

AN ASSESSMENT OF FACTORS AFFECTING FLEET FUEL PERFORMANCE

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ABSTRACT

Improving fuel performance in all modes of transportation is becoming more important as fuel prices increase and concerns over environmental issues rise. This is particularly relevant in the class 8 motor carrier sector which accounts for the majority of fuel consumption among all classes of motor freight movement. The present study evaluated the extent that existing technologies, systems and policies designed to improve fuel efficiency have been and are expected to be adopted by current class 8 fleets. Results suggest that while many of the efforts of suppliers to the industry are focused on new technologies, there remains an opportunity to improve performance from proven existing technologies and policies.

INTRODUCTION

In October 2005, Wal-Mart posed a challenge to truck manufacturers to develop and implement technologies that will allow the doubling of fleet fuel efficiency from 6.5 to 13 miles per gallon by 2015. In February 2006, United Parcel Service announced it would purchase 50 new-generation hybrid delivery trucks in two sizes from International Truck and Engine and Freightliner LLC. The dramatic rise in fuel prices combined with growing environmental concerns are pressing freight transportation companies to

pursue new systems and methods to improve fuel efficiency and reduce environmental impact.

Technologies such as advanced hybrid systems and redesigned body panels that reduce drag are examples of technologies that may lead to significant fuel efficiency improvements. At the same time, policies such as those to reduce truck idling time illustrate a more immediate means to influence performance. The EPA, through their SmartWaySM Transport Partnership, is facilitating the adoption of new technologies and methods by motor carriers and encouraging

shippers to consider fuel efficiency and environmental impact as part of their transportation decisions. While select major carriers appear to be leading efforts to adopt technologies that support a dramatic improvement in fuel performance, there appears to be little understanding as to the breadth and depth of efforts being taken by the broader motor carrier community consisting of over 20,000 companies of all sizes.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the level of adoption of technologies and policies to support improved fuel efficiency among motor carrier fleets. The specific research questions addressed in this study include

1. What is the current state of adoption of each of the various technologies, methods and policies?
2. What is the anticipated extent of future adoption of current and future technologies, methods and policies?

This article discusses the types of systems and technologies currently being employed to improve fuel performance among class 8 motor carrier fleets. The technologies discussed were then incorporated into a survey distributed to fleet management organizations. The survey inquired about current and future plans for adoption of the technologies identified, their current operating performance and their expectations for future performance. A comparison among companies operating enclosed trailers is presented as a means to assess the potential impact among fleets with similar equipment characteristics. Finally, study conclusions and implications are presented, followed by suggestions for future research. Recent technologies such as hybrid drive systems have been excluded from the study due to the likely low rate of adoption this early into their development.

FUEL PERFORMANCE INITIATIVES

Efforts to improve the fuel efficiency of class 8 truck fleets range from driver training and policy enforcement to more dramatic changes involving the implementation of hybrid drive trains and air flow management systems. A number of industry and industry/government partnerships pursuing research into more complex methods that involve significant unit design and equipment modifications have also been established.

The 21st Century Truck Partnership, formed in April 2000, consists of government agencies, research institutions, industry members and other concerned organizations. The ultimate goal of the partnership is to provide “safe, secure, and environmentally friendly trucks and buses, using sustainable and self-sufficient energy sources that enhance America’s global competitiveness (US. DOE 2006 p. 1).” The five areas of focus for the partnership include engine systems, heavy-duty hybrids, parasitic losses, idle reduction and safety.

Research institutions investigating technologies to improve fuel performance and environmental impact include the Rocky Mountain Institute, Argonne National Laboratories and Oak Ridge National Laboratories. In addition, U.S. government institutions including the Environmental Protection Agency, Department of Energy, Department of Transportation and Department of Defense are all involved in the 21st Century Truck Partnership as well as other research consortiums.

In the United States, the EPA’s SmartWaysm Transportation Partnership provides carriers with information and analytical tools to evaluate the benefits of specific equipment and management strategies. Through their certification program, member organizations gain access to low interest loans to retrofit equipment with fuel saving technologies.

In Canada, a similar program, FleetSmart is operated by the Natural Resources of Canada Office of Energy Efficiency. A recent FleetSmart Benchmark study surveyed approximately 100 Canadian-based motor carrier fleets regarding their efforts to improve fuel performance. Forty-two companies responded to the survey. Technologies and policies that were being used by carriers included improving aerodynamics, installing in-cab fuel performance displays, providing driver training, monitoring tire inflation, restricting maximum speed, reducing idling time, initiating driver incentive programs, insuring regular vehicle maintenance, remote monitoring of engine performance and the installation of efficiency add-ons such as cab heaters and auxiliary power units (APU's)

(Ogburn and Ramroth 2007). Table 1 outlines estimated fuel performance improvements identified in a series of studies and articles.

While emission regulations implemented in 2002 and most recently in 2007 are helping to reduce the impact of fleet operations on the natural environment, changes in engine and exhaust requirements and the adoption of ultra low sulfur diesel have reduced fuel performance by an estimated 3-4%.

METHODOLOGY

The study targeted companies operating class 8 tractor trailer fleets. Before implementation, a review of academic and popular press literature

TABLE 1
PERFORMANCE ESTIMATES FROM CURRENT ARTICLES AND STUDIES
(REDUCTION IN TOTAL FUEL CONSUMPTION, EXCEPT AS NOTED)

	RMI/ CTA	Ang-Olso n/ Schroeer	Kilcar r	Smart way	Bachman, Erb, Bynum	Langer	Ogburn, Ramrot h	Wood
Power Unit								
Auto Shutdown		5.9%						
APU	8% (80%)*	8.9%		(75%)*		1.5-6%	8% (80%)*	
Heaters		3.4%						
Speed	7%	13.6%	10%	20%			7%	
Transmission			5%			2%		
Tires/Wheels								
Low Resistance	4-6%		10%			3%	4%	
Super-wide		2-5%		2-5%	6-12%	3%	4-6%	
Auto-Inflation		.5-1%	3%	.5-1%				
Aerodynamics								
Cab Extender	2%	1-2%	3%	2%	5-12%**	2.5%	1-2%	3%
Cab Fairing		6%	10%			2%	2%	
Bumper-Dam	2%		1.5%					
Mirrors			1-2%					
Trailer Skirts	4%	5-18%	3%	5%			4%	5%
Trailer Tail	6%						6%	5%
Management								
Training		5-20%		10%				

* The values in () are based on an estimated reduction in the amount of fuel used to operate the main engine for power

** Based on an unspecified combination of aerodynamic features.

for the motor carrier industry was completed in an effort to document the types of equipment, information technologies, and corporate policies that were being employed by carriers in an effort to improve fuel performance. The list formed the foundation to lead interviews with operations managers at four large motor carrier companies as well as with researchers in the logistics transportation arena. Notes from the interviews were reviewed and compared with content from the literature review to identify any other methods to improve fuel performance using equipment, information technologies or corporate policies.

The literature review and interview responses led to the development of a survey instrument to be distributed to individuals responsible for the management of class 8 motor carrier fleets including private, contract and common carrier organizations. In addition to demographic data, the survey questions focused on four categories of methods that may be used to improved fuel performance. The categories included tractor equipment technologies (18 items), trailer equipment technologies (5 items), management policies (7 items) and information systems technologies (5 items). The survey addressed current and future actions that may be taken to address fuel performance concerns. Specifically, respondents were asked to address the state of policy, method and technology adoption by indicating whether they had completed implementation, were in the process of implementation, had plans for implementation in the next 1-2 or 2-4 years or had no plans for implementation.

In addition, the survey addressed issues related to engine replacement strategies, compliance with federal emission regulations and expectations of changes in fuel performance that may result from technology and regulation. Finally, participants indicated the estimated percent of total miles traveled above 45 miles per hour and whether or not the company currently participated in the EPA SmartWaysm Transportation Partnership.

With regard to the current average fleet mileage, the survey asked participants to categorize their performance in miles per gallon into one of 12 categories ranging from less than 5 mpg to between 7.8 and 8.0 mpg. Each category represented a .3 mpg range. While this does not provide for a more refined analysis, this question type was selected in an effort to encourage responses. In cases where open ended questions are presented for such specific information, participants frequently choose not to respond either because of competitive concerns or the need for specificity. The draft survey was reviewed for content, language, and structure by experts in survey development as well as industry practitioners.

The survey was distributed through email to the individual representing the highest level of management in either fleet operations, purchasing or fleet maintenance at 24,000 carriers who subscribe to *Commercial Carrier Journal*. The email provided a link to an on-line two page survey which could only be administered once to anyone who chose to participate. The email linked to the survey was redistributed to the population two weeks after the first distribution with a request for participation if they had not done so to that point. A list of survey questions is provided in appendix B.

Of the initial distribution of 24,000 email surveys a total of 164, or less than one percent of surveys were completed. The poor level of participation was attributed to the potential for survey fatigue among the participants, the potential for deletion from email despite efforts to present the distribution as distinctive from emails referred to as "spam", and the perceived length and detail of the survey questions.

Of those organizations participating in the survey, 31 percent classified themselves as private carriers, 12.5 percent as contract carriers, 35.1 percent as common carriers and 14.3 percent as a combination of common and contract carriage. The 7.1 percent of

participants who selected the “other” category consisted of government related organizations. Fleet sizes ranged from less than 10 motor units (26.8%) to greater than 1000 motor units (4.2%).

Each participant was asked to break down their trailer type by percentage into seven categories including box van, flatbed, temperature controlled, tanker, soft-sided, auto-hauler, and other. The majority (98 participants) indicated at least 50% of their fleet included box vans or temperature controlled van. Regarding the average age of motor units, 30.4 percent placed their fleets in the two to three years old category and 33.3 percent in the greater than four years old category.

Of the 164 participants, 84 percent indicated that over 50 percent of their total miles included speeds above 45 miles per hour. Forty-four percent indicated that over 75 percent of their total miles were traveled at speeds above 45 miles per hour. Fuel performance for those participating in the survey centered in the 5.7 to 5.9 miles per gallon range with a rather normal distribution to the extremes of less than five miles per gallon and 7.5 to 7.7 miles per gallon.

In most cases, carriers acknowledged it was too early to assess the impact from the implementation of new engine standards at the beginning of 2007. In response to a question about motor unit replacement strategies over the next two years, almost 10 percent indicated that they planned to employ engine rebuild over new unit purchase.

The following sections address the adoption of technologies, policies and methods employed by carriers to improve fleet fuel performance. The sections represent four categories including motor unit technologies, trailer technologies, management policies and information system technologies. These categories vary from the original discussion by separating tire and wheel technologies and

aerodynamics into their application on the motor unit and trailer respectively. In each section, results are ranked

by the current and planned level of adoption among survey participants beginning with those that have been fully implemented, those that are in the process of implementation, those that are expected to be implemented in the next 1 to 2 years, the next 2 to 4 years, and those in which participants have no plans for future adoption.

MOTOR UNIT TECHNOLOGIES

Motor unit related technologies (see Figure 1) that have been or are in the process of being adopted by at least 50 percent of participants include two engine-related systems, three aerodynamic modifications and a drive-train related system.

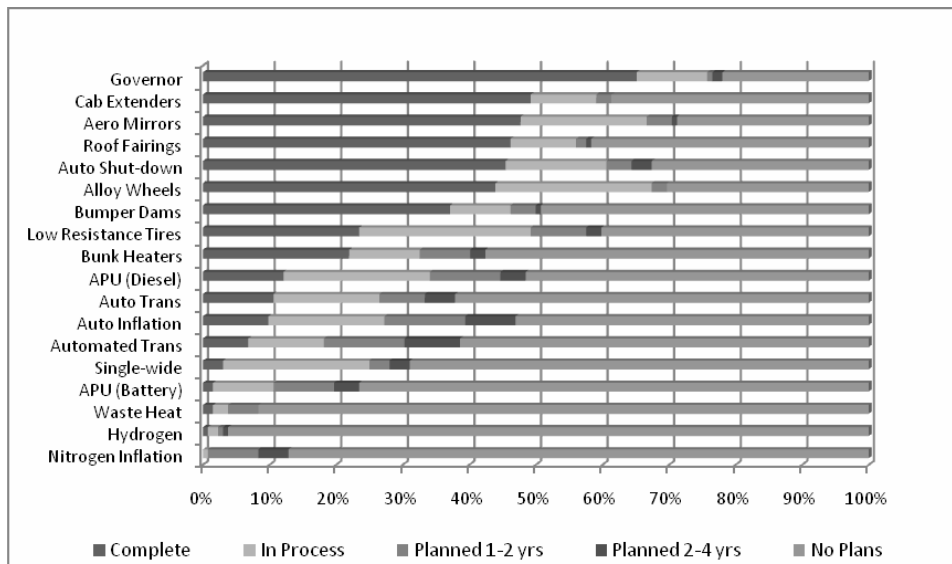
Governors to limit top vehicle speeds have been implemented on nearly 65 percent of participants, with another 10 percent in the process of adoption. Aerodynamic components including cab extenders, mirrors, and roof fairings have been or are in the process of being implemented by nearly 60 percent of

participants. Approximately 60 percent of participants have or are in the process of implementing automated shutdown systems to reduce engine idling. Finally, alloy wheels have been installed by about 44 percent of participants with another 25 percent in the process of implementation. Those systems seeing little current or planned adoption include battery auxiliary power units, waste heat systems, hydrogen injection and nitrogen tire inflation.

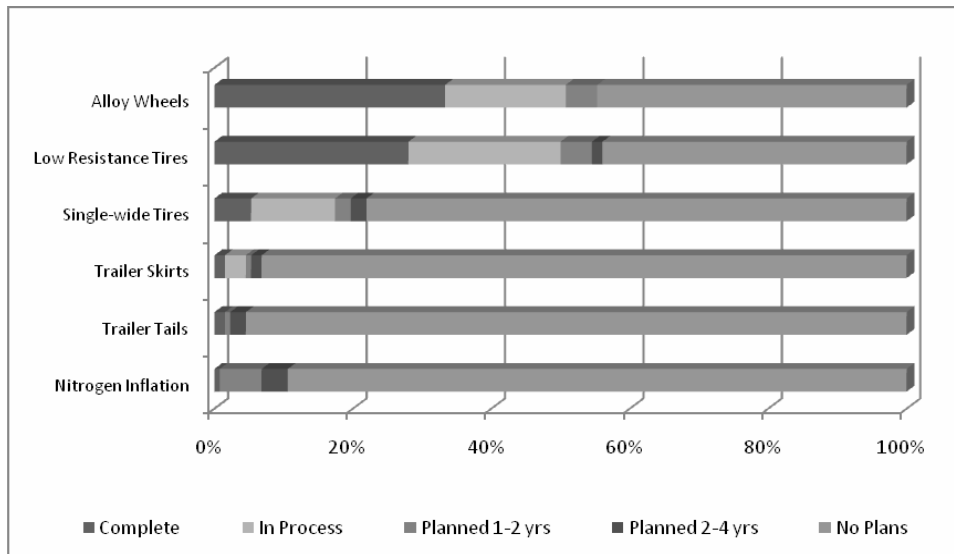
TRAILER TECHNOLOGIES

Trailer technologies (see Figure 2) appear to be focused on wheel modifications including alloy wheels to lower trailer weight and the application of low rolling resistance tire technologies. In both cases approximately 50 percent of participants have or are in the process of implementation. The remaining systems including single-wide tires, trailer skirts, trailer tails and nitrogen tire inflation are expected to see little adoption in the next four years.

**FIGURE 1
MOTOR UNIT TECHNOLOGIES**



**FIGURE 2
TRAILER TECHNOLOGIES**



MANAGEMENT POLICIES

Management policies (see Figure 3) appear to be seeing broad adoption across class 8 carrier operations. Scheduled maintenance has been implemented by nearly 90% of participants with most of the remaining participants in the process of implementation or planning implementation in the next two years.

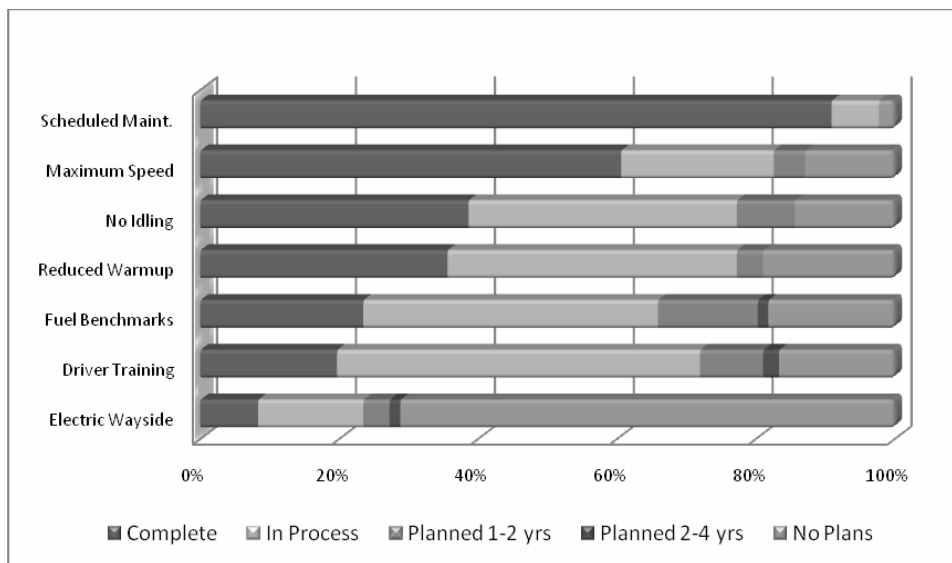
More than 80 percent of participants have or are in the process of adopting a maximum speed policy, followed closely by no idling, reduced warm up, fuel benchmarks and driver training. The only management policy that appears to have little support of participants at this point is the mandatory use of electric wayside facilities which provide electrical, HVAC and other external sources for environmental control while the engine is off. This is likely influenced by the

limited availability of such facilities at the present time.

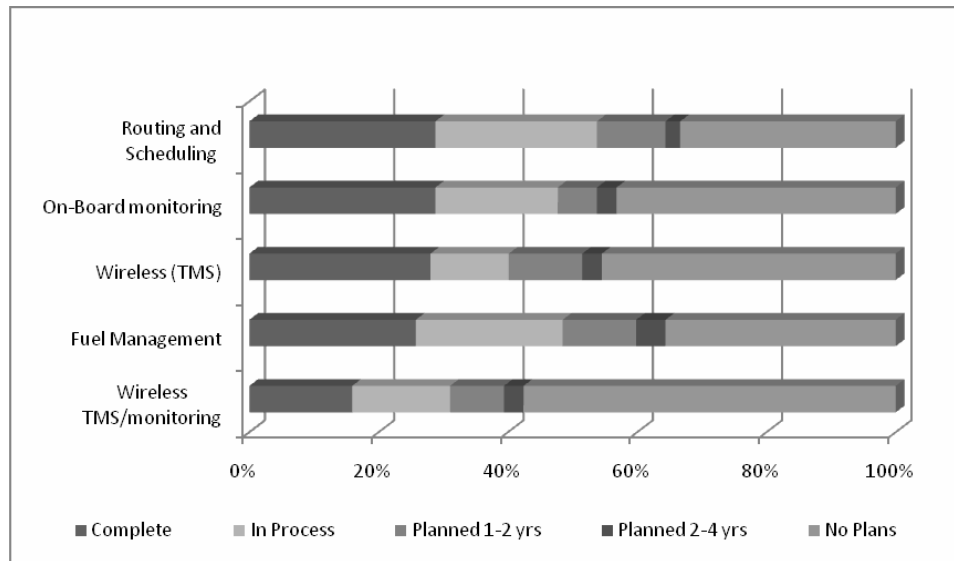
INFORMATION SYSTEMS

Routing and scheduling, on-board monitoring, wireless transportation management systems and fuel management systems appear to have a similar level of current and planned adoption with between 20 percent and 25 percent of participants having completed implementation of such systems and with an additional 15 percent to 20 percent of participants in the process of adoption (see Figure 4). Wireless TMS with monitoring is the least likely to be implemented with less than 20 percent having completed implementation, and an additional approximately 20 percent in process or planning adoption in the next four years.

**FIGURE 3
MANAGEMENT POLICIES**



**FIGURE 4
INFORMATION SYSTEMS**



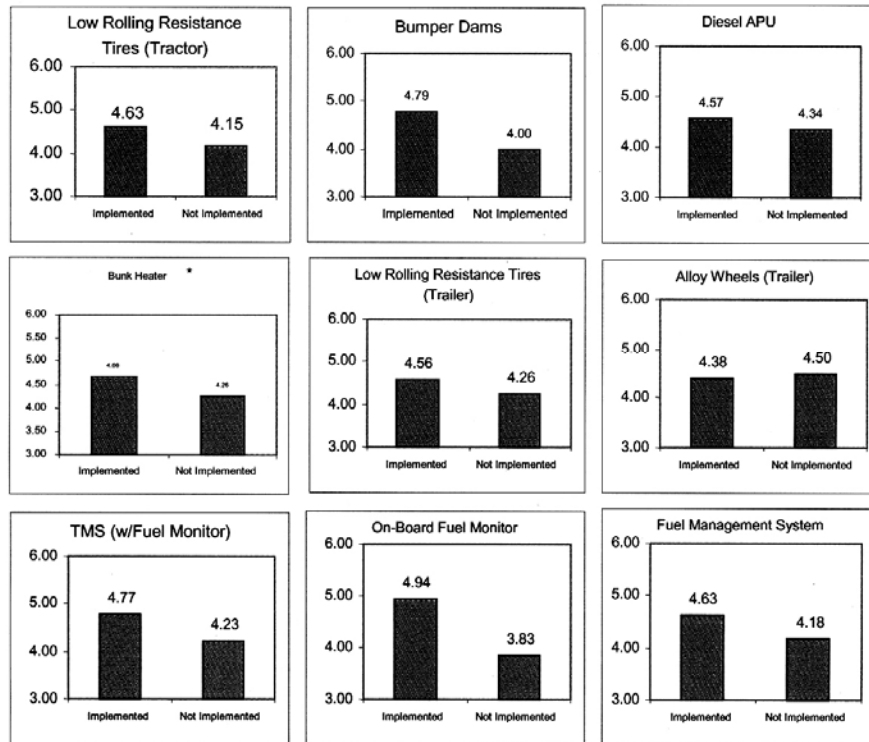
TECHNOLOGY IMPLEMENTATION COMPARISON

In an effort to assess whether current policies, methods or systems employed by carriers were supporting improved fuel performance, a subset of study results was evaluated to compare the performance of carriers who have completed or are in the process of the adoption of alternative technologies, policies and systems with those who have not initiated adoption. This particular analysis was limited in two ways. First the analysis includes responses from only those carriers operating either box van or temperature controlled trailers to insure a more consistent configuration among units. Second, the analysis is limited to those methods where each category (implemented, or not implemented) had greater than 27 responses for comparison. This was established as a cutoff since cases with fewer observations may have a significant level of variance and do not represent an effective sample size. A total of 96 survey participants indicated that the majority of their trailers were box van or refrigerated units.

The samples were divided into two categories, those participants who have completed or are in the process of adoption representing “implemented” and those who plan adoption in the next 1-2 years, 2-4 years, or do not plan representing “not implemented” as a response. While implementation of equipment and systems suggest improved fuel performance in all but one of the nine categories illustrated (see Figure 5), the only statistically significant difference showed in the implementation of bunk heaters ($p = .036$).

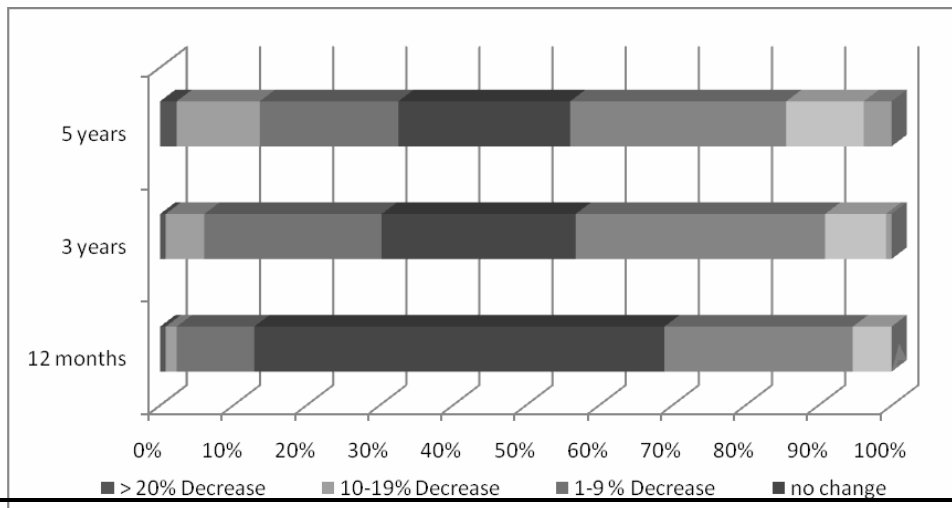
Survey participants were asked to assess their expectation of changes in fuel performance opportunities over the next 12 months, three years and five years (see Figure 6). Results indicate that carriers anticipate little change over the next 12 months. Over three years, the general consensus appears to be more broadly split with most responses ranging between a 1 percent-9 percent decrease and a 1 percent-9 percent increase in performance. Five years into the future a slightly larger

FIGURE 5
COMPARISON OF FUEL PERFORMANCE IN BOX VAN UNITS



*statistically significant, $p = 0.036$

FIGURE 6
EXPECTATIONS OF FUTURE PERFORMANCE CHANGES



than get worse. Finally, current participation in the US SmartWaysm partnership is small among participants at just over 12 percent.

CONCLUSIONS AND IMPLICATIONS

Increasing fuel costs and a growing concern for environmental impact is spurring a significant effort to develop new technologies to improve fuel performance across all transportation modes, including class 8 motor carriers. The impact of increasing oil prices and fuel costs extends beyond the transportation sector to include the cost of production and processing of foods, building materials, manufactured products and a broad range of services.

Recently, advanced technologies including hybrid power trains incorporating battery technologies and fuel cells have been receiving much attention and research funding, yet there are existing technologies, systems and even management policies that can have a more immediate impact on fuel performance. This research sought to assess the extent of current and future adoption of technologies, systems and policies that have a track record of contributing to improved performance.

This study was directed at the over 24,000 motor carrier companies in the United States. Of that population, 169 carriers responded to the survey distributed by email. While the response rate was low, the distribution of carrier sizes ranged from less than 10 power units to over 1000 power units. Fuel performance for the group surveyed averaged between 5.7 and 6.2 miles per gallon. Of the 18 motor unit technologies evaluated, only one (speed governors) was reported as having been adopted by more than 50 percent of respondents. An additional five technologies were adopted by greater than 40 percent of respondents including cab extenders, aerodynamic mirrors, roof fairings, automatic shut-down and alloy wheels. Of six trailer technologies listed, two (alloy wheels and low

Results of the present study indicate a relatively low rate of adoption of existing

rolling resistance tires) had been adopted by greater than 25 percent of respondents. Of seven management policy actions that support fuel performance improvement, scheduled maintenance activities have been adopted by more than 90 percent of respondents and a maximum speed policy had been implemented by nearly 60 percent of respondents. Finally, of the five information technologies assessed, four have been implemented by more than 20 percent of respondents.

These results suggest that there remains a significant opportunity for class 8 motor carriers to improve fuel performance with the implementation of existing equipment, technologies and policies. While suppliers to the industry direct efforts at equipment that may provide major improvements in operating performance, such technologies will likely not be ready for wide spread adoption for a number of years. In the mean time, increases in fuel costs make adoption of existing technologies more attractive from a financial perspective. In the United States, programs such as SmartWaysm are also providing a financial incentive through low cost loans for carriers to acquire APU systems and aerodynamics, yet participation is low within the surveyed group.

Research into technologies and systems to improve fleet fuel performance generally incorporates structured experimental designs to insure that conditions remain consistent as alternative units and configurations are tested. Such studies provide the grounding from which to bring new technologies to market. The present study and future studies like it make a contribution by assessing the level of adoption and providing some insights as to the benefits of technologies in practice. While the variables assessed are not exhaustive and operating conditions are not controlled, this research begins to offer some insight into the state of practice and future opportunities for improvement across the motor carrier industry.

technologies, systems and policies. The industry would benefit from more in-depth

analyses to validate these findings and gain a better understanding of factors contributing to the low rate of adoption. Replications of this study would also begin to provide a longitudinal assessment illustrating adoption of current and new technologies, systems and policies across the motor carrier industry. This may present input that can be used to better predict the impact of current and future technologies on the industry, the broader economy and the environment. It may also offer a means to validate existing models of adoption in this particular domain.

The present study suffered from a poor level of participation among the motor carrier population. Future studies should investigate methods to help improve participation either by

employing another method of data collection or perhaps focusing the analysis on more specific populations in an effort to focus collection efforts. For example, an analysis of carriers operating primarily enclosed van equipment may be implemented using a phone survey or by using an initial call to identify key informants and encourage their participation in a survey distributed via email.

The importance of improving fuel performance among all modes of transportation will continue to grow as costs rise, other economies grow and require greater volumes of freight transportation and as environmental concerns become more critical.

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APPENDIX A TECHNOLOGIES, SYSTEMS AND POLICY DESCRIPTIONS

Power Unit Technologies

Power unit technologies include equipment that may affect the configuration of engine, cab, chassis and drive-train systems. Many of these technologies are specified during initial unit purchase, for example the selection of transmission type and configuration. Other technologies may be retrofitted to existing units as in the case of auxiliary power units.

Auto shut-down: Automatic shut-down systems provide a method to insure the reduction in the time power units are left idling during overnight parking or waiting to complete a scheduled delivery or pick up. A similar outcome can be addressed through management policies that require shutdown. However, the automated system helps to insure compliance with no-idle policies. Such shutdown devices are estimated to contribute as much as a 5.9 percent improvement in fuel performance by eliminating unnecessary idle time (Ang-Olson and Schroer 2002).

Transmissions (Automated, Automatic): Transmission technologies affect fuel performance in two ways, from a mechanical perspective. The electronics in automatic and automated systems help to insure the most effective shift timing. From a human resources perspective, the automated transmissions are not as susceptible to driver variation as a result of distraction or fatigue (Kilcarr 2006A). Estimated improvements in performance range from 2 percent - 5 percent (Kilcarr 2006A; Langer 2004).

Automated transmissions automatically determine gear selection. Pneumatic or electronic actuators move the shift forks and rails. No foot clutch is needed. Automatic transmission shifts via electronic controls help to eliminate the potential for torque loss during shifting. When manual transmissions are specified for units, firms are paying closer attention to the number and ratio of gears. This determination is influenced by application and operating conditions (Kilcarr 2006A).

Transmission selection is an important specification issue that is influenced by the type of operation the unit is expected to serve, the engine power selection, the rear axle ratio and driver habits, among other factors.

Speed governor implementation: Reducing highway speed can have a significant impact on mileage performance. Whether mandated through policy or implemented via systems such as engine governors, estimated fuel improvement from such actions range from 7 percent - 20 percent (Ogburn and Ramroth 2007; Smartway 2004) depending upon the original and reduced speed

levels. For example, simulations of long haul truck operation show a near 14 percent improvement in fuel economy as average speed decreases from 70 mph to 55 mph (Ang-Olsen and Schroeer 2002).

Auxiliary power units (diesel/battery): Auxiliary power units improve overall fuel performance by significantly reducing the time a power unit is left idling. The common practice for many operators of power units with cab sleepers is to run the primary engine at idle to power HVAC and accessory systems when parked for an extended rest period or overnight. Installation of a small diesel generator or battery power unit dramatically reduces or eliminates the use of fuel for such operations. Overall fuel improvement is estimated to be as much as 8 percent or when considering just the fuel burned during the idling period, the estimated savings is as much as 80 percent (Ogburn and Ramroth 2007).

Bunk heaters: Bunk heaters serve a similar though more limited purpose as APU's. They provide heat to the cab living quarters during cool weather operation and therefore allow for engine shutdown rather than idling for extended periods.

Hydrogen injection system: Hydrogen injection systems provide a means of on-board electrolysis to create hydrogen gas. The hydrogen gas is then included in the combustion mixture. Including hydrogen in the fuel mixture results in a more complete combustion and results in increased power, fuel performance and lower emissions.

Tire and Wheel Technologies

Tire and wheel technologies are being used to reduce weight and rolling resistance in fleets. The EPA estimates that heavy trucks use as much as 15 percent-30 percent of fuel consumption to overcome rolling resistance (variability is due in part to the current weight of the unit and load). Each of the methods addressed can be included as part of an original vehicle configuration or can be installed on existing fleet vehicles. Technologies such as the installation of low-rolling-resistance tires may be employed on trailers as well as power units.

Low rolling resistance tires: Tire technologies and materials are helping to reduce the amount of rolling resistance created by automotive and truck tires. For heavy trucks, a 3 percent reduction in rolling resistance is estimated to improve fuel efficiency by 1 percent. The current level of technology is estimated to help reduce fuel consumption by 3 percent - 6 percent (Langer 2004, Ogburn and Ramroth 2007).

Single-wide tires: Single wide tires support improved fuel performance in part as a result of lowering the rolling resistance in vehicle operation due to materials and a smaller contact footprint than a dual tire configuration. In addition, single wide tires typically reduce wheel weight by several hundred pounds.

A study by Oak Ridge National Laboratories indicated that replacing the standard truck configuration of two thinner tires per wheel with a single wide tire improves fuel efficiency and provides more stability. The study estimated a 2.9 percent fuel savings from newer generation single wide tires (ORNL 2006). Tests of a Michelin wide-base tire showed improvement of 3.7 – 4.9 percent. Computer simulation suggested an improvement of 2.7 percent (Ang-Olsen and Schroer 2002).

Aluminum alloy wheels: Aluminum wheels support improved fuel performance predominantly as a result of their lower weight than traditional metal cast wheels.

Automated tire inflation: A 10 psi reduction in tire pressure is estimated to reduce fuel efficiency by .5 percent – 1 percent on heavy duty trucks. Automated tire systems facilitate

improved performance by monitoring tire pressure and insuring that pressure remains at an optimal level (Ang-Olson and Schroeer 2002).

Nitrogen tire inflation: Nitrogen tire inflation is expected to improve fuel performance because of the lower likelihood of pressure loss. In addition to the fuel performance improvement, nitrogen inflation is expected to help tires run cooler, improve tread life, reduces oxidation of tire components, and reduces rim and wheel corrosion.

Aerodynamics

Methods to improve tractor-trailer aerodynamics can have a significant impact on fuel performance for vehicles operating at speeds above 45 miles per hour. Highway speeds require more significant amounts of energy to overcome aerodynamic drag. Components that improve tractor and trailer aerodynamics can be specified on new vehicles or added to existing vehicles.

A Rocky Mountain Institute report of efficiency opportunities in Canadian fleets suggests that modifications to trailer aerodynamics can reduce drag by as much as 20 percent and lead to an approximately 10 percent decrease in fuel consumption for trucks operating at 105 km/h (approximately 65 miles/h). These improvements are identified with tractor trailer configurations employing a traditional box-type trailer.

Power Unit modifications include roof fairings, cab extenders, aerodynamic bumpers and mirrors and fuel tank fairings. Trailer modifications can include trailer skirts, trailer tails, and other means to affect wind flows around the trailer unit.

Cab extenders: Cab extenders reduce the gap between the sides of the tractor unit and the trailer. This may also be accomplished to some extent with the use of a trailer fairing that attaches to the front of the trailer unit. Reducing the gap from 45 – 25 inches shows a 1-2 percent improvement (Ang-Olsen and Schroeer 2002). In general, employment of extenders is expected to improve performance between 1 percent and 3 percent (Kilcarr 2006B; Smartway 2004; Langer 2004; Ang-Olson and Schroeer 2002).

Aerodynamic mirrors: Aerodynamic mirrors reduce the wind resistance along the side of the tractor unit and are estimated to improve fuel performance between 1 percent and 2 percent (Kilcarr, 2006B).

Roof fairings: Roof fairings help to direct the flow of air above and around the trailer. Savings of as much as 10 percent are estimated for trucks traveling at an average speed above 45 miles per hour (Kilcarr 2006B). Compared with trucks with no fairings, improvements of 15 percent have been identified (Ang-Olsen and Schroeer 2002, Smartway 2004; Bachman, Erb and Bynum; Ogburn and Ramroth 2007).

Trailer Skirts: Trailer skirts line the sides of a trailer unit between the wheels and reduce drag along the side of the trailer. Skirts are estimated to improved fuel performance by 3 percent - 5 percent on average (Kilcarr 2006B; Ang-Olson and Schroeer 2002; Smartway 2004, Ogburn and Ramroth 2007).

Trailer tails: The air-flow around the back end of a trailer can contribute to overall drag. Trailer tails which attach to the back end of a trailer unit to direct air more smoothly around the trailer are estimated to provide an additional 6 percent fuel savings (Ogburn and Ramroth 2007).

Management Policies

Management policies can help to focus driver attention on factors that contribute to improving fuel performance. Perhaps the least expensive means to reduce fuel consumption, management policies rely on driver compliance.

No idling policy: A 2006 report by Argonne National Labs estimated that over 1.5 billion gallons of diesel fuel annually may be lost to long duration idling (Gaines, Vyas and Anderson 2006). Estimates of fuel consumption range from 1800 – 2400 gallons of fuel per truck per year. Establishing an idling policy related to the use of main engine operations during overnight parking and waiting during shipment drop-off and pick-up can significantly affect performance in a manner similar to that achieved with the implementation of idle reduction technologies.

Reduced warm-up time: New engine technologies are reducing the need for engine warm-up and warm-down periods. Here again, any actions to reduce warm-up time serves a similar purpose as an effort to reduce idling time.

Required use of electric wayside facilities: More truck stop facilities are beginning to outfit their parking areas with connections for electrical power, internet service, HVAC, and other similar devices. The use of these facilities offers a more efficient means of accessory operations than running the main power unit. Mandating their use when available offers another means to reduce vehicle idling and gain the related fuel performance improvements.

Maximum speed policy: As noted earlier, speed reduction strategies can significantly reduce fuel consumption. As an alternative to system installation such as governors, such a policy can achieve much of the same benefit with compliance.

Driver training for fuel performance: Variation in performance due to driver skills and practices can be significant. Some estimates of fuel performance improvement resulting from driving skills suggest as much as a 35 percent difference (Kilcarr 2006B). The benefits of training will vary a great deal more than the implementation of particular systems, however training may very well be one of the most inexpensive and productive ways to improve performance.

Fuel performance benchmarking: Fuel performance benchmarking employs an incentive plan to encourage drivers to focus more on their driving habits. Some companies will use benchmark criteria combined with financial incentives to motivate drivers to pay attention and change behaviors that will contribute to improved performance.

Required maintenance: Maintenance operations support fuel performance by assessing the wear and tear on fleet operations and insuring that fuel systems, air intake systems, drive systems and so forth, remain in top working order.

Information System Technologies

Information system technologies support improvements in fleet fuel performance by helping to identify and implement improvements in the routing and scheduling of fleet operations and by providing systems to monitor on-going performance as a base from which to implement improvements in systems and training.

Wireless transportation management systems (TMS): Satellite based transportation management systems provide a means to communicate with drivers and monitor unit operation. System features can include the monitoring of truck operations from speed, to fuel consumption, to other more detailed engine operating factors. Such systems can also provide updated information regarding routing that can help drivers to circumvent areas of congestion and improve fuel performance.

On-board fuel/systems performance monitoring: On-board monitoring systems help drivers to better monitor their fuel consumption and adopt habits that may help to improved fuel performance.

Fuel management systems: While they don't directly influence fuel performance, fuel management systems help to improve overall fleet fuel costs by providing information regarding fueling locations that offer lower fuel prices considering their current fuel levels and present and future routing.

Advanced routing and scheduling systems: Routing and scheduling systems help to improve fuel performance by scheduling pick up and delivery activities to reduce the potential for idle time.

They also support better performance by directing drivers to loads that minimize empty driving time and help to improve load planning and fuel consumption per load.

APPENDIX B SURVEY INSTRUMENT

- What systems and equipment contribute to improved fuel performance?
- Which management policies support improved fuel performance?

These are just a few of the questions being investigated as part of study by Missouri State University. Please complete the following 2 page survey identifying the equipment, systems and policies that contribute to improved MPG performance of Class 8 fleets.

Your responses are anonymous and are not tied to specific email addresses or companies. As a subscriber to CCJ, you will receive a copy of the final report.

If your organization utilizes owner/operators as well as company owned vehicles, please base your answers on the company owned portion of your fleet.

1. How would you describe your fleet as a transportation provider?
(Private Fleet, Contract Fleet, Common Carrier, Combination Common/Contract, Other)
2. How many company owned Class 8 Tractor units are in your fleet?
(<10, 11-50, 51-100, 101-250, 251-500, 501-1000, >1000)
3. How many company owned trailer units are in your fleet?
(<10, 11-50, 51-100, 101-250, 251-500, 501-1000, >1000)
4. Indicate the breakdown between TL and LTL services provided by your company.
(Total should = 100%)

Truckload
Less-than-Truckload
Other

5. If you answered "Other" as part of your response to number 4, please indicate the other type of service you provide.
6. Indicate the percentage breakdown of trailer types in your fleet. (total should = 100%)
Box Van
Flatbed
Temperature Controlled
Tanker
Soft Sided
Auto Hauler
Other
7. If you answered "Other" as part of your response to number 6, please indicate the other type of trailers you operate.
8. What is the average age of your company owned tractor fleet?
(1 year or less, 1-2 years, 2-3 years, 3-4 years, >4 years)
9. What percentage of total fleet miles are traveled at speeds above 45 MPH?
(1 – 100% at 5% increments)
10. What percentage of your tractor fleet meet 2007 EPA Engine standards?
(1 – 100% at 5% increments)
11. Considering your motor unit replacement strategy over the next two years, what percent of those replacement units do you expect to address with engine rebuild vs. new unit purchase?
(1 – 100% at 5% increments)
12. What is your current average fuel performance (MPG)?
(< 5 MPG, 5.1-5.3 MPG, 5.4-5.6 MPG, 5.7-5.9 MPG, 6.0-6.2 MPG, 6.3-6.5 MPG, 6.6-6.8 MPG, 6.9-7.1 MPG, 7.2-7.4 MPG, 7.5-7.7 MPG, 7.8-8.0 MPG, > 8 MPG)
13. How has your fuel performance changed since the implementation of 2007 EPA Standards?
(fewer miles per gallon, about the same, more miles per gallon, too early to tell)
14. For each of the following tractor equipment technologies, indicate the current status of fleet implementation. (Complete, In Process, Planned 1-2 yrs, Planned 2-4 yrs, No Plans)
Low Rolling Resistance Tires
Single-wide Tires
Aluminum Alloy Wheels
Nitrogen Tire Inflation
Cab Extenders
Roof Fairings
Aerodynamic Mirrors
Bumper Dams
Automated Tire Inflation

Auto Shut-down
Automatic Transmissions
Automated Transmissions
Speed Governor Implementation
Auxiliary Power Units (Diesel)
Auxiliary Power Units (Battery)
Waste Heat Recovery System
Bunk Heaters
Hydrogen Injection System

15. For each of the following trailer equipment technologies, indicate current status of fleet implementation. (Complete, In Process, Planned 1-2 yrs, Planned 2-4 yrs, No Plans)

Low Rolling Resistance Tires
Single-wide Tires
Aluminum Alloy Wheels
Nitrogen Tire Inflation
Trailer Skirts
Trailer Tails

16. For each of the following management policies, please indicate the current status of fleet implementation. . (Complete, In Process, Planned 1-2 yrs, Planned 2-4 yrs, No Plans)

No Idling Policy
Reduced Warm-up Time
Required Use of Electric Wayside Facilities
Driver Training for Fuel Performance
Fuel Performance Benchmarking
Maximum Speed Policy
Required Scheduled Maintenance

17. For each of the following information system technologies, please indicate the current status of fleet implementation. . (Complete, In Process, Planned 1-2 yrs, Planned 2-4 yrs, No Plans)

Wireless Transportation Management Systems (TMS)
Wireless TMS with remote performance monitoring
On-Board fuel/systems performance monitoring
Fuel Management Systems
Advanced Routing and Scheduling Systems

18. Considering you fleets current average MPG, how do you believe your fuel performance will change over the next....

(> 20% Decrease, 10-19% Decrease, 1-9 % Decrease, no change, 1-9% Increase, 10-19% Increase, > 20% Increase)

12 months

3 years

5 years

19. What types of equipment do you believe will most improve fuel performance over the next five (5) years? (Hybrid Diesel/ Electric, Hybrid Fuel Cell/Electric, Body Design/Aerodynamics, Improvements in Diesel Technology, Other)

20. Do you currently participate in the EPA SmartWay Transportation Program?

(Yes, No)

21. Which best describes your position in your organization?

- Corporate Management/Corporate Official
- Transportations/Operations/Safety Management
- Maintenance/Fleet Management
- Purchasing Management
- Other (please specify)

22. Which best describes the primary industry you serve?

- Agricultural/Livestock
- Automotive
- Bulk Chemical/Petroleum
- Construction
- Mining/Logging/Excavating
- Household Product Manufacturing
- Food and Beverage Product Manufacturing
- Food Service Wholesale
- Waste Management/Recycling
- Government (Federal/State/Local)
- Manufacturing/Processing
- Retail Product Delivery
- Wholesale Delivery
- Package Freight Services
- Health Care Manufacturing/Wholesale
- Other (please specify)

23. If you have identified other equipment, systems or management policies that are helping your company improve fleet fuel performance, please share them with us in the space provided below.

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