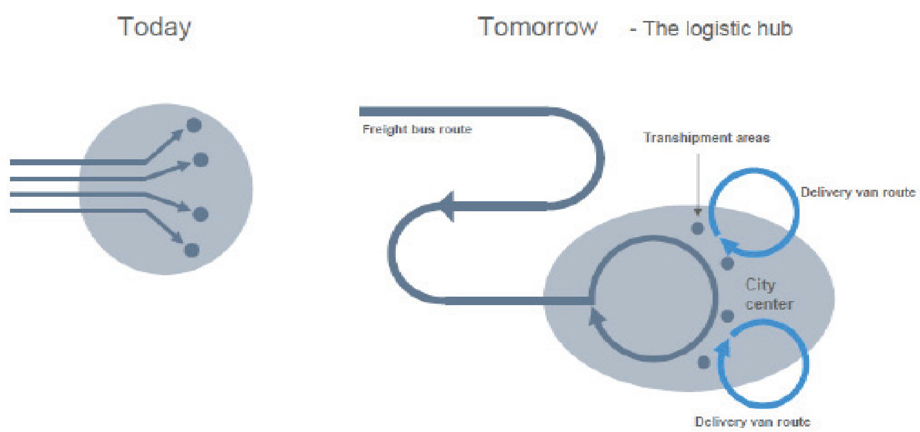
Carriers control truck specifications, the purchase of trailers, and the matching of trailers to tractors. Maximum road speed settings are also controlled by carriers and all long-haul trucks are equipped with programmable road speed governors. Fuel efficiency improves between 1.5 and 2.0 percent for every mph speed decrease between 70 and 55 mph. Therefore, a decrease from 68 to 63 mph can deliver a fuel savings of about 7 percent. Carriers can also use increasingly sophisticated logistics tools to increase the average load per truck, decrease the distance traveled, and optimize routes for fuel efficiency. Many carriers also work with railroads to provide intermodal service when it best meets customer needs. However, in reality, logistics demands and shipper expectations include delivery timing precision, total operating cost, driver satisfaction, and many other concerns that may not be compatible with maximum fuel efficiency.

Shippers can contribute by establishing manufacturing, warehousing, and distribution systems to minimize transport demand. This could include less reliance on just-in-time delivery, which often requires a truck to move before a full load is available and often precludes transport by rail or even forces air transport. Shippers could also reduce packaging that takes up valuable space while adding to the refuse transportation demand. Manufacturing facilities can be located to minimize distance for transport of incoming materials and finished products. Once again, however, there are many factors beyond freight transport efficiency that factor into the decisions made by shippers.

It is not feasible to regulate most of the potential efficiencies possible by carriers and shippers. The related factors are far too numerous and the trade-offs are too complex. Nonetheless, transportation costs are a factor in these decisions. If fuel and carbon emissions costs are increased, the choices will become more biased toward reducing these costs with resulting efficiency gains. Of course, many of these adjustments will take years to implement, since the system infrastructure includes buildings, highways, railroads, terminals, and other components.

Another key element in the road freight system is the public highway system and related facilities and regulations. As highways become increasingly congested, more fuel is burned to travel the same distance. Also, insufficient truck stops for parking during driver rest periods with electrification forces more trucks to seek alternate places to stop with more engine idle time. Regulations on truck weight, trailer length, and permissible combinations, which vary by state, preclude some of the available fuel efficiency upgrades that require more weight, for example, for idle reduction, or more length, such as for trailer boat tails. Even in cases where federal provision is intended to provide for such features, it may not be accepted or understood by state enforcement agencies and truckers will not take the chance of being ticketed. Ideally, trucks would be provided with unique lanes that avoid congestion and allow for low speed on grades without interfering with car traffic.

Figure 12-4: Freight truck movement patterns today and tomorrow



As urban areas grow, there is a need to design better systems for freight and package delivery into urban centers. One proposal is to use a structure similar to bus rapid transit (BRT) systems or even to use the same routes as BRT. This would have large trucks run a circular route, dropping off freight at terminals where smaller trucks would make local deliveries. Figure 12-4 compares the freight delivery pattern of today's system with a proposal for the future modeled after BRT systems.

Public Policy Issues

Given the complexities of the freight system and the fact that freight delivery is a highly competitive business, an effective policy to improve the overall system efficiency and reduce CO_2 emissions is to increase the cost of carbon emissions. Ultimately, this cost will impact all private aspects of the system:

vehicle technology, carrier purchase decisions, logistics, warehousing and distribution, shipper demands, and even manufacturing strategies. Some of the impacts occur quickly, as was evidenced during the 2008 fuel price spike, when carriers placed a great emphasis on fuel savings and many inefficient trucks were taken out of long-haul service. However, many of the impacts require long-term infrastructure changes or technology development that can only occur with sustained carbon pricing policy at sufficient level to offset other factors. Furthermore, these longer-term decisions require confidence by decision-makers and investors that policies will stay in place long enough to provide return on the investments.

Major fluctuations in the price of oil reduce confidence in investment in fuel savings. Hence, policies that contribute to a predictable, increasing cost in petroleum diesel fuel will have the greatest impact. However, the relationship between cost for fossil fuel or CO_2 emissions and the resulting short and long term reduction in emissions is not well established and needs further study.

The federal 12 percent excise tax on new trucks has a negative impact on truck fuel efficiency, since it taxes the value of fuel efficiency and increases the cost to replace older, less efficient equipment. Elimination of this tax and recouping the revenue by increasing the fuel tax would both lower the purchase cost and increase the value of fuel efficiency features.

Increasing the length of trailer combinations to allow twin 48-foot trailers has been shown to offer up to 28 percent improvement in ton-mpg for volume limited freight. Increasing the weight allowance for this combination, while maintaining current axle weight limits, can improve ton-mpg up to 39 percent (ATRI 2008). Although studies have shown that such combinations can actually improve safety, if done with proper equipment and trained drivers, there are still many concerns about safety for cars passing such long trucks and for road or bridge damage in the case of increased weight. There is also concern that such allowances might shift freight from rail to truck, with loss of efficiency, although the same argument could be made against any improvement in truck efficiency. Even if length and weight limits are not generally increased, it would be helpful to at least establish consistent limits rather than the current system where states set inconsistent limits that require trucks to load for the most restrictive state they must cross. Also, weight and length limits should allow for increases to accommodate fuel saving features such as anti-idling systems, tractor and trailer skirts, or trailer boat-tails.

Incentivizing a shift from road freight to rail is another viable policy, since rail can decrease fuel required by approximately 50 percent. Incentives could include provisions for intermodal terminals and assuring adequate bridge clearance for double stacked containers on rail cars. However, the amount of freight that can be moved to rail is limited by a variety of factors.

Significant fuel savings can also be realized while increasing safety by restricting maximum truck speeds. The ATA supports a mandatory road speed limiter set at 65 mph. Even lower limits could be considered.

There is currently a federal mandate created in the Energy Independence and Security Act of 2008 for the Department of Transportation to establish fuel efficiency regulations for trucks. The EPA is also working to establish GHG emission limits that will essentially be fuel efficiency standards, in the absence of significant availability of low carbon fuels. Such standards will be difficult to develop because of the great variety of trucks with varying duty cycles, sizes, and load factors. Effective regulation needs to account for the work performed. For example, an mpg standard would tend to drive down the size of trucks, to the detriment of freight efficiency, which improves with larger trucks. For freight trucks, ton-mpg and volume-mpg are more appropriate measures, but their implementation would complicate the efficiency measurement process.

For vocational and work trucks, such as refuse or utility, efficiency measurement is further complicated by the energy demands of the work function. Furthermore, the areas for potential improvement in freight efficiency are only partially impacted by vehicle technology, and even these areas are split between manufacturers of truck chassis, tractors, trailers, and body builders. So, there is no single manufacturer in control of most finished trucks. Still, there are good reasons to promulgate efficiency regulations. The trucking industry is very reluctant to accept new, unproven technology, since on-road breakdowns are expensive and result in failures to meet customer delivery demands. Fleets look for short payback time for any technology investment, typically about two years. Establishing firm requirements that force technology by a set date means that improvements are forced into the marketplace even when carriers may not yet freely accept them. The advantage, however, is that it forces manufacturers to allocate engineering and capital to the improvements and limits the risk that customers will not accept the new technology. It would be helpful if federal standards were established for trailers both to require efficiency improvements and to promote a streamlined design profile between tractor and trailer.

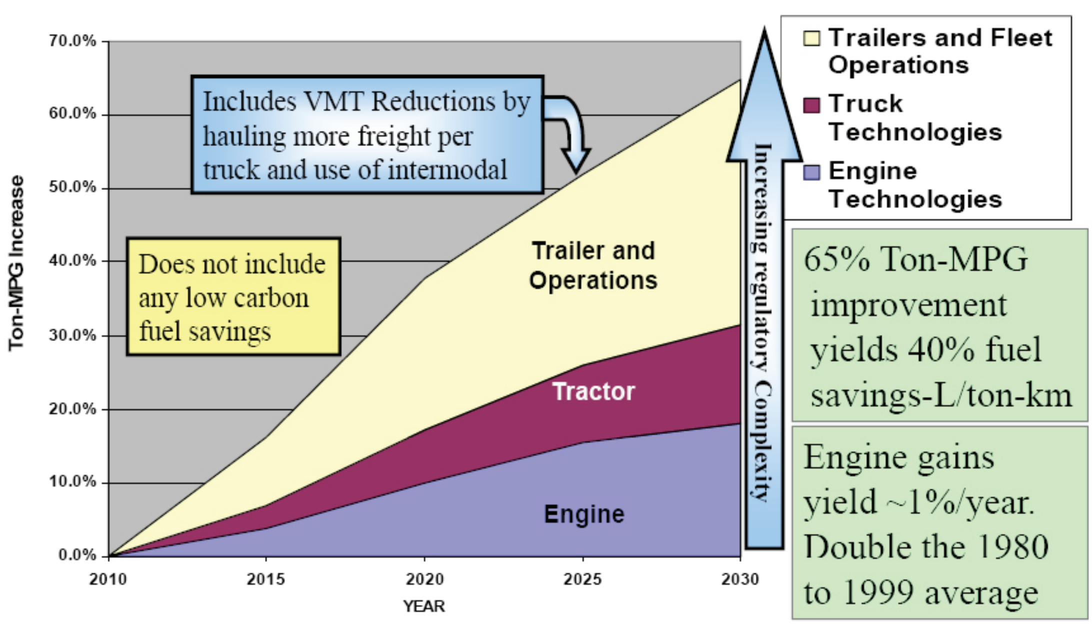
Many states, lead by California, have adopted anti-idling regulations to limit the time trucks spend idling. As noted earlier, idling can consume 6 to 9 percent of fuel in long haul truck operation. Anti-idling regulations force drivers to shut off their engine when it is not needed and can force owners to install systems for sleeper cab hotel function that do not require engine operation, saving most of the fuel otherwise consumed.

There is a great need for long-term planning for the U.S. freight delivery infrastructure. This should include plans for trucks to avoid congestion, adequate truck stops with electrification facilities to avoid idling, consideration for truck-only lanes to allow for slower trucks in busy areas, intelligent highway systems, and urban delivery systems.

Another key policy issue is the development of low carbon fuels for the freight sector. Due to much higher average power requirements, it is far more difficult to provide significant vehicle driving range on battery power in trucks than with passenger cars. There are currently no serious alternatives to fossil diesel, except for limited amounts of biodiesel, with questionable GHG benefits. There are many proposals to develop fuel alternatives, including biomass gasification, algae, natural gas, and dimethyl ether. All of these have major cost, efficiency, infrastructure, and scaling issues that will require federal support and policies to resolve.

There is a need for significant investment in technology development before many efficiency improvements can be realized. Additional focus and funding for this effort can help to demonstrate what is feasible and accelerate the rate of improvement. If these are provided by the federal government, significant gains are possible.

Figure 12-5: : A Prospective Scenario for Vehicle Efficiency Gains and VMT Reductions for a Class 8 Truck



Summary

This has been an overview of potential efficiency gains in the very complex but critical U.S. freight transport system. Significant gains are possible in truck technology, trailers, fleet operations, logistics, and public policy. An estimate of potential gains for new vehicles is presented in Figure 12-5.

The figure shows over 60 percent improvement in ton-mpg by 2030 through technology improvements. If low carbon fuels are introduced, even more gains are possible. All this will require a major focus in government policy and huge investments by industry. This means a shift in focus to expand beyond light duty vehicles to include the important and growing freight transportation sector.

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