Report of a study conducted by the
North American Council for Freight Efficiency

May 6, 2015

Acknowledgements:

NACFE Study Team:
Tessa Lee, CWR
Helen Marks, CWR
Rob McIntosh, Senior Associate RMI
Denise Rondini, NACFE Rondini Communications
Mike Roeth, Executive Director NACFE

Participating Fleets:
Bison Transport
CR England
Challenger Motor Freight
Con-way Truckload
Crete
Frito Lay
Nussbaum
Paper Transport
Prime
Ryder
Schneider National
United Parcel Service
Werner Enterprises

NACFE Technical Advisory Committee:
Randy Cornell, Conway TL
Dan Deppeler, Paper Transport
Steve Duley, Schneider
Tim Dzojko, Air Products
Ken Marko, Frito Lay
Ezel Baltali, Ryder
Steve Phillips, Werner Enterprises
Mike Roeth, NACFE
Dale Spencer, UPS
Bruce Stockton, Kenan Advantage Group

Contents

1 Executive Summary

This report contains the results of a deep-dive investigation into the adoption of various products and practices for improving freight efficiency among 14 major North American fleets, and identifies benchmark competencies of those companies in many different subject areas. This is the third annual update of the 2011 inaugural study that has been called "The most comprehensive study of Class 8 fuel efficiency adoption ever conducted" (Truck News, 2012). Last year's study included 11 fleets; they are now joined by Crete, Nussbaum and Prime, while one fleet has left with their data ending in 2012. The findings of this report should prove invaluable to efforts both to improve the fuel economy of a fleet and to develop and deliver fuel efficiency products to the marketplace.

The scope of this work encompassed Class 8 day cab and sleeper tractors and trailers in regional and long haul applications. Fleets in the 2015 study included Bison Transport, CR England, Challenger Motor Freight, Con-way Truckload, Crete, Frito Lay, Nussbaum, Paper Transport, Prime, Ryder System Inc., Schneider, United Parcel Service and Werner Enterprises. The primary goal was to study their levels of adoption of 68 technologies and practices, and the results those drove in each organization. All 68 are currently available technologies, and not prototypes, validation test units, or pre-production units. This study focuses on what was actually purchased and implemented onto a fleet's trucks and trailers. In certain cases, fleets were asked if they had retrofitted any of the devices on their equipment, but this was done for context, and is not included in the adoption data.

This report includes information on adoption rates by fleet for each technology, as well as specific highlights on transmissions, aerodynamics availability for CNG tractors, and engine parameters. It also shares information on the most recent tractors and trailers put into service in 2014, and some insights on the value of technology adoption by these fleets.

The primary finding of this report is that the 14 fleets studied are increasing their rate of adoption of these technologies, and that they are enjoying improved fuel economy as a result. The fuel savings in 2014 between the business-as-usual 6.1 MPG and the NACFE average of 7.0 MPG amounts to $9,000 per year per truck; an increase from the 2011 report of the original eight fleets of $4,400 per year. The average purchased adoption rate of these 68 products increased from 18% to 42% over the period of 2003 through 2014, and the average fuel economy performance of the trucks improved 0.8 MPG, as shown by the Average MPG line in Figure 1 below. A Business as Usual line is included for comparison, showing a projection of what average MPG might have been given the combined impact of 2002, 2007 and 2010 emission regulations, the introduction of Selective Catalytic Reduction (SCR), and an assumption of the effect of 2014 GHG base powertrain improvements.

Three additional highlights emerged from this work. With so much data available there are many items of note, but three stood out to the study team for sharing. They include the uptake of electronically controlled transmissions (ECTs); automated manuals (AMTs) and fully automatics with Conway Truckload's recent commitment to and announcements for going to 100% adoption of AMTs for driver comfort, performance and safety. Another on Frito Lay's path to aerodynamic daycabs, two times, once for diesel tractors and again for natural gas ones. And finally, small fleets taking advantage of engine parameters and Cummins' sharing a rather large uptake in PowerSpec™ downloads as an indication of end users taking advantage of optimizing their electronic engine parameters.

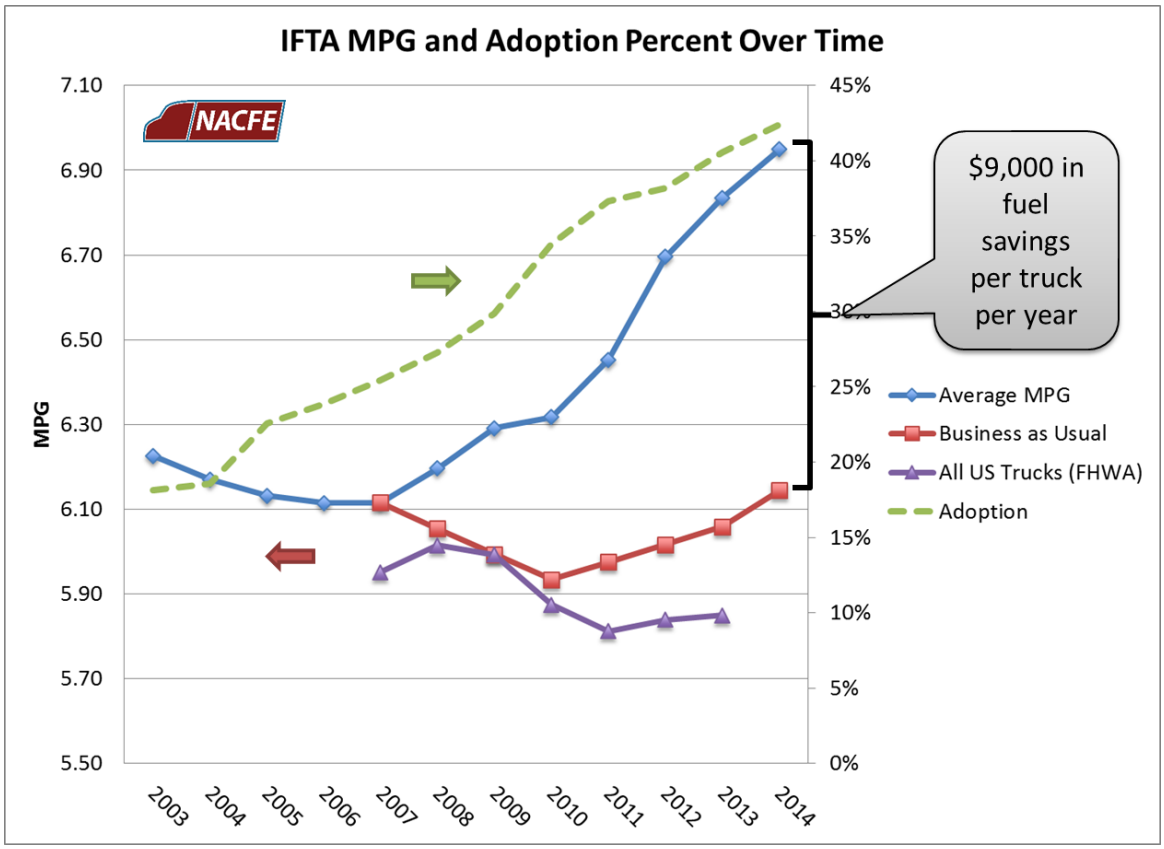


Figure 1: Adoption and Fuel Mileage

This study provides other end users a roadmap in navigating the many available technologies that can have a positive impact on lowering fuel expenses.

2 Introduction

2.1 Overview

The North American Council for Freight Efficiency (NACFE, www.nacfe.org) is a nonprofit organization dedicated to doubling the freight efficiency of North American goods movement. NACFE was created to bring solutions to the freight industry which radically increase fuel efficiency, by serving as an independent, unbiased research organization for the transformation of the transportation industry. Success for NACFE includes providing a place for the significant sharing of proven products and practices and identifying those that are not promoting the efficient movement of goods. This study highlights the success achieved by some of the more innovative fleets in North America; we hope that by giving them an opportunity to share this information we will encourage quicker adoption rates.

Late in 2013, NACFE entered into a cooperation with the Carbon War Room (CWR, www.carbonwarroom.com), a non-profit founded by Sir Richard Branson and dedicated to scaling energy

efficiency technologies. Recognizing the opportunity to accelerate the trucking sector's fuel efficiency, NACFE and CWR launched Trucking Efficiency. Trucking Efficiency collaborates with industry experts to address the barriers to the large-scale deployment of fuel-efficiency technologies for tractors and trailers. The group completes Technology Overviews and Confidence Reports on promising available technologies, holds workshops to openly debate their findings and recommendations, and launched an online Tech Guide in late 2014, www.truckingefficiency.org, which collects all of this information into one centralized location. Success for Trucking Efficiency will be measured in the accelerated adoption of technologies and practices that promote freight efficiency (Figure 2).

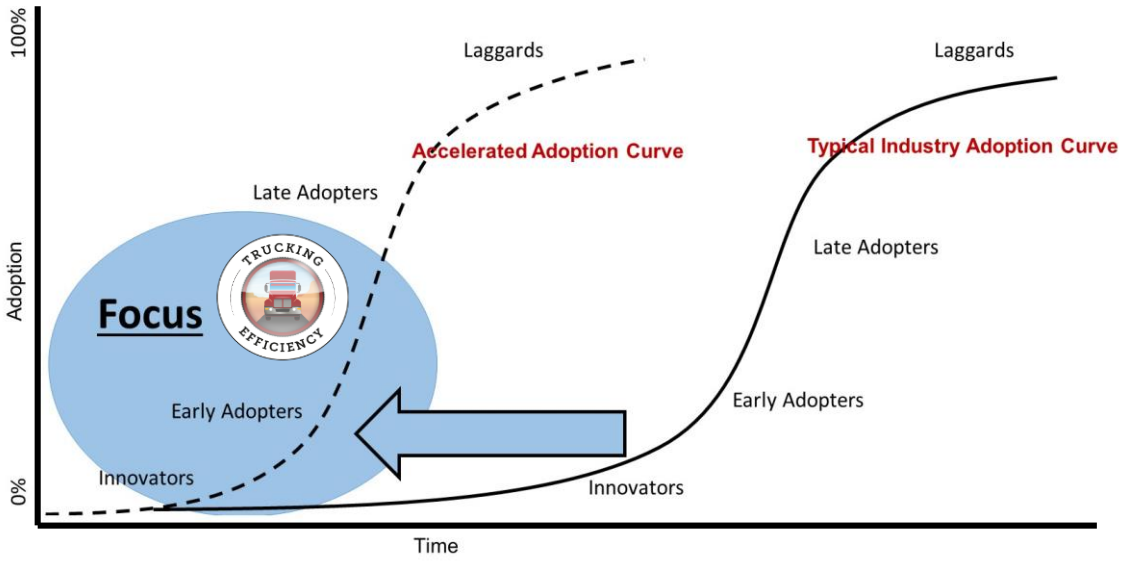


Figure 2: Accelerating Adoption

2.2 Background

The fuel costs faced by the tractor-trailer industry have been swiftly and steadily rising over the past decade and had been averaging about $4.00 for the last four years up to the end of 2014 (Figure 3). As shown in Figure 4, by 2013, fuel costs had reached $0.65 per mile, as reported by the American Transportation Research Institute, surpassing even the costs for the driver (wages plus benefits) (ATRI, 2014). These costs have driven fleets to want to include fuel efficiency in their new equipment specifications and operational strategies, but many do not know where to start. Very recently prices have dropped and this report reflects purchase decisions for technologies and their results for the time period up to the end of 2014. More on lower fuel prices later.

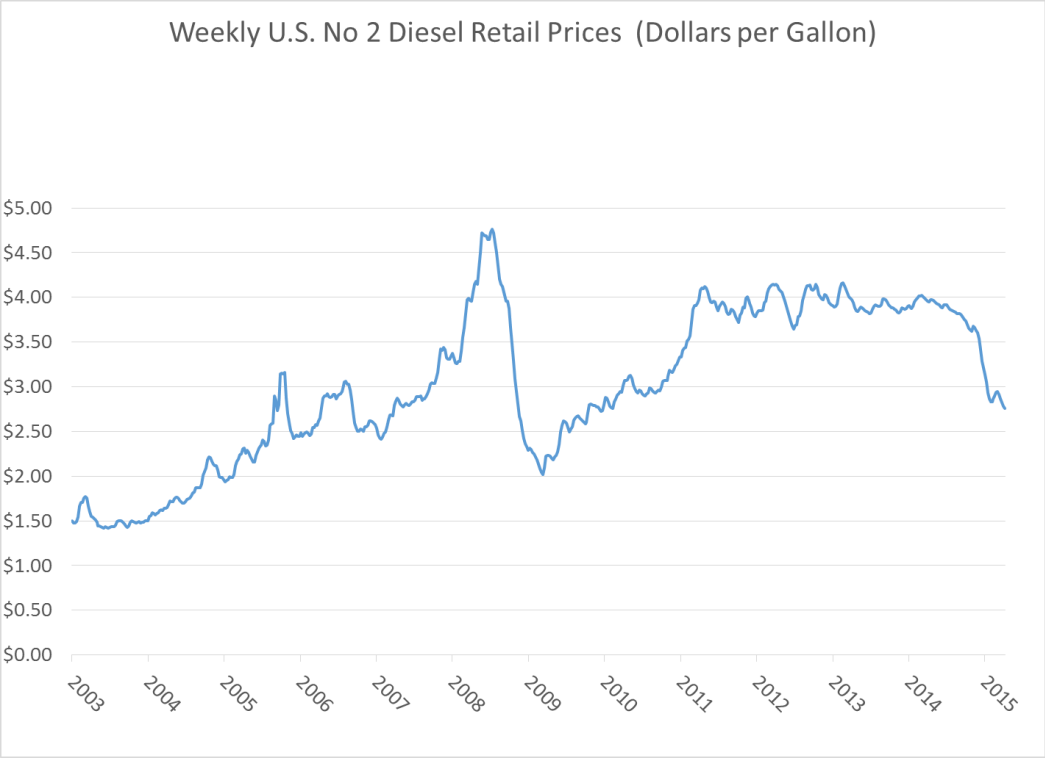


Figure 3: U.S. Annual Diesel Fuel Prices

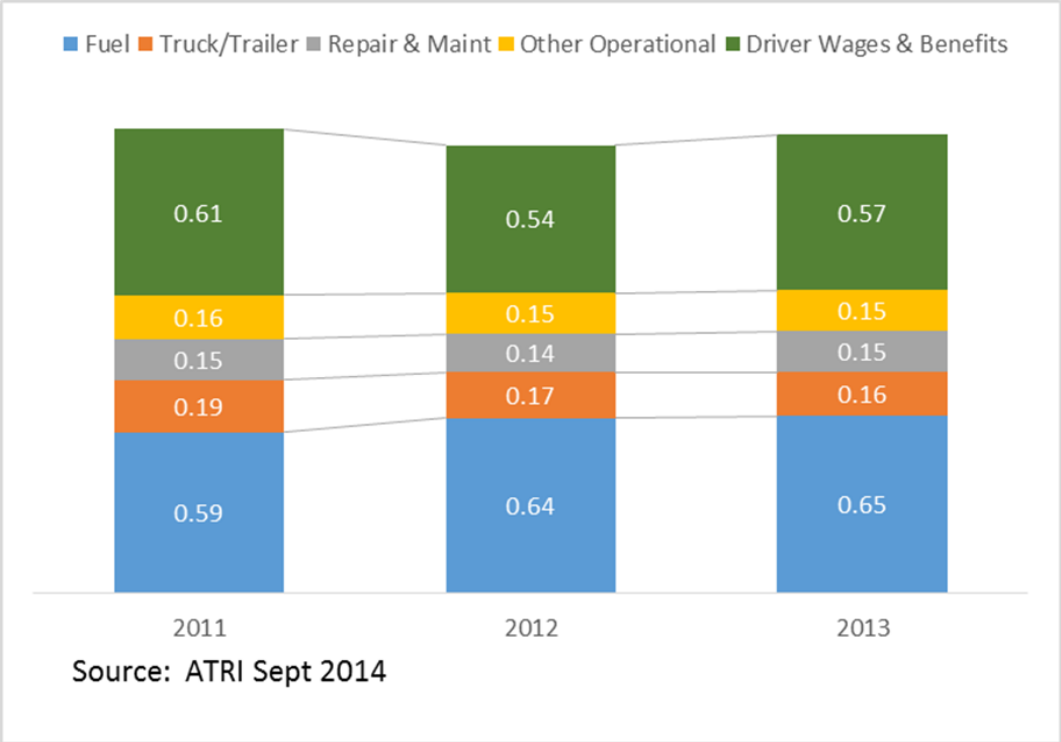


Figure 4: HD Tractor Operating Costs per Mile

Investment in proven technologies and practices that allow a truck or fleet to increase its fuel efficiency – meaning that they let the fleet do the same amount of business while spending less on fuel – is a hugely promising option for the industry in light of these trends.

However, the vast diversity of needs in the industry can make adoption difficult. These needs are driven by multiple and sometimes seemingly incompatible demands, including a fleet's access to capital, level of risk tolerance, and even their business model (lease vs buy equipment, use company drivers or independent contractors, in-house or contracted maintenance). Moreover, the equipment must operate in differing duty cycles, created by variations in operating locations (urban, rural, or a combination) and/or geographies (mountainous/flat, hot/cold, etc.). These factors combine to create a significant challenge for end users seeking to determine which technologies to pursue and which companies to consider purchasing from.

To better understand the history of adoption, in 2010 NACFE created a methodology for sharing best practices, in order to document and learn from data-driven fleets, and provide an early roadmap for the industry on technologies that improve the efficiency of Class 8 tractor trailers. By this report, the fourth annual fleet fuel study, completed in early 2015, data has been accumulated on the purchasing habits of 14 fleets, operating more than 53,000 tractors and nearly 160,000 trailers. To be included in this dataset, fleets provided data on the tractors and trailers for which they specified the features (technologies) and purchased the fuel for the tractors. This makes for a clean dataset for comparing the fuel efficiency to the adoption decisions. For instance, Ryder owns about 50,000 Class 8 tractors, but only buys fuel for 3,100 of them in their dedicated operations. Only those tractors are included in this study.

Information gathered and shared in this report includes the percent of each fleet's annual purchases that involved any of 68 currently available technologies for lowering fuel consumption, from 2003 up to 2014. They also shared their overall fleet-wide fuel efficiency in terms of miles travelled and fuel consumed. Some of the technologies are shown in Figure 5. With 68 technologies, 14 fleets and 12 years of data, this process provides nearly 11,500 data points of purchasing behavior on new features by these end users.

Figure 5: Technologies to Save Fuel

This report distills those data points into adoption curves for all 68 technologies, fleet diversity of adoption, and the associated fleet-wide fuel economy average, for all 12 years in the study period. Armed with this powerful data, much can be learned about the past and inferred to help forecast the future of these features. The opportunity is enormous as there are about 1.5 million tractors operating in the U.S. consuming approximately 26B gallons of diesel fuel. For every 1% reduction in fuel use, 260M gallons of fuel or about $1B per year are saved.

3 Price of Fuel

We would be remiss if we did not address the subject of the recent drop in fuel prices in this report.

While it's true that diesel fuel prices are at their lowest levels in five years, if history is any indication, they won't stay low forever. The U.S. Energy Information Administration's Short-term Energy Outlook shows that, while the on-highway retail price of diesel will average $2.85 in 2015, by 2016 it will be back up to $3.25 a gallon. Longer-term predictions are for prices to rise to more than $6 a gallon by 2040.

It is important to remember that the U.S. is not the only country that consumes crude oil. Developments in other parts of the world, including growing economies, will impact the price of crude and by extension the price of diesel. Diesel prices, like all other products, are subject to the laws of supply and demand. When demand goes up, prices usually increase as well.

The cost of fuel must be taken into account when doing payback calculations for investments in fuel efficiency technologies. But regardless of the price of diesel, fleets would be unwise to lose their focus on improving fuel economy. Yes, lower diesel prices make the paybacks for some technologies longer, but the price of diesel isn't the only reason fleets should strive to improve their fuel economy. Whether fuel is $4 a gallon or $3 a gallon, when you improve fuel economy you cut expenses from the bottom line.

"Continuing to make investments in technologies that improve fuel efficiency makes good sense despite the current low price of diesel fuel," says Steve Phillips, Senior Vice President Fleet Resources at Werner Enterprises. He continues, "Given the historic volatility of oil prices, it's a safe bet that we'll see the price of diesel go up before long. Fleets who've improved their fuel economy will be at a competitive advantage when that happens."

4 Technology Adoption by the Fleets

This section will describe the technology adoption with respect to their fleet diversity, individual technology curves and the consistency of technology adoption across the fleets. For the first time, this data is provided in a separate spreadsheet that allows the reader to analyze the information. Please contact NACFE with specific questions if further clarification is needed.

4.1 Fleet Adoption Diversity

As is true for nearly all products, be they business-to-consumer or business-to-business, trucking end users tend to fall into different categories when new offerings become available. Some adopt early while some

wait to learn from others' experience – depending on their own calculations of the benefits versus the risks of being on the leading edge of new technologies. The 14 fleets in this study are no different (Figure 6). Fleets E, J, and L can be considered early adopters who have continued to expand their adoption. Meanwhile fleets A, G, and H were later adopters, but have closed the gap and in some cases surpassed their faster more innovative counterparts. This may imply that as the fuel costs continue to rise, some end users are more aggressively moving to use these new products earlier in the overall adoption process of a given product.

It is important to note that no fleet could adopt all 68 technologies on a single tractor trailer combination, as some are "competing" solutions for a single function. For instance, a truck would not have both a diesel auxiliary power unit and a battery HVAC system. The maximum adoption by a fleet would be around 65%, depending on the set of technology combinations. The fleets in this year's study range from about 30% to 54% of the available technologies employed on their tractors.

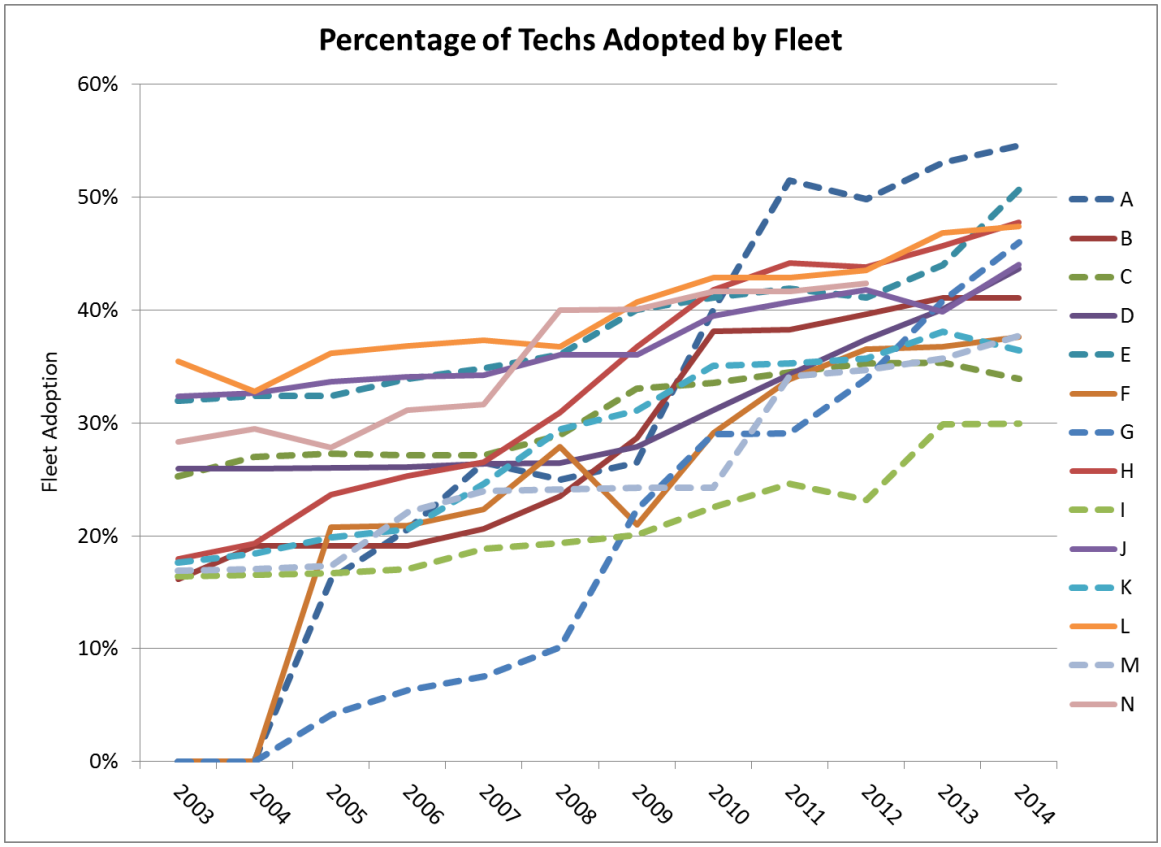


Figure 6: Fleet Adoption over Time

4.2 Technology Adoption Curves

Given the data provided, 68 adoption curves were created. Keep in mind that these charts show only the adoption practices of the 14 fleets studied, which represent about 4% of the overall heavy-duty over-the-road vehicles in North America. They also show each fleet as a single decision in the adoption calculation; fleets are not weighted by the total volume of tractors or trailers procured or miles driven. This provides new insight into not only the current level of adoption, but into the ramp up over the last decade. For

example, the ramp up of the purchase of trailer skirts to over 82% adoption is the quickest current rate of all technologies.

The 68 technologies were grouped into seven categories: tractor aerodynamics, trailer aerodynamics, powertrains, tires/wheels, idle reduction, chassis, and fleet practices. Technology adoption by category is displayed here in Figure 7, while the adoption curves for each technology are provided in the appendix. All categories show increasing levels of adoption with trailer aerodynamics increasing the most dramatically in the last five years.

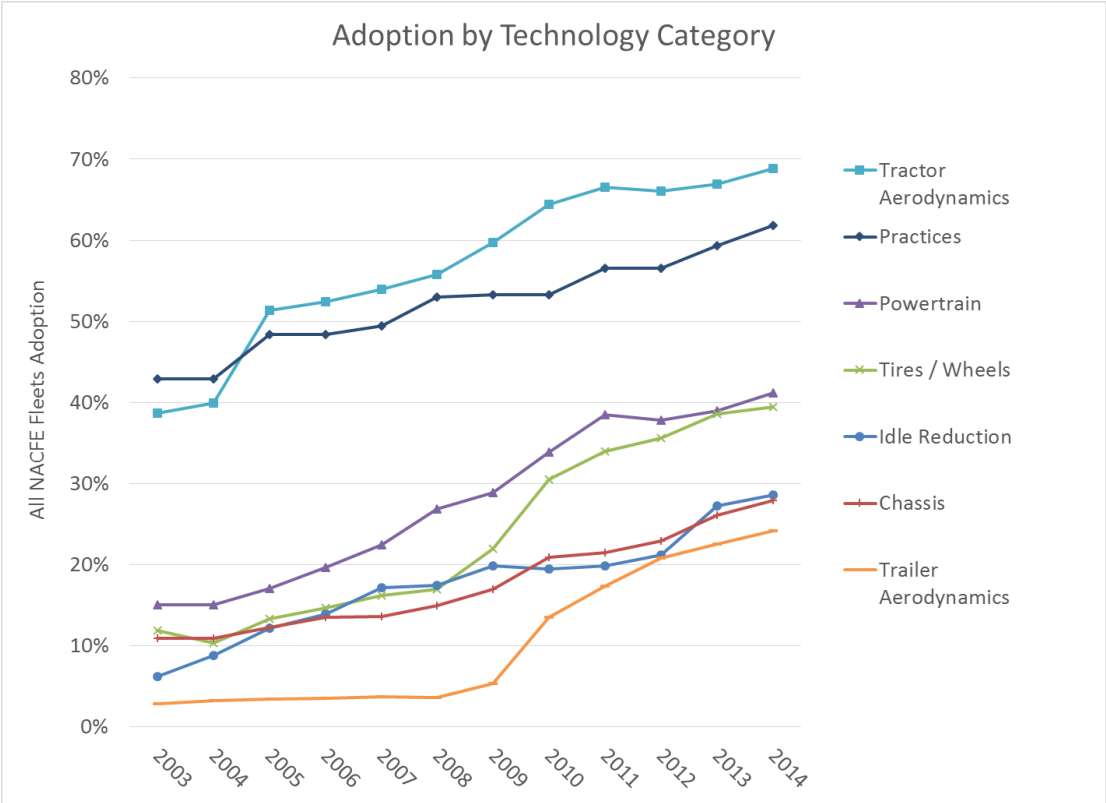


Figure 7: Adoption by Category

The percent adoption of a technology is a measure of the rate at which fleets purchased a given technology or implemented a given practice in any particular year. The goal is to determine adoption in terms of each fleet's selection and use. Therefore, the data in these charts is not weighted by the number of tractors or trailers purchased per year by the fleet. It measures fleet decisions, rather than the number of trucks with the technologies. Under this methodology, a decision made by the smaller fleets, who purchase about 100 trucks per year, has the same value as that of the largest fleet buying thousands. Appendix B shares calculations used to define adoption in this study. For the first time, NACFE is providing data, given the miles travelled by each fleet as another reference adoption percentage. This therefore delivers a representation of the amount of the new technology sold in each year. This methodology therefore does value a purchase of 2,000 per year of a given technology by a large fleet as 20 times greater than someone buying only 100 new trucks. This data is presented in Appendix C and D and in the separate spreadsheet provided with this report.

4.3 Fleet Consistency of Adoption

Finally, as in previous years' reports, the consistency of adoption by the various fleets was evaluated. To do so, each of the 68 technology decisions (i.e. whether to adopt or not) made by each of the 14 fleets is compared using a categorization methodology showing whether the technology is being purchased by the fleet, how quickly the fleet moved from testing the technology on a few vehicles to spec'ing it on 100% of all purchases, or even if a fleet decided to stop buying something after initial deployment. Figure 8 includes this data demonstrating the technologies' adoption stacked in order of popularity, by the various fleets denoted by A to M.

	A	B	C	D	E	F	G	H	I	J	K	L	M
Aero hoods and fenders	5	5	4	4	5	5	4	4	5	5	4	5	5
Aerodynamic bumpers	5	5	4	4	5	5	5	4	5	5	4	5	4
Aerodynamic mirrors	5	5	4	4	5	5	4	5	5	5	4	5	4
Engine parameters set for fuel economy	5	5	5	4	5	5	3	5	4	5	5	5	5
Full height roof air fairing	5	5	5	3	5	4	5	5	3	5	5	5	5
Synthetic axle lube	5	5	5	3	5	5	3	5	5	5	5	5	5
Anti Idle Electronic Engine Controls	5	5	5	5	5	4	5	5	5	5	5	3	5
Synthetic transmission oil	1	5	5	5	5	5	5	5	5	5	5	5	5
Limit Speed <65 mph	5	5	5	5	5	5	5	5	5	4	2	5	5
Cab Extenders	5	5	5	3	5	5	5	3	3	5	5	5	5
Driver training for fuel economy	5	1	5	5	5	5	3	5	5	5	5	5	5
Reduce empty miles	5	1	5	5	5	5	3	5	5	5	5	5	5
Low rolling resistance duals (Smartway)	1	5	5	5	5	5	5	5	3	5	5	5	5
Aluminum wheels tractors	5	5	5	3	5	5	5	4	3	5	5	5	1
Geardown protection	1	5	5	3	5	5	5	5	4	5	5	5	5
Trailer skirts	5	5	2	3	5	5	5	5	3	5	5	3	3
Tractor chassis skirts - full	5	5	4	4	3	4	5	3	3	5	4	5	1
Routing optimization	1	1	5	5	5	5	1	5	5	4	5	5	5
Change vehicle gearing	5	5	5	3	1	1	1	5	5	5	5	5	5
Diesel Fired Heater	5	5	4	3	5	5	3	3	3	1	5	5	1
Remove parts - bug deflectors, etc.	5	1	5	4	4	1	5	4	1	5	1	5	1
Aluminum wheels trailers	1	5	5	3	4	1	3	4	3	1	3	5	1
Specified weight reduction on tractors	5	1	1	5	5	1	3	4	5	3	3	5	1
Downsize engine (e.g. 15L - 13L)	1	1	1	3	3	4	3	5	3	3	3	3	5
Fixed 5th wheel w/ minimum gap	2	1	3	3	5	5	3	1	1	3	1	5	5
Vented mudflaps - trailer	5	1	1	3	3	1	4	5	1	5	1	1	5
Tire pressure inflation - trailer	5	5	3	3	4	3	3	3	3	3	5	5	3
Direct drive transmission	5	1	1	3	3	4	1	2	3	5	1	2	5
Synthetic engine oil	3	5	1	3	5	1	5	4	1	5	1	1	1
Narrow mudflap width	5	5	1	1	1	1	5	1	1	5	3	5	1
Highest level of cab insulation	1	5	1	1	5	5	5	5	1	1	1	1	1
Predictive cruise control	5	1	5	1	4	1	1	1	3	4	1	1	5
Vented mudflaps - tractors	5	1	1	3	3	1	4	5	1	1	1	1	5
Automated manual transmissions	5	3	1	3	3	3	4	3	3	3	3	5	3
Wide based tires - tractors	5	5	2	3	1	1	3	1	3	3	3	5	1
In cab behavior modifications	1	1	1	1	5	5	2	5	3	5	5	5	1
Tractor chassis skirts - partial	1	2	4	4	3	1	1	3	3	3	4	1	1
Remove or relocate any trailer drag parts?	5	5	1	1	1	1	5	1	1	5	5	1	1
Specified weight reduction on trailers	1	5	1	1	5	1	1	4	1	1	1	5	1
Wheel covers - tractors	5	1	3	3	3	3	3	3	3	3	1	1	1
Driver incentives for FE	5	1	1	1	1	1	3	1	1	5	1	5	1
Battery HVAC	5	1	1	1	3	3	3	1	3	3	1	1	1
Wide based tires - trailers	1	5	1	3	1	1	3	1	3	3	3	2	1
Coasting before engine braking	5	1	1	1	3	1	1	1	1	3	1	5	1
6x2 axles	5	1	1	3	1	1	3	3	3	3	1	2	3
Boat tails	5	5	1	1	1	1	1	3	1	3	1	1	1
Tire pressure monitoring - tractor	5	5	1	1	1	1	1	2	1	3	1	1	1
Automatic Engine Start/Stop	1	1	1	3	1	5	3	1	1	1	3	1	1
2 Speed Fan Clutch	1	1	1	3	3	1	3	3	1	1	1	1	3
Use of clutched air compressor	1	1	1	1	1	1	3	5	3	2	1	3	1
Clutched Water Pump	5	1	1	1	1	3	3	1	1	1	1	1	1
Use of doubles or triples trailers	1	1	1	1	3	1	3	3	3	3	1	1	5
Automatic transmissions	1	1	3	3	1	1	1	3	1	1	1	2	1
AC Power Port	1	1	1	1	3	1	5	1	1	1	1	1	1
Tire pressure monitoring - trailer	1	1	1	3	1	1	1	1	1	1	5	1	1
Diesel APU	1	5	1	3	2	1	1	1	3	1	3	1	1
CNG	1	1	1	3	1	1	1	3	3	1	1	1	3
Move from 6x4 to 4x2 tractor specs	1	1	1	3	1	1	1	3	1	2	1	1	1
Trailer nose cones	1	1	1	1	1	1	1	5	1	1	1	1	1
LNG	1	1	1	1	1	1	1	1	3	1	1	1	5
Vortex generators	1	1	1	1	1	1	3	1	1	1	1	1	1
Truck Stop Electrification (Snorkel type)	1	1	1	1	1	1	1	1	1	1	1	1	1
Thermal Storage System	1	1	1	1	1	1	1	1	1	1	1	1	1
Tires filled using Nitrogen	1	1	1	1	1	1	1	1	1	1	1	1	1
Fuel additives	1	1	1	1	1	1	1	1	1	1	1	1	1
Mechanical Turbo-compounding	6	6	6	6	6	6	6	6	6	6	6	6	6
Wheel covers - trailers	1	1	1	1	1	1	2	1	1	1	1	1	1
Trailer undertray or bogie fairing	1	1	1	1	1	1	1	1	1	1	1	2	1

Legend	
1	Not Explored
2	Started and stopped
3	On some trucks
4	Slow climb to 100%
5	Fast climb to 100%
6	Part discontinued

Figure 8: Adoption Diversity across Fleets

Fleets should use this chart as a critical roadmap in navigating the many available technologies that can have a positive impact on lowering fuel expenses. A simple method by which fleets could approach this data is:

1. Consider the top third of the table, containing the technologies most commonly adopted by the fleets in this study for specifying on your next tractor and trailer. Ask yourself very specifically, why are we not buying these technologies?
2. Investigate the technologies in the middle third of the table. These technologies likely have less uniformity of adoption by the fleets as they may be more specific to certain duty cycles or business models. At least some of these technologies will also offer good options for you to consider purchasing. Ask, with respect to our fleet, why do we think these fleets are not uniform in adoption of these technologies?
3. Explore the technologies on the bottom third of the table. Many of these technologies may be new to the market, so their likely adoption down the road is not yet reflected here. Ask yourself if any of them offer an opportunity for your fleet to be an innovative early adopter? Or are they not valuable technologies, yet, and need further development.

5 Efficiency and Purchase Content of Latest Equipment

By 2014, the fleets in this study had adopted many of the 68 technologies, though each fleet has chosen its own unique suite to pursue. It is difficult to compare the fuel efficiency of different fleets as they vary in terms of the cargo they haul (weight), the geography and climate they operate in, and their business model for freight movement. Other variables such as driver makeup, company drivers versus independent contractors, length of time they plan to own the equipment, etc. will also have an impact on adoption decisions.

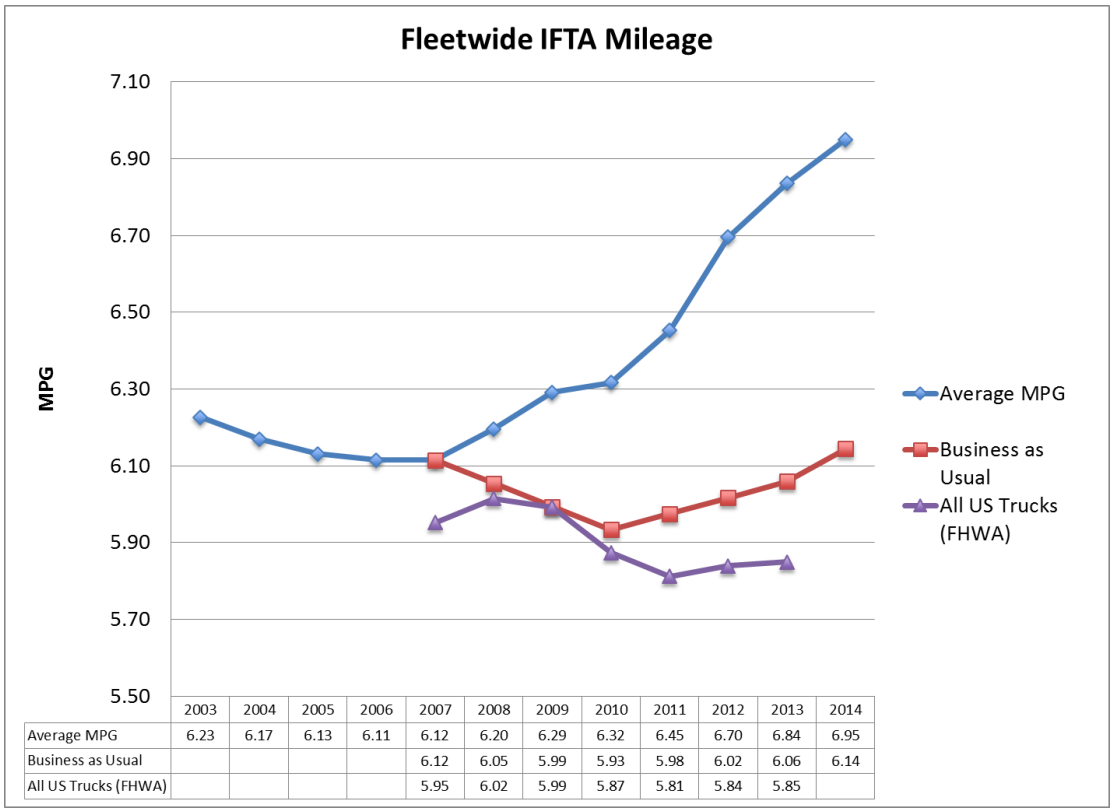
For this study, the fleets provided NACFE with fleet-wide fuel efficiency data, and required that we only publicly share aggregated averages of that data; they did not generally provide data for their equipment by model year. However, during this year's data collection, NACFE did obtain and discuss some of the fuel efficiency results obtained by many of the fleets with respect to their 2015 model year equipment and how they operated in 2014.

This research concludes that these fleets are operating their latest vehicles in a range of 7.5 to 8.5 miles per gallon. Some trucks were even found to approach 9.0 MPG in certain routes, conditions and seasons. This rate of improvement stems from the purchase content of efficiency technologies, and the fact that the improvements delivered by Diesel Exhaust Fluid-equipped (2010 emission) trucks have reached saturation, and most recently gains from some base engine improvements made in response to the 2014 Greenhouse Gas rule.

6 Fuel Savings from Efficiency Actions

The data on the uptake over time of these technologies, shown earlier, raises many additional questions. Among them: What impact do these technologies have on the fuel efficiency of the trucks in the fleet? What is the payback on investment in each of these technologies? What were other benefits and consequences of adoption other than the purchase price and fuel savings?

The average fuel efficiency of these fleets is shown in Figure 9 below. The MPG shown is for all trucks in the fleet in that year, so it does include tractors and trailers procured in years prior to a fleet's decision to adopt any given technology. It is therefore expected that the fuel efficiency curve will lag the adoption curve by a few years, as older trucks with fewer or none of the technologies installed are phased out.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Average MPG	6.23	6.17	6.13	6.11	6.12	6.20	6.29	6.32	6.45	6.70	6.84	6.95
Business as Usual					6.12	6.05	5.99	5.93	5.98	6.02	6.06	6.14
All US Trucks (FHWA)					5.95	6.02	5.99	5.87	5.81	5.84	5.85	

Figure 9: MPG over the Study Period

You may note the "U" shape of the Average MPG curve. In the first half of the time period, 2003 to 2009, the impact of the introduction and purchase of engines which met EPA04 and EPA07 emissions level requirements caused an overall decrease in fuel efficiency. In the period between 2007 and 2010, procurement of new fuel economy technologies at these fleets grew and began to stabilize the MPG, overcoming the degrading effect of the new engines. Finally, over the years 2011 to 2014, the average fuel efficiency of NACFE's study fleets improved, due to a dramatic increase in the adoption rates of new fuel efficiency technologies, along with the introduction of DEF in 2010, as well as the 2014 GHG emissions regulations' effects on the base powertrain.

The study team also created a Business as Usual prediction, to show the likely fuel economy these fleets would have experienced over this time period if they had not adopted any technologies, and solely enjoyed the benefits of the recent base engine efficiency improvements. NACFE's hypothetical Business as Usual scenario in fact maps well against the actual data reported by the U.S. Department of Transportation's Federal Highway Administration (FHWA) for the approximately 1.5 million over-the-road tractor trailers operating in the United States. This complete set of trucks lags the NACFE fleets as they tend to run older equipment, in some cases purchasing their tractors from the fleets in this study. They also tend to lag in pursuing the technologies to improve fuel economy.

The studied fleets are saving over $9,000 per truck per year in fuel compared to the level they would have been without buying these technologies (Figure 10). This amounts to around $45,000 over a five-year first-user ownership period. Comparing the efficiency of the 53,000 tractors (total in the 14 fleets combined) to the FHWA average shows a fuel cost improvement of $13,000 per truck per year or $18.2 B in fuel savings across all heavy-duty over the road tractors operating in the United States. A simple analysis was conducted on the payback of the technologies that provide the majority of the savings for these fleets. That review determined about a 2.5-year payback for those technologies. This payback will improve in the future, as higher adoption leads to lower upfront purchase prices. The value of these technologies is discussed further in Chapter 7 of this report.

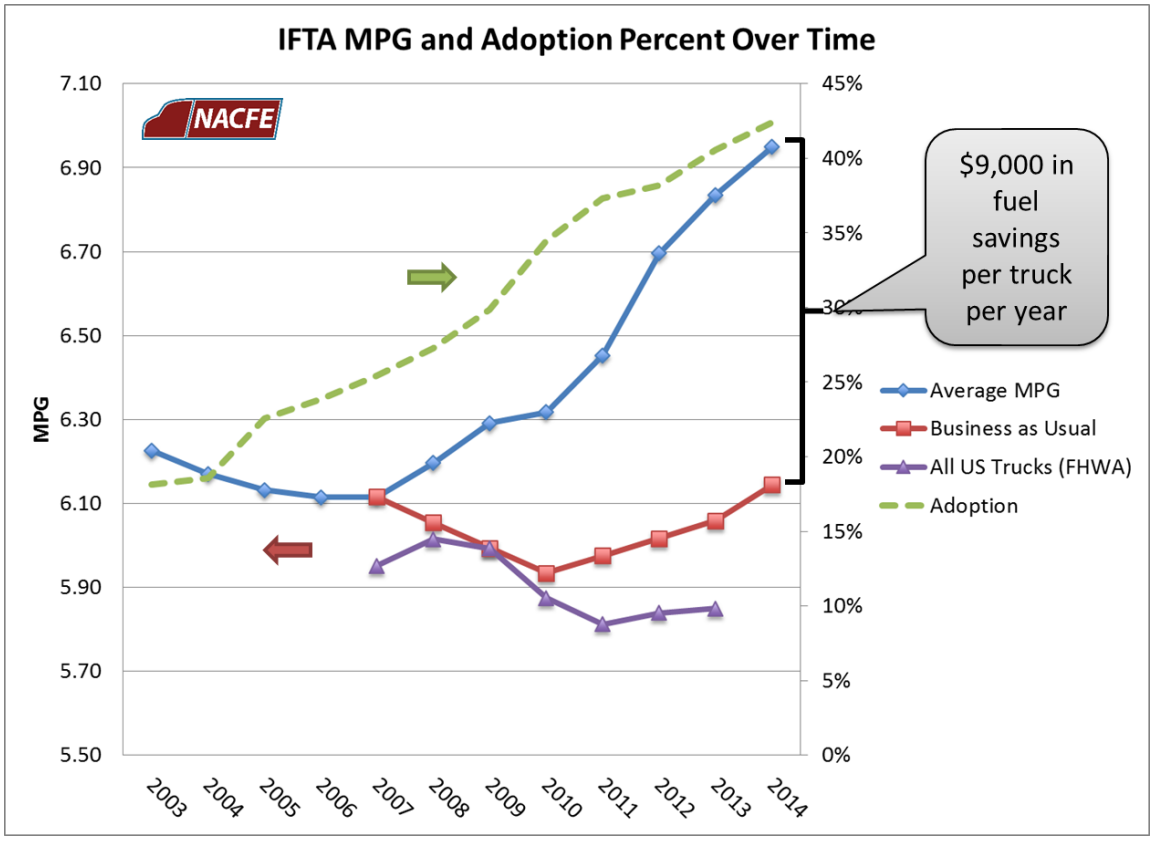


Figure 10: Fuel Mileage and Adoption

7 Trucking Efficiency Confidence Reports

The learnings from these Annual Fleet Fuel Studies provide useful insights into adoption trends in the industry, as well as into the specific practices of different major fleets. NACFE hopes that this information alone could spur additional investment, particularly by fleets that may be lagging behind the overall industry when it comes to certain widely-adopted technologies. However, in the course of conducting the study, it became clear that some technologies are still only being adopted by the most progressive or innovative fleets in spite of their showing strong potential for achieving cost-effective gains in fuel efficiency. In order to facilitate the wider industry's trust in and adoption of such technologies, NACFE and CWR formed

Trucking Efficiency and began a series of reports, called "Confidence Reports," which take an in-depth look at those most-promising but least-adopted technologies one-by-one.

Confidence Reports provide a concise introduction to a promising category of fuel efficiency technologies, covering key details of their applications, benefits, and consequences. The reports are produced via a data mining process that both combs public information and collects otherwise-private information (which is shared with Trucking Efficiency for the purpose of the reports). This information from manufacturers, end user fleets, tractor and trailer builders and others such as government and non-government organizations is aggregated in order to centralize an unparalleled range of testing data and case studies on a given technology set. All this information including tools for decision making can be found at www.truckingefficiency.org.

As of the release of this report, the group has finished in-depth work in tire pressure systems, 6x2 axles, idle reduction solutions, electronically controlled transmissions and optimizing engine parameters. Work in process include studies on low rolling resistance tires, downspeeding, lightweighting and maintenance for fuel economy with plans to work on driver coaching, tractor and trailer aerodynamics, more powertrain technologies and fuels and lubricants. Contact us to get involved in this important work.

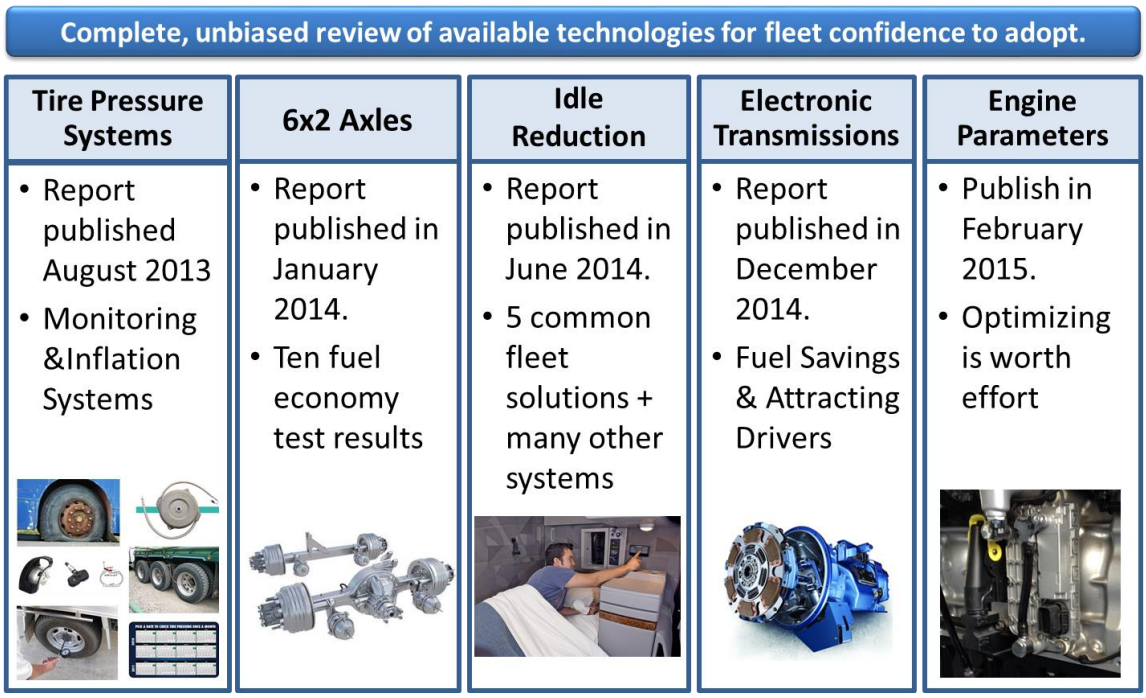


Figure 11: Trucking Efficiency Reports Completed by March 2015

8 Value of Technology Adoption

Each technology has a unique total cost of ownership and return on investment. Trucking Efficiency's series of Confidence Reports provide insight into each technology's primary benefits and consequences, and in most cases organizes the findings into a suggested payback calculation, delivered along with a transparent payback calculator tool, for fleets to plug-in their own specific metrics for improved decision making.

Some technologies such as automated manual transmissions and diesel auxiliary power units do cost thousands of dollars, but they offer significant benefits, and therefore possibly acceptable paybacks. Other technologies such as vented mudflaps or wheel covers cost little, while others such as optimizing engine parameters or choosing light-colored exterior paint cost nothing at all. For each technology studied, the team offers a confidence matrix. Figure 12 shows an example of such a matrix from the Confidence Report on Idle Reduction technologies. These graphics locate the technology in question on a grid comparing simple payback in years (value) against the amount of information and performance data available (confidence rating). Fleets should have high confidence in immediately pursuing technologies in the upper right quadrant, as those technologies that have a short payback and are well-proven to impact their operations in a very positive manner. Technologies to the top and left of the matrix are those for which there may not be a significant amount of information available, but what data is available suggested they would be very good for most fleets. As more information becomes available to the Trucking Efficiency team these ratings and the information on the online Tech Guide will be updated.

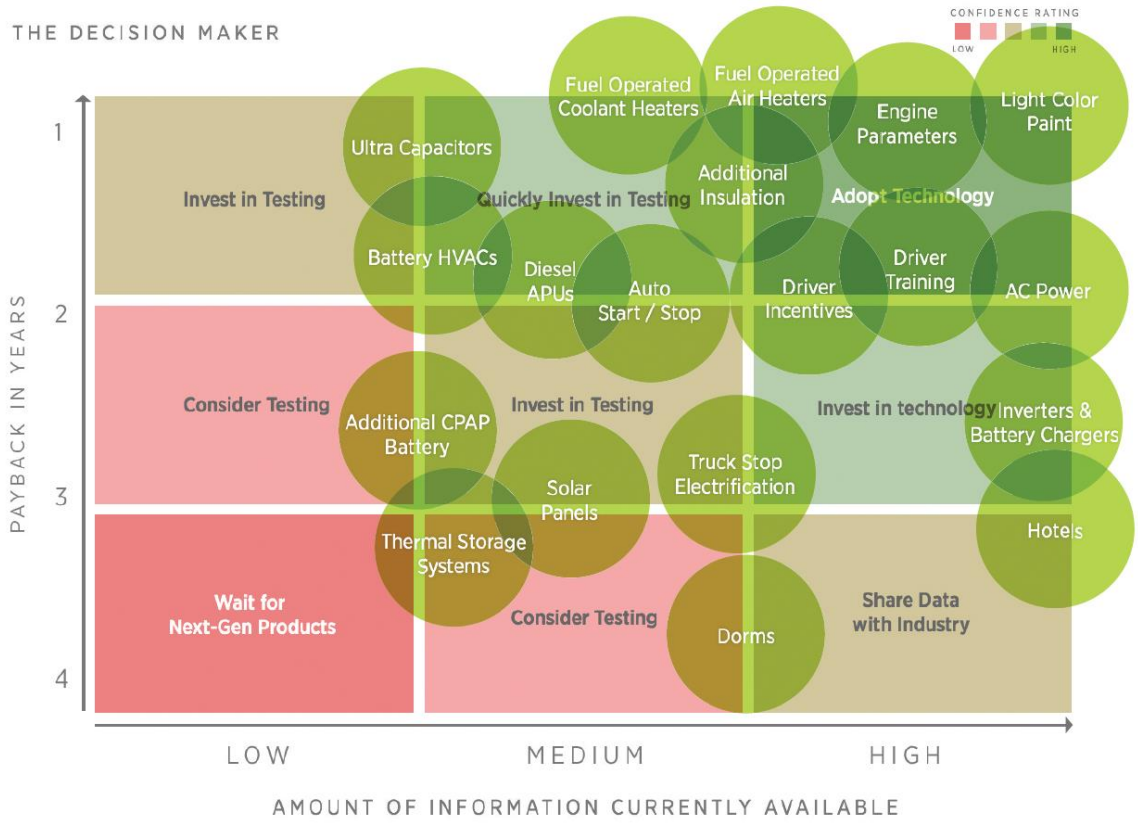


Figure 12: Confidence Matrix for Idle Reduction Solutions

9 Adoption Highlights

During the course of analyzing the data provided for this study, a number of interesting highlights emerged. With so much data available there are many items of note, but three stood out to the study team for sharing in the report. They include the uptake of electronically controlled transmissions (ECTs); automated manuals (AMTs) and fully automatics with Conway Truckload's recent commitment to and announcements for going to 100% adoption of AMTs for driver comfort, performance and safety. Another on Frito Lay's path to aerodynamic daycabs, two times, once for diesel tractors and again for natural gas ones. And finally, small fleets taking advantage of engine parameters and Cummins' sharing a rather large uptake in PowerSpec™ downloads as an indication of end users taking advantage of optimizing their electronic engine parameters.

9.1 Decision-Making Trends: Transmissions

In December of 2014 Trucking Efficiency published a Confidence Report (more information on that series of studies in Chapter 8) on electronically controlled transmissions, concluding that 2014/2015 would be the tipping point for their adoption in over-the-road tractors. An early finding of that report was that much of the industry refers to all non-manual transmissions as "automatics." In fact, these technologies are best defined as one of two types of electronically controlled transmissions: automatics, which are torque converter fully automatic transmissions, and automated manuals, which are a far more common choice

Fleets are aggressively considering these transmissions due to their fuel savings, reliability and performance capabilities, role in helping to attract and retain drivers, and enablement of future fuel efficiency opportunities such as downspeeding. The 2015 Annual Fleet Fuel Study found that five fleets are already purchasing electronically controlled transmissions on all of their new tractors, while the other nine are all buying at least a small portion of their new trucks with ECTs. For diesel applications, these fleets are specifically buying automated manual transmissions (AMTs). The value proposition of AMTs is well-described in the Confidence Report, which can be downloaded here. Automatic transmissions are also being purchased by study participants, specifically on some of their CNG-powered tractors. Figure 13 shows the adoption rate of electronically controlled transmissions as reported by the fleets in this study.

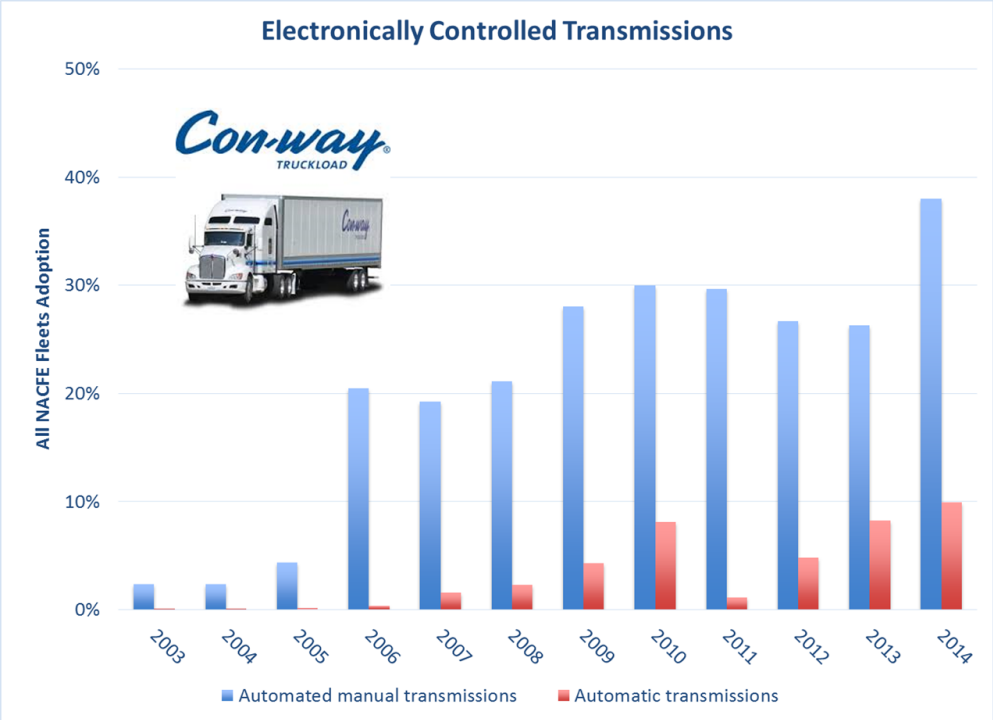


Figure 13: Adoption Rate for Transmissions (Class 8 Tractors)

In May 2014 Con-way Truckload announced that their 2014 purchase would be equipped almost exclusively with automated manual transmissions. Fleet Owner reported at the time that…."Responding to what it said are driver demands, Con-way Truckload has purchased 550 new tractors, 540 of which will be equipped with automatic transmissions. All of the tractors feature 6x4 axles." [1]

The company reported to NACFE that, previously, only about 50 tractors in the 2,700-vehicle fleet were automated manuals. The decision to ramp up their adoption was motivated in part by "more and more driver requests for automatics, along with the company's desire to lower the barrier of entry into a driving career," as Con-way Truckload's VP of Maintenance and Asset Management Randy Cornell said.

"We've found that many younger drivers looking to enter the industry prefer the automatic transmissions (AMTs) because it removes the perception that operating a truck is outside of their ability," said Gretchen Jackson, recruiting manager. "Truck driving is an essential role within the economy and, given the current driver shortage, we want to provide career opportunities for those who have an interest but may think the job is unattainable."

Today, these transmissions are performing well for Con-way Truckload and in April 2015, they announced that almost their entire 2015 purchase will have AMTs. Cornell further reported that "We will continue to buy these automated manual transmissions as they are providing the fuel savings and drivers appreciate their performance. Also, we expect future powertrains to almost require the smarter transmission to enable future fuel savings."

[1] http://fleetowner.com/equipment/con-way-truckload-adds-550-new-tractors-mostly-automatics

9.2 Improved Technology Availability: Aerodynamics

Many barriers hinder the adoption of fuel efficiency technology. A market-research study funded by the International Council for Clean Transportation and completed by NACFE in 2013 gave an in-depth assessment of the most salient barriers facing the industry today; that report can be viewed and downloaded here. One of the barriers documented in that research surrounded possible issues with the availability of a given technology. That is, a technology might be available from one truck builder, but not a fleet's preferred builder, or it may not be available in combination with other features that the fleet desires.

For about 10 years, Frito Lay has been aggressively pursuing fuel savings and freight efficiency on their tractors and trailers. Historically, aerodynamic devices were not generally offered on daycab tractors, like the ones operated by Frito Lay, as it was assumed their benefit was not sufficient as those trucks' generally operated at lower average speeds compared to sleeper tractors in long-haul applications. In 2004 to 2006, Frito Lay spearheaded an effort with a number of tractor manufacturers to add more aerodynamic devices to its daycabs, and by 2007 they had introduced cab extenders, with chassis skirts following in 2009. (Figures 14 and 15) These were two of many features adopted by Frito Lay that increased their fleet-wide average fuel economy over the last few years.

2011
Diesel tractor

Light Aero - 2013
CNG tractor

Full Aero - 2015
CNG tractor

Medium Aero - 2014
CNG tractor

Figure 14: Frito Lay Tractors

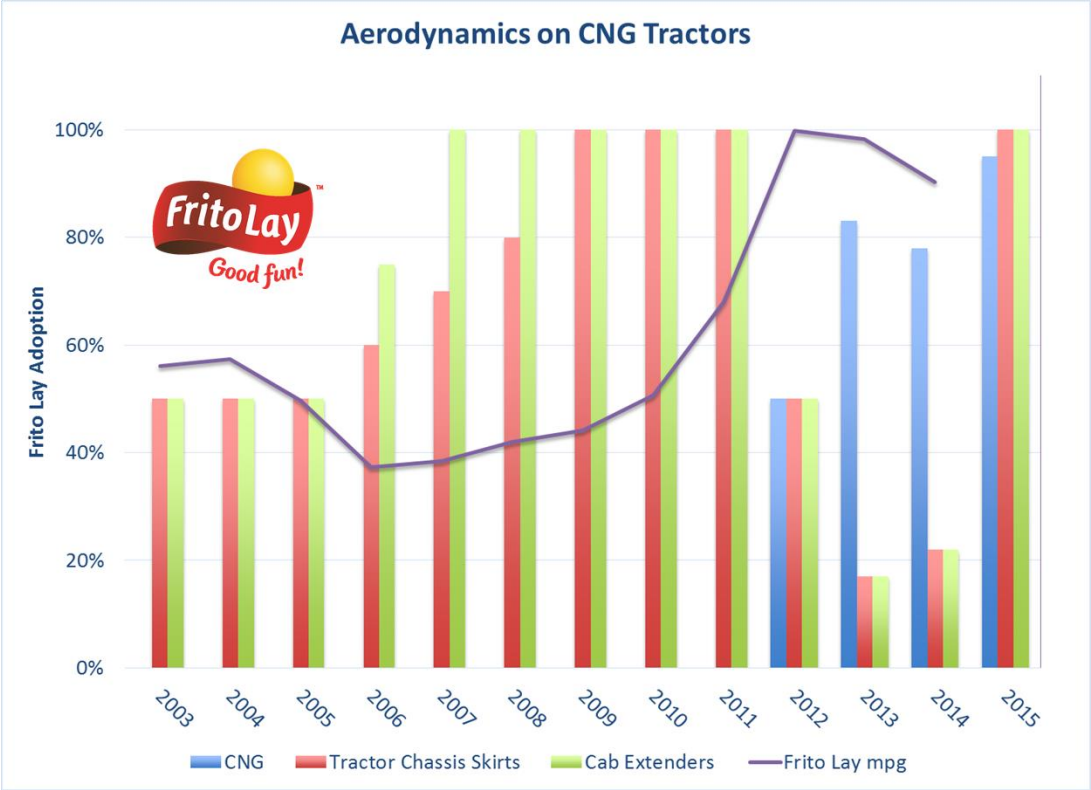


Figure 15: Adoption and Fuel Economy at Frito Lay

In 2011, Frito decided to pursue Compressed Natural Gas (CNG) powered trucks, beginning procurement in 2012 and ramping to about 80% of their purchases by 2013. But they found that, for a number of reasons, these CNG-trucks were not available with cab extenders and chassis skirts, as fuel tank package designs were emerging to satisfy the fuel capacity needed for the required range of these trucks, which interfered with the available designs of the aerodynamics. Meanwhile, in spite of Frito Lay's requests, the tractor OEMs remained focused on improving the aerodynamics of sleeper tractors, and struggled to justify the product development of these aerodynamic devices on the smaller purchase volume of CNG daycabs.

The great news is that through collaboration between the tractor builders and the aerodynamics and fuel tank manufacturers, along with Frito Lay, the 2015 purchase of CNG tractors will have the aerodynamics desired included. This is important as the fleet-wide fuel efficiency of the Frito Lay fleet has dropped a bit in the last few years due to this issue.

"We have been aggressively pursuing fuel savings and freight efficiency for many years", says Steve Hanson, Frito Lay Director Fleet Engineering. "Through collaboration with tractor builders and aerodynamic device and fuel system suppliers, we are now able to get the aerodynamics we desire on our CNG powered tractors. This will help us continue to increase our overall fleet-wide fuel efficiency."

9.3 Growing Industry Interest: Optimized Engine Parameters

By 2008, 90% of the trucks procured by the fleets in this study had optimized their electronic engine parameters for fuel economy, and 100% by 2014. Selecting the appropriate settings for the initial electronic

engine parameters of a truck, and also then going through the process to actually optimize them, delivers fuel savings of as much as 8%, per the Confidence Report published by the Trucking Efficiency team in February 2015 and available here.

That report also found that engine parameters are being exploited by large fleets, but that smaller fleets often lack the resources to manage the selecting and upkeep of the parameters on their trucks, and so do nothing to customize these parameters for their operations. The findings showed many obstacles exist, and that these are higher for smaller fleets with limited resources and access to assistance from the engine OEMs and others. However, it is by no means impossible, as two of the fleets in this Annual Fleet Fuel Study operate fewer than 500 trucks each, and both were actually among the first half of adopters to optimize their electronic engine parameters.

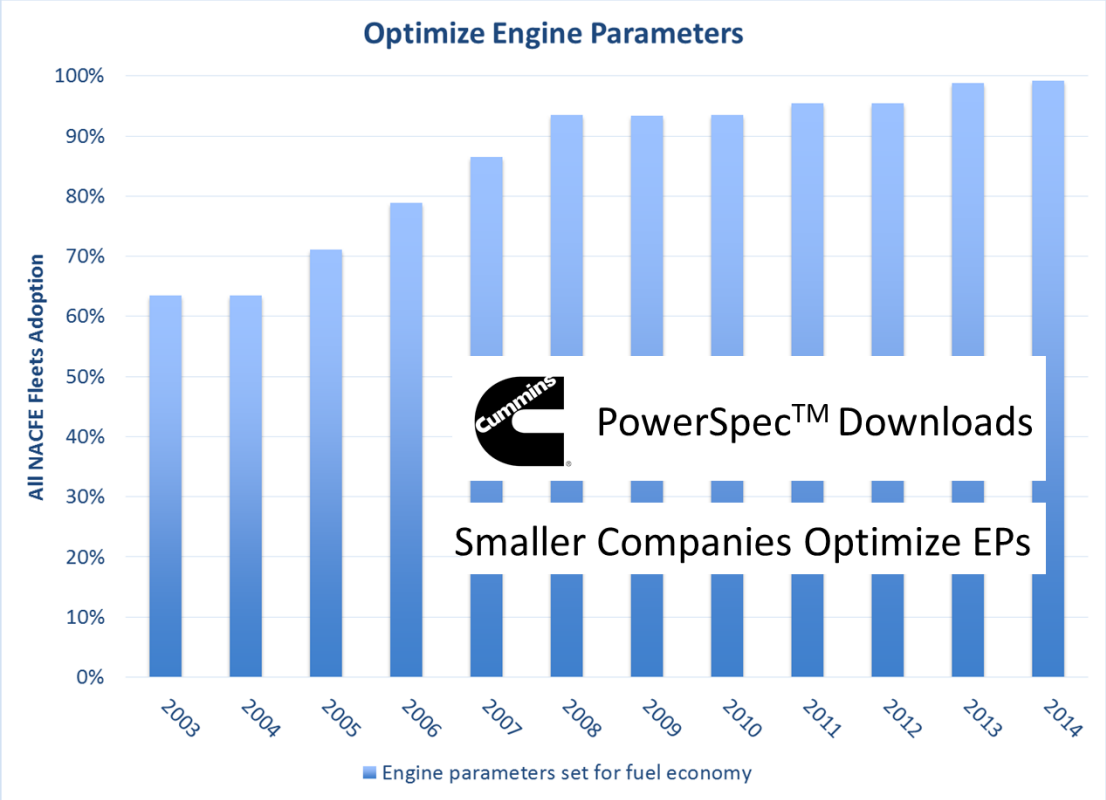


Figure 15: Optimizing Engine Parameters

Fleets may now be focusing on this opportunity to learn about engine parameters and to program them for better fuel efficiency. Cummins reported a recent uptake of interest in their electronic engine parameter software. Mario Sanchez-Lara, Director Technical Sales Support shared, "We recently experienced a surge in the website traffic, downloads of our PowerSpec™ software and licensing. PowerSpec™ enables Cummins Customers to adjust parameters that could improve fuel efficiency of their engine. PowerSpec™ has been available for over a decade and we had kept modest promotion efforts, hence we wondered what had prompted the increase. On further investigation, we realized the surge was due directly to the release of Trucking Efficiency's Confidence Report recommending electronic engine parameters." He continued, "The report helped many to realize about the significant gains in fuel economy when engine parameters are optimized. Cummins is very pleased with both the report and the increased awareness it has created in the industry."

10 Conclusion

NACFE would like to thank the participating fleets for offering such important information to the rest of the industry. This study does provide a benchmarking opportunity for those fleets to continue to improve the operations and increase freight efficiency. If you are interested in joining this study, please contact the North American Council for Freight Efficiency. For other fleets, serving our population by moving the goods around that we require for our quality of life, the details in this study will provide a roadmap for your consideration of technologies and practices to help reduce fuel costs.

The results of this annual survey clearly reflect a growing use of fuel savings systems and procedures. However not all fleets operate under the same philosophies and operation conditions so strategies and results differ from fleet to fleet. NACFE (in conjunction with Trucking Efficiency) conducts a series of workshops that allow fleets, dealerships and industry suppliers to gather in an environment of open discussions regarding these industry changes. NACFE realizes that printed materials alone are not the entire answer and personal interface opportunities are also valuable to the industry. Information on upcoming workshops can be found under the "Events" section of the truckingefficiency.org website as well as the NACFE pages on LinkedIn and Facebook. If your fleet would like direct contact, please send a message to david.schaller@nacfe.org.

11 References

"NACFE conducts extensive benchmarking study on fleet fuel efficiency," Truck News, February 21, 2012.

United States Energy Information Administration, April 2015.

American Transportation Research Institute, "Operational Costs of Trucking Report", September 4, 2014.

North American Council for Freight Efficiency, 2014 Fleet Fuel Study, which includes prior information on best practices of adoption at the fleets. http://nacfe.org/wp-content/uploads/2014/09/NACFE-2014-Study-Report-FINAL-083114.pdf

12 Appendices

12.1 Appendix A: How adoption percentage is calculated

The percent adoption of a technology is a measure of the rate at which fleets purchased a given technology or implemented a given practice in any particular year. The goal is to determine adoption in terms of each fleet's selection and use. Therefore, the figure is not weighted by the number of tractors or trailers purchased per year by the fleet. It measures fleet decisions, rather than the number of trucks with the technologies. Under this methodology, a decision made by the smaller fleets, who purchase about 100 trucks per year, has the same value as that of the largest fleet buying thousands. The calculations shown in Appendix B are as follows:

- Each Technology Adoption
  - % Adoption = (% of new trucks purchased with technology @ fleet A + % @ fleet B + …) / Number of Fleets
- Technology Adoption across all Fleets
  - Total % Adoption = (% Tech Adoption #1 + % #2 + …) / Number of Technologies

Appendix C is provided as a truer representation of the amount of the new technology sold in each year. Here the data from Appendix B is recalculated using the miles travelled by each fleet. This methodology therefore does value a purchase of 2,000 per year of a given technology by a large fleet as 20 times greater than someone buying only 100 new trucks.

12.2 Appendix B: Adoption of Technologies by Fleets

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Idle Reduction												
Highest level of cab insulation	0%	0%	8%	8%	8%	3%	15%	15%	15%	15%	31%	38%
Anti Idle Electronic Engine Controls	38%	46%	54%	62%	77%	82%	90%	90%	92%	95%	96%	96%
Diesel Fired Heater	6%	13%	21%	29%	29%	26%	22%	21%	27%	29%	64%	66%
Diesel APU	8%	16%	16%	16%	22%	28%	27%	16%	11%	10%	8%	9%
Battery HVAC	0%	0%	0%	0%	8%	12%	13%	21%	21%	24%	24%	24%
Automatic Engine Start/Stop	4%	4%	11%	12%	12%	4%	4%	4%	4%	10%	14%	15%
AC Power Port	0%	0%	0%	0%	0%	0%	8%	8%	8%	8%	8%	9%
Uses Truck Stop Electrification (Snorkel type)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Thermal Storage System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Chassis												
6x2 axles	1%	1%	1%	1%	1%	1%	5%	15%	17%	18%	22%	20%
Synthetic axle lube	62%	62%	69%	77%	77%	85%	85%	92%	93%	93%	92%	97%
2 Speed Fan Clutch	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	16%	15%
Clutched Water Pump	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	14%
Use of clutched air compressor	0%	0%	0%	0%	0%	0%	8%	12%	12%	12%	14%	14%
Move from 6x4 to 4x2 tractor specs	3%	3%	3%	3%	3%	3%	3%	7%	7%	6%	9%	8%
Tires / Rolling Resistance												
Tire pressure inflation - trailer	1%	1%	1%	4%	13%	9%	25%	32%	34%	34%	36%	45%
Tire pressure monitoring - trailer	0%	0%	0%	0%	0%	0%	0%	9%	9%	9%	9%	9%
Tire pressure monitoring - tractor	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	16%	16%
Low rolling resistance duals (Smartway)	31%	23%	27%	27%	31%	31%	46%	54%	70%	70%	81%	88%
Wide based tires - tractors	0%	8%	8%	9%	9%	9%	16%	30%	36%	40%	39%	37%
Wide based tires - trailers	8%	1%	8%	8%	8%	8%	9%	30%	31%	31%	29%	23%
Tires filled using Nitrogen	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Aluminum wheels tractors	46%	46%	56%	62%	62%	71%	68%	70%	76%	82%	83%	84%
Aluminum wheels trailers	22%	15%	22%	23%	23%	24%	34%	49%	51%	47%	54%	54%
Powertrain												
Automated manual transmissions	2%	2%	4%	20%	19%	21%	28%	30%	30%	27%	26%	38%
Automatic transmissions	0%	0%	0%	0%	2%	2%	4%	8%	1%	5%	8%	10%
Direct drive transmission	8%	8%	8%	8%	8%	12%	22%	33%	48%	42%	48%	42%
Synthetic transmission oil	62%	62%	69%	69%	77%	84%	78%	85%	84%	85%	91%	92%
Downsize engine (e.g. 15L - 13L)	3%	3%	7%	3%	6%	6%	10%	15%	39%	42%	43%	47%
Engine parameters set for fuel economy	63%	63%	71%	79%	87%	93%	93%	93%	95%	95%	99%	99%
Geardown protection	38%	38%	42%	54%	61%	68%	73%	78%	78%	79%	84%	84%
Predictive cruise control	0%	0%	0%	0%	2%	5%	15%	20%	32%	36%	38%	38%
Change vehicle gearing	26%	26%	26%	26%	34%	49%	50%	57%	67%	60%	68%	68%
Synthetic engine oil	8%	8%	12%	16%	16%	16%	16%	23%	31%	28%	33%	41%
Fuel additives	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Mechanical Turbo-compounding	0%	0%	0%	0%	2%	20%	16%	31%	33%	28%	0%	0%
CNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	6%	8%
LNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%
Tractor Aerodynamics												
Aero hoods and fenders	64%	67%	87%	87%	90%	92%	96%	100%	100%	100%	100%	100%
Aerodynamic bumpers	51%	53%	78%	81%	84%	87%	90%	96%	100%	100%	100%	100%
Aerodynamic mirrors	62%	65%	86%	87%	91%	93%	98%	100%	100%	100%	100%	100%
Full height roof air fairing	73%	73%	80%	80%	80%	88%	89%	91%	95%	97%	97%	97%
Specified weight reduction on tractors	25%	27%	40%	46%	46%	46%	46%	55%	56%	57%	49%	49%
Remove parts - bug deflectors, etc.	33%	33%	35%	35%	37%	37%	48%	59%	62%	62%	62%	61%
Tractor chassis skirts - full	25%	27%	40%	42%	52%	56%	68%	76%	65%	66%	74%	80%
Tractor chassis skirts - partial	37%	38%	43%	45%	39%	42%	41%	44%	36%	36%	31%	33%
Fixed 5th wheel w/ minimum gap	28%	29%	44%	42%	42%	42%	47%	55%	55%	47%	47%	47%
Cab Extenders	67%	67%	82%	84%	86%	86%	94%	95%	95%	87%	91%	92%
Wheel covers - tractors	0%	0%	0%	0%	0%	0%	0%	3%	8%	10%	19%	29%
Vented mudflaps - tractors	0%	0%	0%	0%	0%	0%	0%	2%	27%	32%	33%	38%
Trailer Aerodynamics												
Specified weight reduction on	15%	19%	21%	23%	23%	23%	23%	31%	31%	31%	31%	31%
Trailer skirts	0%	0%	0%	0%	1%	0%	15%	59%	66%	73%	77%	82%
Use of doubles or triples trailers	8%	8%	8%	8%	9%	9%	10%	10%	10%	10%	10%	12%
Trailer nose cones	0%	0%	0%	0%	0%	0%	0%	8%	8%	8%	8%	8%
Remove or relocate any trailer drag parts?	0%	0%	0%	0%	0%	0%	0%	8%	8%	25%	31%	31%
Narrow mudflap width	8%	8%	8%	8%	8%	8%	12%	24%	33%	41%	39%	39%
Vented mudflaps - trailer	0%	0%	0%	0%	0%	0%	0%	2%	27%	32%	32%	45%
Wheel covers - trailers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trailer undertray or bogie fairing	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	4%	0%
Boat tails	0%	0%	0%	0%	0%	0%	0%	8%	8%	8%	15%	19%
Vortex generators	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Practices												
Limit Speed <65 mph	58%	58%	73%	73%	73%	90%	92%	92%	92%	92%	100%	92%
Reduce empty miles (back-hauls, routing, etc)	69%	69%	85%	85%	85%	85%	85%	85%	85%	85%	87%	88%
Driver training for fuel economy	69%	69%	77%	77%	77%	77%	77%	77%	85%	85%	92%	90%
Driver incentives for FE	8%	8%	8%	8%	8%	8%	8%	8%	15%	15%	15%	29%
In cab behavior modifications	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	32%	34%
Routing optimization	58%	58%	58%	58%	65%	73%	73%	73%	73%	73%	73%	77%
Coasting before engine braking	8%	8%	8%	8%	8%	8%	8%	8%	15%	15%	15%	22%

12.3 Appendix C: Adoption Scaled by the Number of Miles Driven

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Idle Reduction												
Highest level of cab insulation	0%	0%	10%	10%	10%	4%	22%	22%	22%	22%	27%	29%
Anti Idle Electronic Engine Controls	35%	45%	55%	73%	78%	90%	88%	91%	94%	96%	97%	97%
Diesel Fired Heater	0%	13%	23%	23%	23%	20%	14%	13%	21%	24%	57%	57%
Diesel APU	3%	15%	15%	15%	16%	32%	33%	23%	15%	13%	13%	14%
Battery HVAC	0%	0%	0%	0%	1%	6%	5%	13%	12%	15%	15%	9%
Automatic Engine Start/Stop	0%	0%	10%	10%	10%	1%	0%	0%	1%	9%	15%	16%
AC Power Port	0%	0%	0%	0%	0%	0%	2%	2%	2%	2%	2%	2%
Uses Truck Stop Electrification (Snorkel type)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Thermal Storage System	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Chassis												
6x2 axles	0%	0%	0%	0%	0%	0%	3%	7%	6%	7%	11%	17%
Synthetic axle lube	85%	85%	87%	88%	88%	98%	97%	99%	99%	99%	99%	100%
2 Speed Fan Clutch	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	13%	4%
Clutched Water Pump	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	8%
Use of clutched air compressor	0%	0%	0%	0%	0%	0%	3%	5%	5%	6%	7%	7%
Move from 6x4 to 4x2 tractor specs	1%	1%	1%	1%	1%	1%	1%	2%	2%	2%	3%	2%
Tires / Rolling Resistance												
Tire pressure inflation - trailer	0%	0%	0%	1%	3%	3%	16%	31%	32%	32%	34%	41%
Tire pressure monitoring - trailer	0%	0%	0%	0%	0%	0%	0%	15%	15%	15%	15%	15%
Tire pressure monitoring - tractor	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	14%	14%
Low rolling resistance duals (Smartway)	33%	28%	32%	32%	37%	37%	54%	67%	87%	87%	92%	97%
Wide based tires - tractors	0%	6%	6%	6%	6%	6%	7%	22%	26%	31%	27%	23%
Wide based tires - trailers	6%	1%	6%	6%	6%	6%	7%	20%	22%	22%	20%	15%
Tires filled using Nitrogen	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Aluminum wheels tractors	63%	63%	65%	67%	67%	75%	69%	71%	76%	78%	78%	78%
Aluminum wheels trailers	17%	12%	17%	18%	18%	18%	32%	34%	36%	37%	36%	36%
Powertrain												
Automated manual transmissions	1%	1%	5%	7%	4%	4%	7%	7%	7%	6%	7%	15%
Automatic transmissions	0%	0%	0%	0%	0%	1%	1%	3%	0%	1%	2%	2%
Direct drive transmission	17%	17%	17%	17%	17%	18%	23%	29%	53%	52%	54%	49%
Synthetic transmission oil	73%	73%	76%	75%	88%	97%	89%	98%	98%	98%	99%	99%
Downsize engine (e.g. 15L - 13L)	1%	1%	5%	1%	2%	2%	5%	8%	37%	39%	39%	42%
Engine parameters set for fuel economy	68%	68%	78%	96%	96%	98%	98%	98%	98%	98%	100%	100%
Geardown protection	40%	40%	48%	72%	83%	86%	91%	96%	96%	96%	98%	98%
Predictive cruise control	0%	0%	0%	0%	1%	2%	12%	13%	33%	44%	47%	47%
Change vehicle gearing	38%	38%	38%	38%	56%	71%	71%	72%	76%	72%	76%	76%
Synthetic engine oil	3%	3%	11%	20%	20%	20%	20%	32%	35%	34%	34%	37%
Fuel additives	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Mechanical Turbo-compounding	0%	0%	0%	0%	5%	33%	27%	36%	31%	29%	0%	0%
CNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	3%
LNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%
Tractor Aerodynamics												
Aero hoods and fenders	72%	75%	88%	89%	93%	97%	98%	100%	100%	100%	100%	100%
Aerodynamic bumpers	52%	54%	70%	74%	79%	86%	88%	90%	100%	100%	100%	100%
Aerodynamic mirrors	64%	68%	83%	86%	93%	98%	99%	100%	100%	100%	100%	100%
Full height roof air fairing	86%	86%	87%	87%	87%	96%	89%	92%	96%	99%	99%	99%
Specified weight reduction on tractors	21%	22%	26%	29%	29%	29%	29%	35%	36%	37%	21%	20%
Remove parts - bug deflectors, etc.	34%	34%	35%	35%	36%	36%	39%	40%	40%	40%	40%	40%
Tractor chassis skirts - full	29%	31%	35%	37%	47%	51%	55%	63%	62%	62%	75%	77%
Tractor chassis skirts - partial	31%	34%	36%	38%	36%	41%	42%	43%	41%	40%	31%	32%
Fixed 5th wheel w/ minimum gap	33%	36%	46%	41%	41%	41%	46%	47%	47%	47%	47%	47%
Cab Extenders	84%	84%	95%	95%	96%	96%	97%	97%	97%	95%	95%	97%
Wheel covers - tractors	0%	0%	0%	0%	0%	0%	0%	6%	17%	17%	17%	25%
Vented mudflaps - tractors	0%	0%	0%	0%	0%	0%	0%	0%	22%	22%	23%	24%
Trailer Aerodynamics												
Specified weight reduction on	8%	10%	10%	11%	11%	11%	11%	23%	23%	23%	23%	23%
Trailer skirts	0%	0%	0%	0%	1%	0%	9%	56%	69%	78%	80%	83%
Use of doubles or triples trailers	18%	18%	18%	18%	18%	18%	19%	19%	19%	19%	19%	20%
Trailer nose cones	0%	0%	0%	0%	0%	0%	0%	3%	3%	3%	3%	3%
Remove or relocate any trailer drag parts?	0%	0%	0%	0%	0%	0%	0%	17%	17%	22%	34%	34%
Narrow mudflap width	17%	17%	17%	17%	17%	17%	20%	37%	39%	42%	39%	38%
Vented mudflaps - trailer	0%	0%	0%	0%	0%	0%	0%	0%	22%	22%	23%	41%
Wheel covers - trailers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trailer undertray or bogie fairing	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	3%	0%
Boat tails	0%	0%	0%	0%	0%	0%	0%	1%	2%	1%	13%	14%
Vortex generators	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Practices												
Limit Speed <65 mph	61%	61%	72%	72%	72%	94%	94%	94%	94%	94%	100%	85%
Reduce empty miles (back-hauls, routing, etc)	75%	75%	86%	86%	86%	86%	86%	86%	86%	86%	86%	87%
Driver training for fuel economy	75%	75%	85%	85%	85%	85%	85%	85%	86%	86%	88%	87%
Driver incentives for FE	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	24%
In cab behavior modifications	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	41%	42%
Routing optimization	52%	52%	52%	52%	67%	77%	77%	77%	77%	77%	77%	85%
Coasting before engine braking	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	10%

12.4 Appendix E: Adoption Curves by Category