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

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2019 Fiscal

Gold

Pilot, Flying J, Bergstrom, Lubrizol, Shell, Schneider, Navistar, Michelin, Meritor, Dana, PepsiCo, Freightliner

Silver

Cummins, P.S.I. The Inflation System, Werner We Keep America Moving, Aperia Technologies, NRECA America's Electric Cooperatives, Kenworth Sales Company, Great Dane, Geotab management by measurement, Mack, Idle Smart, Volvo, UPS

Bronze

IMI, Flexx More Miles Less Fuel, FlowBelow, Allison Transmission, Velociti, BASF We create chemistry, Stoughton, Goodyear, Fontaine Modification, noodle.ai, Hendrickson, Link Auxiliary Suspensions 20K Pusher, The Aluminum Association, Kenworth

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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 21 major North American fleets. This is the eighth annual update of the 2012 inaugural study that has been described as an important read for anyone working in this area. "I look forward to this report and read it each year within days of it being published. It is important to Schneider's efforts and it can be a critical resource to any fleet or owner/operator as well as manufacturers and others who are working to improve Class 8 efficiency," offers Rob Reich, EVP, Chief Administrative Officer, Schneider. And, each year the report has been published, it has been NACFE's most downloaded report. 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 tractors (daycabs and sleepers) and trailers in regional and long-haul applications. Fleets providing data for this 2019 study include Bison Transport, C&S, Cardinal Logistics, CFI, CR England, Crete, Frito-Lay, Hirschbach, Maverick, Mesilla Valley Transportation, NFI Industries, Nussbaum, Paper Transport, Prime, Schneider, United Parcel Service, and Werner. Over the years new fleets have joined the study while others stopped or failed to report for a year. The primary goal was to study the fleets' levels of adoption of 85 technologies and practices, and the results those drove in each organization. All 85 technologies are currently available and not prototypes, validation test units, or pre-production units. This study focuses on technologies 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.

The primary finding of this report is that the 21 fleets studied are increasing their rate of adoption of these technologies, and that they are enjoying improved fuel economy as a result. The overall adoption rate for the technologies studied in this report has grown from 17% in 2003 to 45% in 2018. Not all technologies could be applied to a single tractor-trailer, as some are clearly an either-or decision. 2018 showed an increase in fuel cost at the pump with diesel fuel, which powers a large majority of this fleet, averaging $3.18 per gallon for 2018 (EIA, 2019), up from 2017 at $2.65. This is a 20% increase, year over year and $0.88 per gallon increase from 2016. The 2011 to 2014 four-year average was $3.89 (See Figure 1), meaning that fuel costs annualized in 2018 is within $0.71 of that level.

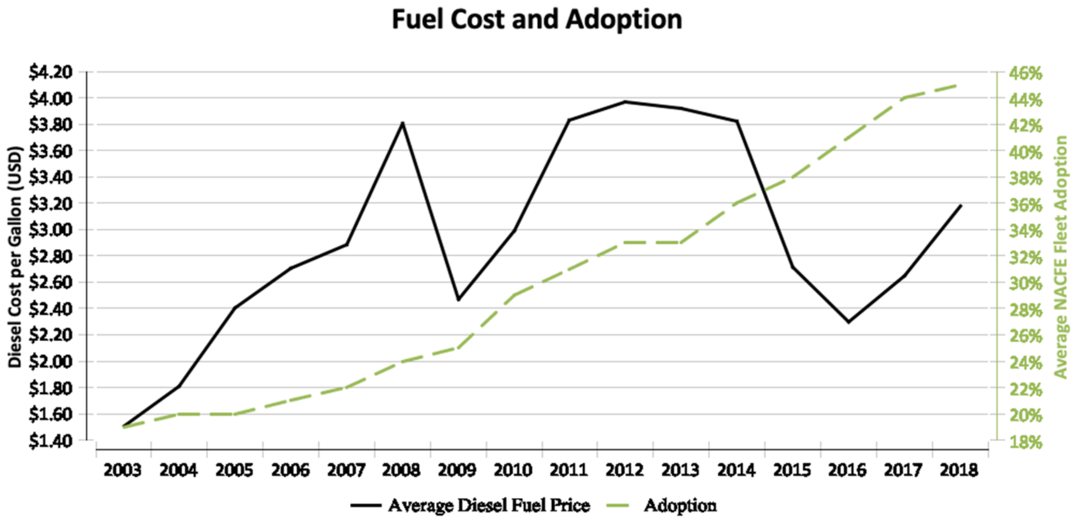

Figure 1: Price of Diesel and NACFE Fleets Adoption

The average fleet-wide fuel economy of the trucks in this study was 7.27 mpg in 2018 — a slight increase from the 7.23 in 2017. There is variability in each fleet's yearly fuel efficiency depending on many factors. For the 16 years of this study, the average rate of improvement in MPG is 2.0%.

Figure 2 shows the average fleet-wide fuel economy for the combined population of trucks in this study compared to the overall U.S. truck population. A business-as-usual (BAU) line is included for comparison. The BAU shows a projection of what average MPG might have been given the combined impact of 2002, 2007, and 2010 emission regulations, and the effect of the 2014 and 2017 Greenhouse Gas (GHG) base powertrain improvements. In other words, this suggests the level of efficiency had the 21 fleets not purchased the technologies that are available to them as options.

The national average for the approximately 1.7 million tractors in over-the-road use is shown and was obtained using International Fuel Tax Reporting data from the Federal Highway Administration (FHWA, 2019). Of note this year is that the national average of these trucks jumped to 5.98 MPG in 2017, a reflection of the fact that the MPG increases over the last 10 years are starting to be reflected in the overall population's efficiency. As of the finalization of this report, 2018 data was still not available.

During NACFE's Run on Less demonstration in September of 2017, the tractor-trailers equipped with the best of the best currently available technologies attained 10.1 MPG. And in October 2019, the group conducted a second Run on Less where the average for the more demanding regional haul duty cycles reached 8.3. More on this later.

The fuel savings in 2018 between the BAU of 6.37 MPG and the NACFE fleets average of 7.27 MPG amounts to $6,492 per year per truck, at the $3.18 per gallon fuel cost over the average tractor mileage of 105,041. The fleets are saving $9,912 over the national average of 5.98 MPG. If fuel costs had been at the four-year average of $3.89 per gallon, the savings would have been $7,941 and $12,124, respectively. And finally, the 21 fleets operating 73,844 trucks saved $895,318,953 in 2018 compared to the average trucks on the road.

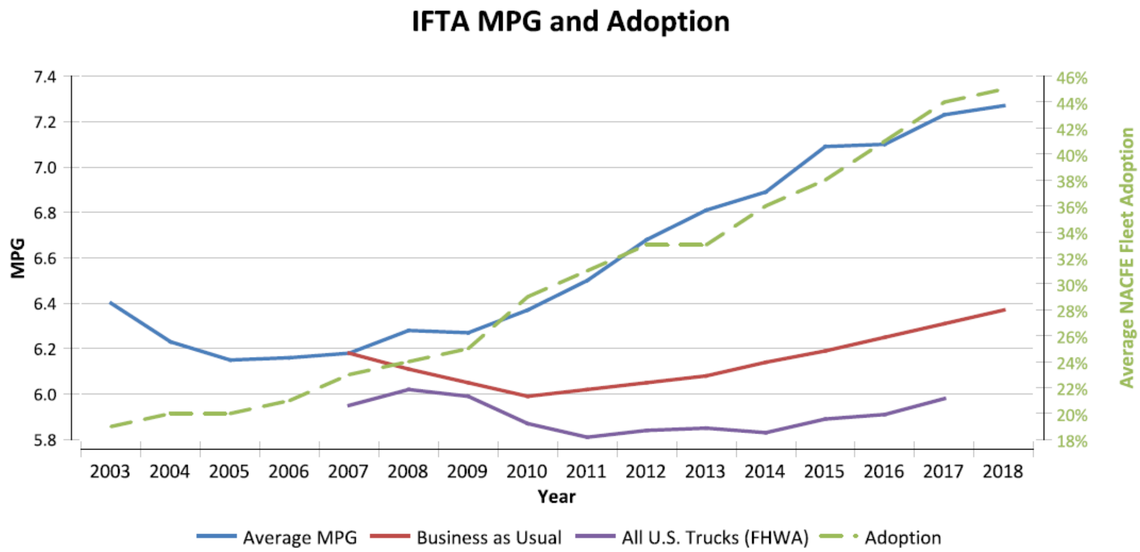

Figure 2: Average Fleet-wide Fuel Economy Over Time

The results of this annual survey clearly reflect a growing use of fuel-saving systems and procedures. The improvement year-over-year in the fleet-wide average is 2.0% from 2011–2018. The study reached the following conclusions:

- *Multiple factors are influencing fleet adoption.* New factors have emerged that influence decisions by fleets to improve efficiency including the current cost of fuel, potential future cost, federal and local regulations and increasing public demand for more sustainable operations.
- *Fleets continue to adopt fuel-saving technologies.* They are implementing technologies on their tractors and trailers improving overall adoption to 45%. Specific technologies adopted vary by fleet duty cycle, business models, fleet size and other factors.
- *Manufacturers accelerated delivery of technologies.* They are delivering more advanced generations of existing technologies to shorten the payback period and mitigate the challenges of adoption. Other advancements come both as novel technologies that provide the same function in a different way and new technologies that address areas not considered in the past. 2018 also provided more new trucks that comply with Phase 1 of the federal GHG rule and manufacturers are also developing technologies to meet GHGp2 starting in January 2021.
- *A significant gap to best-of-the-best still exists.* The average fleet-wide performance of 7.27 MPG improved year-over-year, 2018 compared to 2017, along a rate of 2.0% per year since 2011. It is expected that this level could reach somewhere between the 10.1 and 8.3 MPG demonstrated during the two Run on Less by NACFE best-of-the-best demonstrations.

Our goal is for the information shared in this study to provide other end-user fleets a roadmap for navigating the many available technologies that can have a positive impact on lowering fuel expenses. A benchmarking tool is being released with this study that can be used by any truck owner to compare his or her own technology adoption to that of the fleets in this study. Also, technology developers and manufacturers can use this data to improve the total cost of ownership of their products. The package of information released includes this full report, a full set of graphics, and the dataset and benchmarking tool. We expect it will be helpful in your efforts.

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 is celebrating its 10th year, having been formed from a workshop in 2009 at Rocky Mountain Institute (RMI, www.rmi.org). Its goal is 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.

Late in 2013, recognizing the opportunity to accelerate the trucking sector's freight efficiency, NACFE joined with the Carbon War Room, a nonprofit founded by Sir Richard Branson and dedicated to scaling energy efficiency technologies—to launch the Trucking Efficiency initiative. The group collaborated with industry experts to address the barriers to the large-scale deployment of freight-efficiency technologies for tractors and trailers. Later the Carbon War Room merged with RMI. NACFE completes Technology Overviews and Confidence Reports on promising available and emerging technologies, holds workshops to openly debate their findings and recommendations, and launched an online Tech Guide in late 2014, which collects this information into one centralized location. By mid-2019, the group had published 18 confidence reports covering more than 60 of the technologies for Class 8 over-the-road fleets. In 2018, NACFE launched a new initiative helping fleets, manufacturers and others with fast approaching future innovations. Called Guiding Future Change, the group has now completed a series of four Guidance Reports on electric trucks. Success for NACFE will be measured in the accelerated adoption of technologies and practices that promote freight efficiency (Figure 3).

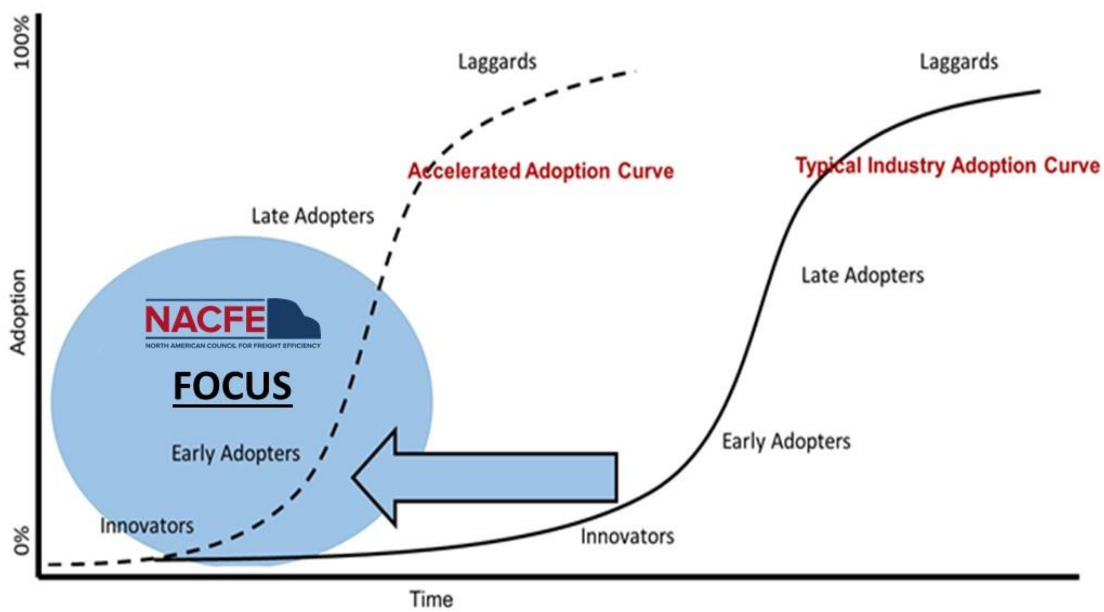

Figure 3: NACFE Approach to Accelerating Adoption

NACFE in partnership with RMI, has conducted two cross-country roadshows to showcase advancements in fuel efficiency. One focused on long haul routes in September 2017 and a second in 2019 on regional haul. There is much to be learned from the drivers, the fleets, manufacturers and from the data accumulated. All can be reviewed at www.runonless.com.

2.2 Background

The fuel costs faced by the trucking industry are a significant part of the expense to operate a tractor-trailer in North America. Over the past decade fuel has been as high as $0.65 per mile driven and then dropped to $0.34 by 2016. At these two points, fuel costs accounted for 39% and 21% of the total cost of operating a commercial vehicle respectively. The price per gallon for diesel as of December 2019 is now at $3.07 per gallon slightly lower than the 2018 yearly average of $3.18.

In parallel, the United States Environmental Protection Agency (US EPA) and the National Highway Traffic Safety Administration (NHTSA) have enacted greenhouse gas emissions regulations on commercial vehicles extended to 2030 that require manufacturers to develop and sell technologies to improve efficiency. These factors have driven fleets, manufacturers, and others to improve the efficiency of over-the-road tractor-trailers.

Fortunately, myriad technologies that can cost-effectively improve the fuel efficiency of Class 8 trucks are readily available on the market today. Unfortunately, multiple barriers have stymied industry adoption of such technologies, including a lack of data about the true performance gains these technologies offer, and a lack of confidence in the payback for investment in these technologies. To overcome those barriers and facilitate the industry's trust in and adoption of the most promising cleaner operating technologies, NACFE produces a series of Confidence Reports; the most recent an update to the group's report on idle reduction technologies was published in the summer of 2019.

The fuel costs faced by the trucking industry have ranged between $2 and $4 over the past 15 years with a period of high fuel prices with a 2011 to 2014 four-year average of $3.89 per gallon (EIA, 2018). Relief from these higher prices arrived in 2015 and 2016, with the 2016 average declining to $2.31. An increase has occurred since early-2016 returning fuel prices to over $3 per gallon. In 2018, the average cost of a gallon of diesel was $3.18 and has been relatively stable since.

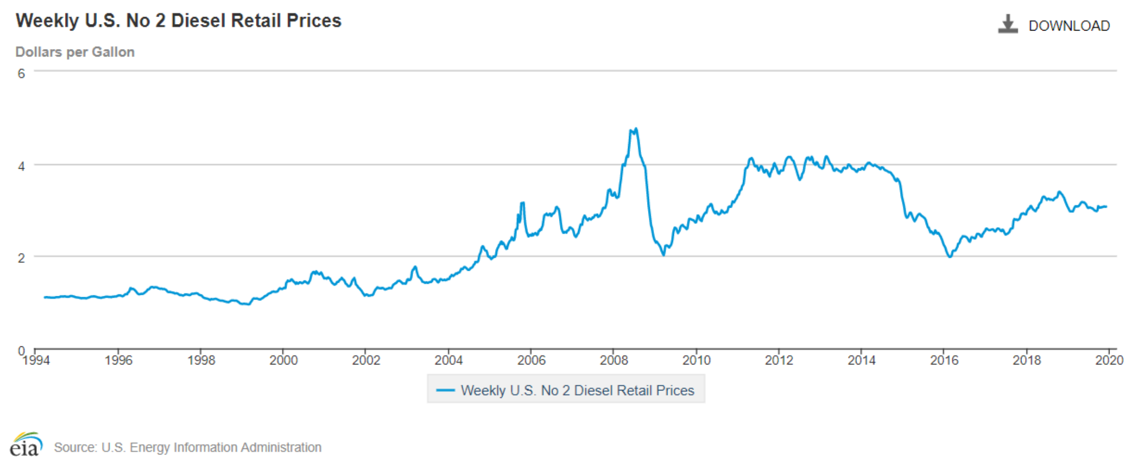

Figure 4: U.S. Annual Diesel Fuel Prices

Figure 4 shows 25 years of the price of diesel fuel in the United States. These years can be categorized in terms of five time periods.

1. 1994 (and even back to the mid-70s) to 2004, where fuel cost less than $1.75 per gallon;
2. 2004 to 2011 when, except for a short correction in 2009, fuel costs generally rose to around $4 per gallon;
3. 2011 to the end of 2014, with fuel costs very consistently at about $4 per gallon;
4. 2015 to 2016 saw a drop in fuel prices to a low of about $2.00;
5. And finally, a run up in fuel prices to $3.07 in December 2019.

No one knows for sure what the price of fuel will be in the future, but fleets should conduct sensitivity analyses with respect to fuel prices and their ownership life expectations. 2019 brought concerns of higher fuel prices given attacks on refineries in the Middle East, continued hurricanes threatening supply and a new maritime regulation, IMO 2020, where demand for on-highway ultra-low sulfur diesel will be used to meet new ship vessel regulations in January 2020. Pressures lowering fuel costs are the decreased demand on gas and diesel due to higher vehicle efficiencies, more alternatives such as natural gas and others. Regardless, fuel costs are a very significant operating expense and should be managed.

As shown in Figure 5, by 2013, fuel costs had reached $0.65 per mile, as reported by the American Transportation Research Institute ATRI), surpassing even the costs for the driver (wages plus benefits) (ATRI, 2019). In recent years, 2016, 2017 and 2018, MPG has been improving slightly while cost at the pump has been increasing. Overall, ATRI's cost per mile in the past few years has increased from $0.34 to $0.43, but the rate at the pump exceeds this, meaning that an improvement in MPG is occurring.

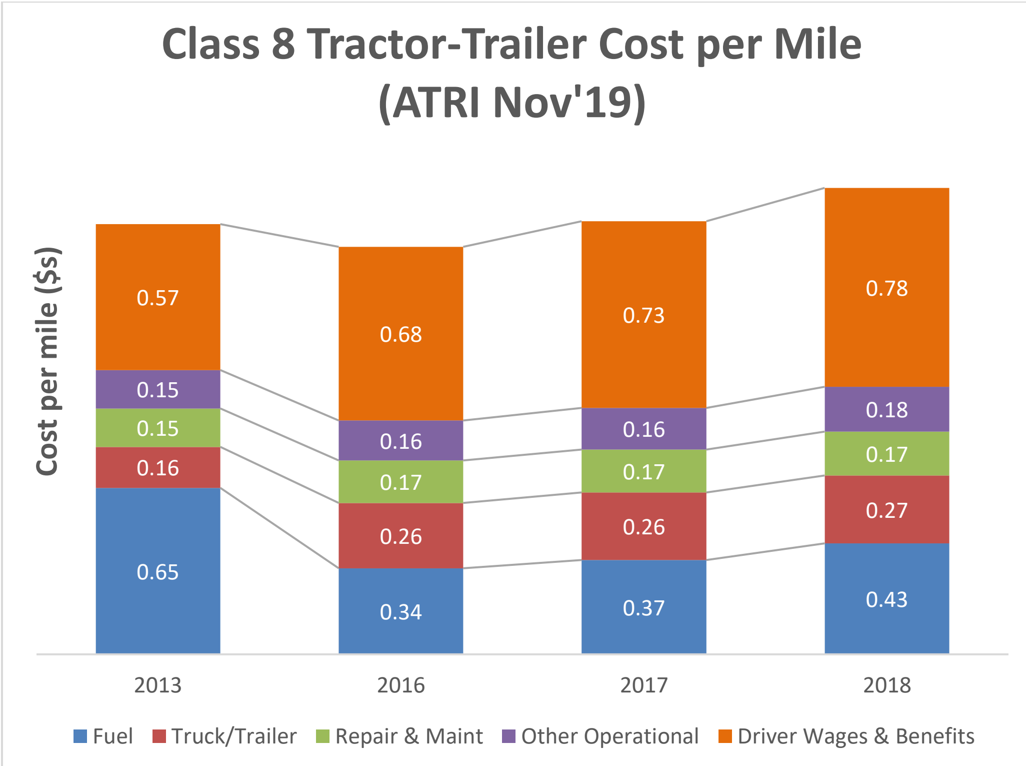

Figure 5: HD Tractor Operating Costs per Mile

Recently fuel prices have dropped and then increased again. This report reflects purchase decisions for technologies and their results during the 2018 calendar year, which was the year that fuel prices had begun increasing again.

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

However, the vast diversity of needs in the industry can make adoption of fuel-saving technologies 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 its business model (lease vs. purchase equipment, use company drivers or independent contractors, in-house or contracted maintenance, etc.). Moreover, the equipment may 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 manufacturers to consider purchasing from.

To better understand the history of adoption of fuel-efficiency technologies, in 2011, its second year, NACFE created a methodology for sharing best practices 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 eighth Annual Fleet Fuel Study (AFFS), completed in 2019, NACFE has accumulated data on the purchasing habits of 21 fleets, operating more than 73,844 tractors and 239,292 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 65,000 Class 8 tractors, but only buys fuel for 3,100 of them in its dedicated operations. Only those tractors for which it buys fuel are included in this study.

The fleets have been very consistent in providing data for this report, but it is likely that over the years, some will continue to participate, and others will elect not to and be replaced by others. NACFE will keep each fleet's data in the data set and make note where any particulate fleet's participation or lack of affected the results in a meaningful way. For 2019, 16 fleets provided data for their 2018 operations.

Information gathered and shared in this report includes the percent of each fleet's annual purchases that involved any of the 85 currently available technologies for lowering fuel consumption, from 2003 to 2018. A summary of the technologies is shown in Figure 6. With 85 technologies, 21 fleets, and 16 years of data, this process provides about 28,000 data points of purchasing behavior on new features by these end users. They also shared their overall fleet-wide fuel efficiency in terms of miles traveled and fuel consumed. It should be noted that one new fleet, C&S Wholesale Grocers, joined the study this year and given its new data, which extends back to 2003, this year's report is not directly comparable to last year's report. Given the addition of new historical data from any new fleet, the past years' totals have all been revised as well.

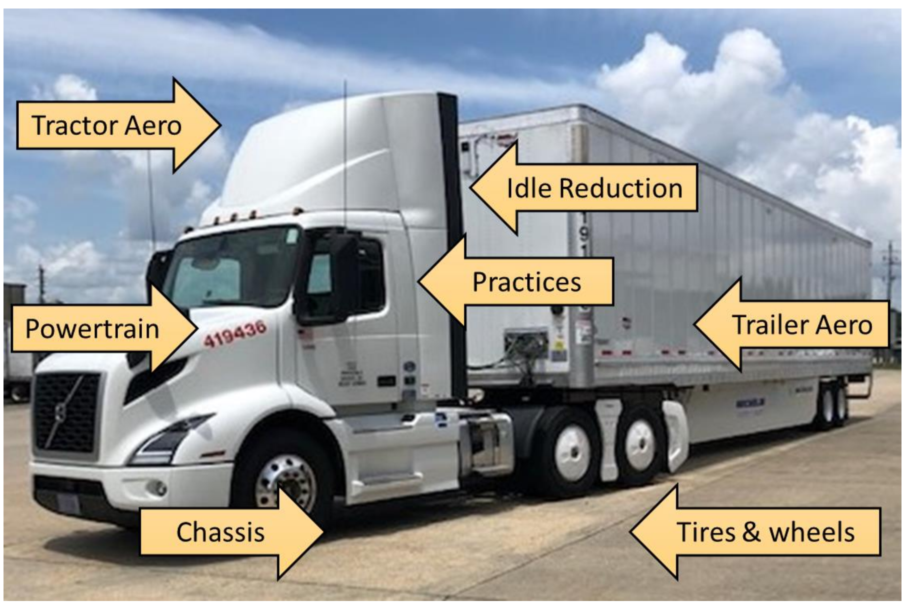

Figure 6: Technologies to Save Fuel (Photo: C&S Wholesale Grocers)

This report distills those data points into adoption curves for all technologies, fleet diversity of adoption, and the associated fleet-wide fuel economy average, for all 16 years in the study period. See all 85 technology adoption curves in Figure 7. Detailed data and figures for all technologies are available in the full set of graphics and the dataset and benchmarking tool published along with this report. For the many industry suppliers reading this report, please encourage business development managers and review boards to consider these adoption rates compared to what they are forecasting in their reports and projections. Rapid rates of change are not common in this industry. Technologies take a long time to scale from small deployment projects, to use by innovators and early adopters. Finally, the late adopter and laggard participants employ the new products to a saturation point where the value of the technology reaches most users. The work in this study is intended to accelerate adoption through all groups.

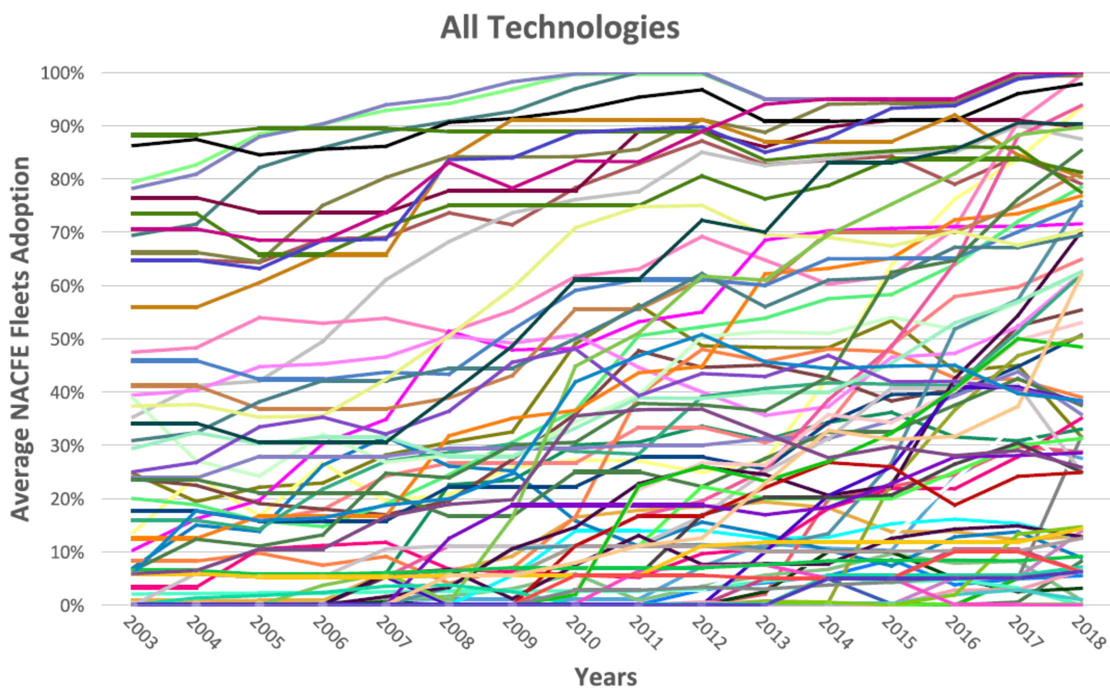

Figure 7: 85 Adoption Curves

2.3 Adoption Calculations' Methodology

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 year. These technology adoption curves, commonly called S-Curves, given their shape, are used to describe how a new product is purchased over time. Over the years NACFE has developed two measures of adoption.

1. This first, ***Fleet Decision Adoption***, has a goal to determine adoption in terms of each fleet's technology selection and use. This methodology recognizes each fleet's decision the same. Therefore, the adoption percentage 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 that purchase about 100 trucks per year, has the same value as that of the largest fleet buying thousands of trucks. The calculations for the data provided in the dataset 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

2. The second, ***Technology Unit Adoption***, provides a truer representation of the absolute number of new technology products sold in each year. In this case, the data is recalculated using the miles

traveled by each fleet. This methodology therefore does value a purchase of 2,500 trucks per year with a given technology by a large fleet as 25 times greater than a fleet buying only 100 new trucks. This methodology is the one used in the Greenhouse Gas adoption data shown later in this report.

Table 1: Comparison of Adoption Methodologies

Fleet DECISION Adoption	Technology UNIT Adoption
Counts each fleet's decision equally	Counts each piece of equipment with the technology equally
Illustrates the number of fleets that have adopted	Illustrates the total number of vehicles now equipped
To be used to understand fleet preferences	To be used to understand actual unit sales of a given technology

Armed with this powerful data, much can be learned about the past and inferred to help forecast the future uptake of these features. The opportunity is enormous as there are about 1.7 million tractors operating in the U.S. consuming approximately 26 billion gallons of diesel fuel. Every 1% reduction in fuel use, saves 260 million gallons of fuel or about $0.85 billion per year.

3 Price of Fuel

We would be remiss if we did not address the subject of the recent drop in fuel prices and more recently a run up in the cost of diesel for these trucks. We have found that fleets not only use the current cost of fuel in their calculations but look at the sensitivity of decisions for higher and lower fuel prices. Therefore, they factor in potential future fuel prices into their purchase decisions on new technology and in their use of various practices to affect the amount of fuel consumed by their fleet.

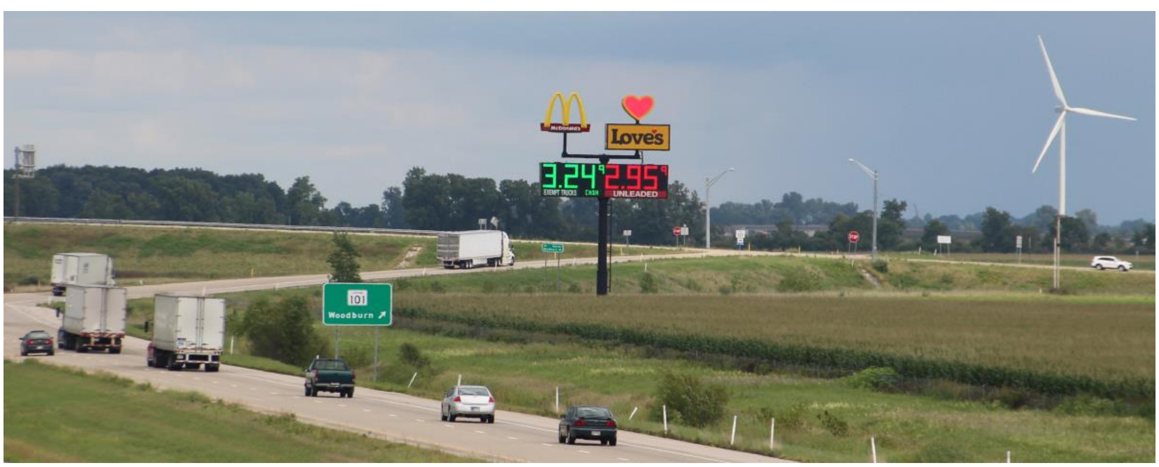

Figure 8: Fuel Pricing (Photo: Schaller)

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. Similarly, if the supply goes down, such as a refinery going off-line, reduction in global production rates, natural disaster, political unrest in a high production country, or other factors, the prices will likely increase.

The cost of fuel must be considered when calculating payback 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 $2 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 a senior executive at one of the large carriers. "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 that have improved their fuel economy will be at a competitive advantage when that happens."

Another consequence of returning to past equipment specifications was shared by numerous fleets, summarized as "change management." It is very difficult for fleets to move to these new technologies; drivers need to be educated on how to drive them and technicians on how to fix them, and new suppliers and many other execution actions may be required. To return to an old feature and then maybe return to the fuel-saving technology when fuel prices rise, can take years, retraining, and a lot of money. These fleets generally stated that they try to make the new specifications their "new norm" and don't look back unless the costs to operate are higher than predicted or the new technology causes significant downtime. For these fleets, lower fuel costs in the possible short term is not reason enough to revert to old specifications.

4 Technology Adoption by the Fleets

This section describes the technology adoption with respect to fleet diversity, individual technology curves, and the consistency of technology adoption across the fleets. This data is provided in a separate spreadsheet that allows the reader to analyze the information further. 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' experiences — depending on their own calculations of the benefits versus the risks of being on the leading edge of new technologies. The 21 fleets (identified as fleets A to U due to privacy agreements) in this study are no different (Figure 9). Five fleets have adoption rates of more than 50%, as defined in this report, while nine are between 40% and 50% and seven are between 30% and 40%. The first five are the most aggressive adopters in 2018, but a closer look shows that two of them were not always leading. Two fleets, A and D, moved from under 20% in 2003 to more than 50% in 2018, showing a remarkable increase in use of these efficiency technologies. They became very committed to specifying these technologies on their new equipment.

It is important to note that no fleet could adopt all 85 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 heating, ventilating, and air conditioning (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 27% to 58% of the available technologies employed on their tractors and trailers.

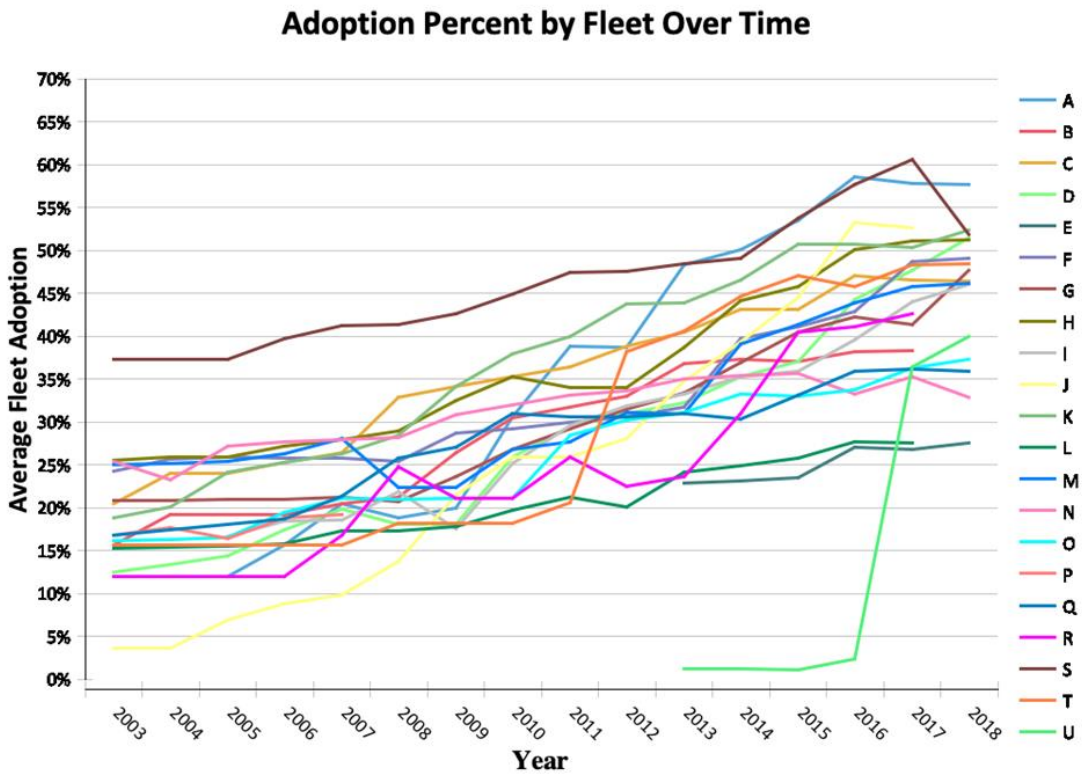

Figure 9: Fleet Adoption over Time

4.2 Technology Adoption Curves

Given the data provided, 85 adoption curves were created and are shown in the dataset. Keep in mind that these charts show only the adoption practices of the 21 fleets studied, which represent about 4% of the overall heavy-duty over-the-road vehicles in North America. Also remember that two sets of data are included here, one where each fleet decision is measured equally and a second where the value of larger fleets purchasing bigger quantities has a greater weight. This provides new insight into not only the current level of adoption, but also into the ramp up over the last decade. For example, the ramp up of the purchase of trailer skirts to over 90% and automated manual transmissions to 93% adoption have the fastest rate of all technologies.

The 85 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 in Figure 10, while the adoption curves for each technology are also provided. All categories show increasing levels of adoption with trailer aerodynamics increasing the most dramatically in the middle five years of the study and now powertrain having the biggest gain from 2013 to 2018.

All 85 technology adoption curves are shown in the Appendix.

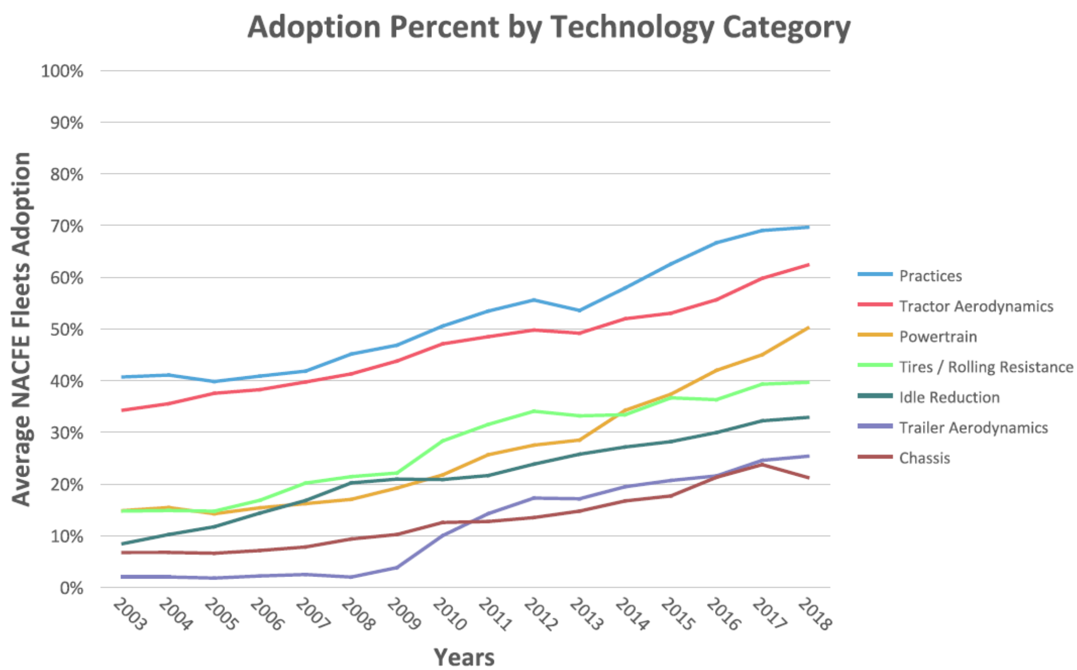

Figure 10: Adoption by Category

4.3 Fleet Individual Technology Adoption

Every year fleets in this study make decisions on their new truck and trailer purchases that affect freight efficiency. In some cases, they started buying new technologies, stopped buying some, continued to buy others, or increased or decreased the percent of trucks and trailers with fuel economy devices.

For this study, the technologies were kept constant from the 2017 study. Meaning, none were added or deleted.

The largest gainers in adoption by these fleets, when comparing their purchases in 2018 to those in 2017, occurred with the following technologies (using the Technology Unit Adoption method). (See Table 2.)

Table 2: Technologies with the Largest Increased Adoption

Technology	2018	% Increase
Predictive cruise control	75.7%	32%
Shift to Neutral	70.1%	29%
LRR duals - tractors	62.0%	21%
Wheel covers - tractors	61.9%	66%
Engine Start/Stop for HVAC	35.0%	26%
FA-4 High Efficiency Engine Oil	31.6%	531%
Use of hotels to avoid idling	14.3%	22%
Tire pressure inflation - tractor	13.8%	168%
Trailer nose cones	12.5%	23%
Tractor Gap Reducers	8.2%	1,389%
Truck Stop Electrification (Snorkel type)	7.1%	29%
Tractor Solar Panels	6.4%	126%
Wheel covers - trailers	6.3%	24%
Mechanical Turbo Compounding	6.3%	25%

Table 2 shows several powertrain technologies with increased adoption rates. Low rolling resistance dual tires on tractors increased adoption at the expense of wide-based. Solar panels used on tractors showed a big gain to 6% in 2018.

Technologies that had the largest decrease in use, 2018 to 2017, as shown in Table 3, were:

Table 3: Technologies with the Largest Decreased Adoption

Technology	2018	% Decrease
Real Time Driver Coaching for Fuel Economy	37.5%	-12%
Light Paint Color: Solar Heat Absorption	35.8%	-18%
Aluminum wheels trailers	31.6%	-30%
2 Speed/Modulated Cooling Fan Clutch	27.6%	-10%
Wide based tires - trailers	25.9%	-11%
Platooning Capable	25.0%	-39%
Tire pressure monitoring - tractor	25.0%	-18%
High Efficiency Alternator	23.4%	-32%
Tire pressure monitoring - trailer	12.8%	-14%
Clutched air compressor	12.5%	-18%
Diesel APU	8.9%	-35%
Smart Air Dryer/Compressor	6.3%	-40%
Vortex generators - tractor	6.3%	-38%
Automatic transmissions	0.9%	-89%

One area noted in the last two AFFS reports and continued to show a negative adoption situation pertains to the fleets that set their maximum cruise speed at less than 65. As discussed in detail in the 2017 NACFE AFFS report, many fleets and truckers have been driving faster in recent years. Several fleets increased the speed on cruise or on pedal during 2017 and even more in 2018. NACFE uses 65 mph as the threshold for this practice adoption. In Unit Adoption Rate, fleets setting maximum speeds below 65 are now only 76% versus a high of 94% in 2016. Speed seriously affects fuel efficiency and this increase in speed negatively affected the fleet-wide average keeping it near 2018 levels.

4.4 Fleet Consistency of Adoption

Finally, as in previous year's reports, NACFE evaluated the consistency of adoption by the various fleets. To do so, each of the 85 technology decisions (i.e., whether to adopt or not) made by each of the 21 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 specifying it on 100% of all purchases, or even if a fleet decided to stop buying something after initial deployment. Figure 11 includes this data demonstrating the technology's adoption stacked in order of popularity by the various fleets denoted by A to P. It is also included in the dataset and benchmarking tool.

TREND COLOR CHART (Also a simple benchmarking tool for your fleet)

Trend 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

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		Your Fleet Goes Here V	A	C	D	E	F	G	H	I	K	M	N	O	Q	S	T	U	Tech Adoption
Idle Reduction	Anti Idle Electronic Engine Controls		5	1	4	5	5	5	5	4	5	5	4	5	5	5	5	1	88%
	Highest level of cab insulation		5	5	4	5	1	4	5	5	5	3	5		5	2	5	1	77%
	Diesel Fired Heater		5	5	3	3	5	4	3	4	2	3	5	1	4	5	5	1	72%
	Light Paint Color: Solar Heat Absorption		1	1	3	3	1	1	5	3	5	5	2	1	3	2	1	5	36%
	Engine Start/Stop for HVAC		5	1	3	1	1	2	3	4		3	2		3	5	2	1	35%
	Battery HVAC		5	5	3	1	1	3	4	2		3	1		2	5	2	1	33%
	Truck Stop Elect via AC Power Port		5	5	2	1	1	1	5	1		1	1		1	5	1	1	29%
	Trailer Solar Panels		1	3	1	3	5	1	3	3	3	1	1	1	2	1	3	2	15%
	Use of hotels to avoid idling		1	1	1	3	1	1	1	1	3	1	1	1	1	1	5	1	14%
	Diesel APU		1	1	2	3	2	2	2	2		3	2		2	2	5	1	9%
	Truck Stop Electrification (Snorkel type)		1	1	2	1	5	1	1	1		1	1		1	1	1	1	7%
	Tractor Solar Panels		5	3	1	1	1	1	3	1	1	1	1	1	1	2	1	1	6%
	Thermal Storage System		1	1	1	1	1	1	1	1		1	1		1	1	1	1	0%
Chassis	Synthetic axle lube		5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	100%
	2 Speed/Variable Speed Water Pump		5	5	2	1	1	1	3	3	1	5	1	1	1	1	1	1	29%
	2 Speed/Modulated Cooling Fan Clutch		1	1	2	1	5	4	4	5	3	1	1	2	1	2	1	1	28%
	High Efficiency Alternator		5	1	4	1	1	1	1	3	1	1	1	1	1	1	1	5	23%
	6x2 axles		5	1	2	1	1	2	1	1	3	3	2	2	2	5	1	1	13%
	Clutched air compressor		1	1	1	1	1	1	2	2	5	2	4	1	1	2	1	1	13%
	Smart Air Dryer/Compressor		1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	6%
	Trailer Lift Axle		2	1	1	3	1	1	1	1	3	1	1	1	1	1	1	1	1%
	Tractor Lift Axle		2	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	0%
	Move from 6x4 to 4x2 tractor specs		1	1	2	1	1	2	1	1	2	1	1	2	1	1	1	1	0%
Tires / Rolling Resistance	Tire pressure inflation - trailer		5	5	4	3	5	4	4	5	5	4	1	5	5	2	5	5	85%
	Aluminum wheels tractors		5	5	5	3	5	4	5	4	2	5	5	1	5	2	5	5	79%
	LRR duals - trailers		1	2	1	1	5	5	5	5	5	3	5	5	3	2	1	5	62%
	LRR duals - tractors		1	1	1	1	5	4	5	5	5	3	5	5	4	1	1	5	62%
	Wide based tires - tractors		5	5	4	3	2	4	1	1	1	3	2	1	3	5	5	1	38%
	Aluminum wheels trailers		5	5	4	1	2	2	4	3	2	3	2	1	2	2	5	1	32%
	Wide based tires - trailers		5	3	4	1	1	2	2	1	1	3	2	1	2	5	5	1	26%
	Tire pressure monitoring - tractor		5	5	5	1	2	2	1	1	2	2	1	1	1	1	5	1	25%
	Tire pressure inflation - tractor		1	1	5	1	2	3	3	1	1	1	1	1	1	1	1	5	14%
	Tire pressure monitoring - trailer		1	1	5	3	1	2	1	1	1	1	1	1	5	1	1	1	13%
	Tires filled using Nitrogen		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0%
Powertrain	Synthetic transmission oil		5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	100%
	Engine parameters set for fuel economy		5	5	5	3	5	4	5	5	5	5	5	5	5	5	5	5	99%
	Lower viscosity engine oil xW-30		5	5	5	2	5	4	5	5	5	5	5	5	5	5	5	5	94%
	Automated manual transmissions		5	5	4	3	5	4	4	3	4	4	4	5	4	3	5	5	93%
	Downspeeding (Rear ratio<2.7:1)		5	1	4	3	5	4	3	3	5	5	5	5	1	5	5	5	78%
	Predictive cruise control		5	5	5	2	5	4	5	3	4	3	1	3	3	5	5	5	76%
	Shift to Neutral		5	5	5	3	5	4	4	3	2	3	1	5	3	5	5	1	70%
	Direct drive transmission		5	5	4	1	5	2	3	5	3	3	2	2	3	3	1	5	55%
	Downsize engine (e.g. 15L - 13L)		1	5	5	3	1	4	3	2	5	3	2	5	3	2	1	1	39%
	FA-4 High Efficiency Engine Oil		1	1	5	1	5	5	1	1	5	1	1	1	1	1	3	5	32%
	Mechanical Turbo Compounding		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	6%
	CNG		1	1	2	1	1	2	1	1	3	1	1	3	2	1	1	1	6%
	Fuel additives		1	2	2	3	1	1	1	1	1	1	2	1	1	1	1	1	3%
	Automatic transmissions		1	1	1	3	2	2	1	1	2	1	2	1	1	3	1	1	1%
	LNG		1	1	2	1	1	1	2	1	1	1	1	3	1	1	1	1	0%
Tractor Aerodynamics	Aero hoods and fenders		5	5	4	5	4	4	5	4	5	5	5	5	4	5	5	5	100%
	Aerodynamic bumpers		5	5	4	5	4	4	5	4	4	5	5	4	4	5	5	5	100%
	Aerodynamic mirrors		5	5	4	5	4	4	5	4	5	5	5	4	4	5	5	5	100%
	Cab extenders		5	5	4	5	4	4	5	5	5	3	5	5	5	5	5	5	99%
	Full height roof air fairing		5	5	4	3	5	4	5	4	5	3	5	5	5	5	5	5	98%
	Remove parts - bug deflectors, etc.		5	5	1	5	5	2	5	5	4	5	5	1	1	5	5	5	75%
	Tractor chassis skirts - full		5	5	2	3	5	4	4	2	4	3	5	3	1	5	5	5	70%
	Fixed 5th wheel w/ minimum gap		1	1	5	1	4	2	4	5	4	2	5	4	3	5	1	5	62%
	Wheel covers - tractors		5	3	5	1	5	4	5	3	3	3	2	3	2	5	5	1	62%
	Vented mud flaps - tractors		5	3	4	3	3	4	2	1	5	3	5	5	1	5	1	5	53%
	Tandem fairings		5	3	1	1	5	3	5	2	1	1	1	5	1	5	5	1	38%
	Tractor chassis skirts - partial		2	1	4	3	4	4	2	5	2	3	2	3	4	1	1	1	38%
	Platooning Capable		2	1	1	1	5	1	1	5	1	5	1	1	1	2	1	5	25%
	Tractor Gap Reducers		1	1	1	1	1	1	1	1	1	1	1	3	1	5	1	1	8%
	Vortex generators - tractor		1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	6%
Trailer Aerodynamics	Trailer skirts		5	5	2	3	4	4	5	5	5	4	5	4	5	5	5	5	90%
	Vented mudflaps - trailer		5	3	4	1	3	4	2	3	2	3	1	5	1	5	5	5	48%
	Remove or relocate any trailer drag parts?		5	1	1	1	1	1	1	5	5	5	1	1	1	5	1	1	31%
	Trailer tail fairings		5	2	1	1	2	1	5	1	3	3	2	1	2	5	3	1	25%
	Trailer nose cones		1	1	1	1	1	1	1	1	5	1	1	1	1	1	5	1	13%
	Use of doubles or triples trailers		2	1	1	3	1	1	3	1	3	3	1	5	2	1	1	1	9%
	Wheel covers - trailers		1	1	1	1	5	1	3	1	1	1	1	1	1	1	1	1	6%
	Vortex generators - trailer		1	1	4	1	1	1	1	1	1	2	1	1	1	1	1	1	6%
	Trailer undertray or bogie fairing		1	1	1	1	1	1	1	1	1	2	2	1	2	1	2	1	0%
Practices	Vehicle Data Analysis for Fuel Efficiency		5	5	5	3	5	5	5	3	5	3	5	2	5	5	5	5	90%
	Driver Training for fuel economy		5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	1	90%
	Maintenance for fuel economy		5	5	5	1	5	5	1	5	5	5	5	1	5	5	5	5	81%
	Routing optimization		1	5	1	4	5	5	5	5	5	4	5	5	5	5	5	1	81%
	Limit Speed <65 mph		5	5	5	3	5	5	5	5	5	3	1	5	3	5	2	5	80%
	Reduce empty miles		5	5	1	3	5	5	5	5	5	5	2	5	5	5	5	1	78%
	Specified weight reduction on tractors		5	5	5	5	1	5	5	5	4	3	2	1	3	5	5	5	69%
	Coasting before engine braking		5	5	4	3	5	4	4	3	3	5	2	1	3	5	5	1	65%
	Specified weight reduction on trailers		1	5	5	5	1	1	5	5	5	5	2	1	3	5	5	5	63%
	Driver Incentives		5	5	1	3	5	4	1	1	1	5	5	1	1	5	5	1	51%
	In cab Cameras		5	5	5	1	1	5	3	3	1	5	1	1	5	5	5	1	50%
	Real Time Driver Coaching for Fuel Economy		5	5	1	1	1	1	1	5	1	5	2	1	5	5	1	1	38%

Figure 11: Adoption Diversity

Fleets should use this as a peer benchmarking tool in navigating the many available technologies that can have a positive impact on lowering fuel expenses. Once a fleet has downloaded this chart, a simple method by which fleets could approach this data is:

1. Consider the technologies shown in across many fleets as green, the 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 where some, but not all fleets are buying 100%. 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 your fleet, *which of these technologies best fits our mode of operation?*
3. Explore the technologies where many of the technologies are white or red in the table. Many of these technologies may be new to the market, so they may be adoption opportunities down the road. *Ask yourself if any of them offer an opportunity for your fleet to be an innovative early adopter?* Or ask if they are not valuable technologies yet and need further development.

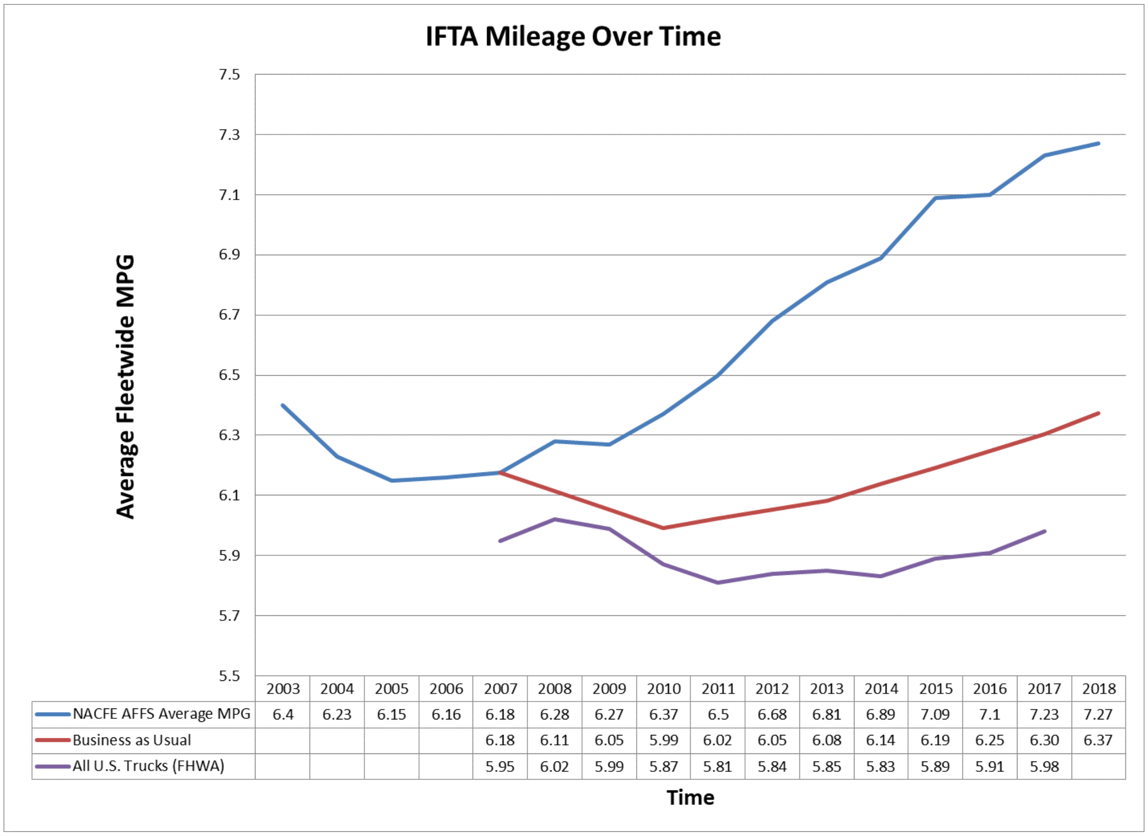
5 Overall Fuel Savings from Efficiency Actions

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 the investment in each of these technologies?
- Other than the fuel savings and purchase price, what are the other benefits and consequences of adoption of a technology?

The average adoption percentage and fuel efficiency of these fleets is shown together in Figure 12. 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.

Adoption improved, in aggregate as it has in prior years, and demonstrates a 2.0% year-over-year improvement during the past nine years.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NACFE AFFS Average MPG	6.4	6.23	6.15	6.16	6.18	6.28	6.27	6.37	6.5	6.68	6.81	6.89	7.09	7.1	7.23	7.27
Business as Usual					6.18	6.11	6.05	5.99	6.02	6.05	6.08	6.14	6.19	6.25	6.30	6.37
All U.S. Trucks (FHWA)					5.95	6.02	5.99	5.87	5.81	5.84	5.85	5.83	5.89	5.91	5.98	

Figure 12: MPG over the Study Period

You may note the "U" shape of the Average MPG curve. In the first half of the period, 2003 to 2010, the impact of the introduction and purchase of engines meeting 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 2017, 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 GHG emissions regulations' effects on the base powertrain. In 2018, the fleet-wide average MPG of the combined fleet has risen to 7.27.

The study team also created a business-as-usual (BAU) prediction, to show the likely fuel economy these study fleets would have experienced over this period if they had not adopted any technologies, and solely enjoyed the benefits of the recent base engine efficiency improvements. NACFE's hypothetical BAU 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 1.7 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 fuel savings in 2018 between the BAU of 6.37 MPG and the NACFE fleets average of 7.27 MPG amounts to $6,492 per year per truck, at the $3.18 per gallon fuel cost over the average tractor mileage of 105,041. The fleets are saving $9,912 over the national average of 5.98 MPG. If fuel costs had been at the four-year average of $3.89 per gallon, the savings would have been $7,941 and $12,124, respectively. And finally, the 21 fleets operating 73,844 trucks saved $895,318,953 in 2018 compared to the average trucks on the road.

A simple analysis was conducted on the payback of the technologies that provide most of the savings for these fleets. That review determined about a 2.8-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 later in this report.

6 Efficiency and Content of Latest Equipment

6.1 2019 Model Year Trucks

By 2018, the fleets in this study had adopted many of the 85 technologies, though each fleet has chosen its own unique suite of technologies and practices. 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 publicly share only 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 2018 model year equipment and how they operated in 2017.

This research concludes that these fleets are operating their newest vehicles in a range of 7.5 to 9.5 MPG. Some trucks were even found to deliver 10 MPG in certain routes, conditions, and seasons. This rate of improvement stems from three areas:

- The purchase content of efficiency technologies,
- The fact that the improvements delivered by diesel exhaust fluid-equipped (2010 emission) trucks have reached saturation, and
- Most recently the gains from some base engine improvements made in response to the GHG emissions rule.

Given how high the MPG numbers are for new tractors within this study, it is reasonable to expect similar overall gains in future years as older vehicles are replaced with these much more efficient tractors.

6.2 Run on Less by NACFE Performance

In 2016, NACFE decided to find the best of the best in real world fuel efficiency and embarked on what has now become Run on Less by NACFE. To date, two events have been conducted, one in 2017 and another in 2019. Both have been a joint effort between NACFE and RMI.

6.2.1 2017 Run on Less by NACFE

The first Run on Less was conducted in 2017 with a focus on long-haul operations. It occurred during September 2017 and concluded at the inaugural North American Commercial Vehicle show in Atlanta. A full report from the event can be downloaded at https://nacfe.org/run-on-less-report/. The team studied the various actions that the seven participants used to reach the high level of performance and summarized it in the follow graphic titled *10 Actions for 10 MPG*. (Figure 13.) This is a roadmap for areas of focus for fleets and manufactures to move the entire industry to higher levels of performance.

Figure 13: Run on Less 10 FOR 10

In total, the seven trucks averaged 10.1 MPG over the 17 days of the inaugural Run on Less. This was compared to a national average of 6.4 MPG for the over-the-road tractor-trailer population. A rationale for defining over-the-road efficiency is shown in the full Run on Less report in a section titled Average Performance of the North American Fleet on page 33. The trucks in the Run covered a total of 50,107 miles at an average gross weight of 55,498 lbs. As expected, the distribution of daily average MPG (ES2) is centered between 10.0 and 10.5. Five truck-days (one truck on one day equals a truck-day) were between 7.0 and 8.0 MPG and four truck-days were between 12.5 and 13.0 MPG (Figure 14).

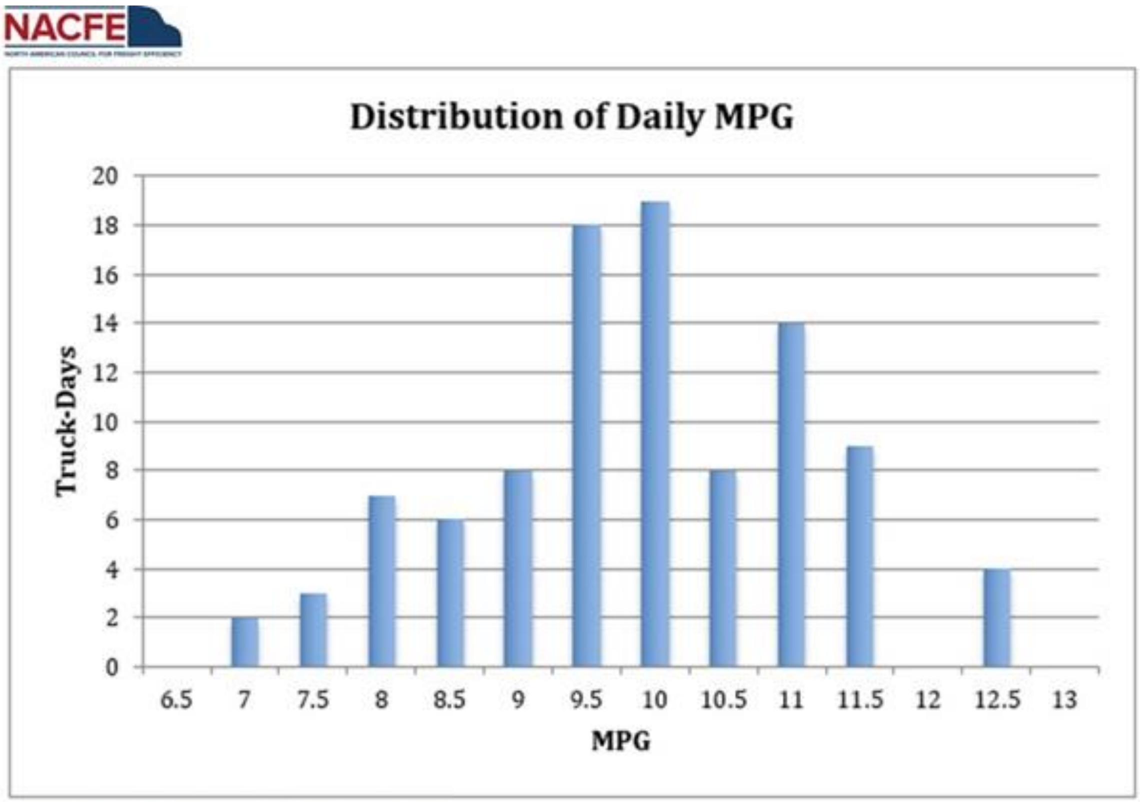


Figure 14: Daily Run on Less MPG

There were 99 truck-days during the 17 days of the Run. The trucks totaled 543,903 feet in elevation gain, and dealt with various weather conditions, including the effects from Hurricanes Harvey and Irma. The overall average speed during the Run was 54 mph. Keeping speeds low is one method drivers can use to reduce their fuel consumption. Several of the drivers kept their highway speeds below 60 mph for much of Run on Less although others spent most of their time in the 62 to 64 mph range. While all drivers recorded some time above 65 mph, very little time was spent at 68 mph or higher. The drivers kept idle time very low, aided by the available array of idle reduction technologies, and the fact that the event occurred for two and a half weeks in September when temperatures are moderate.

6.2.2 2019 Run on Less Regional

The second Run on Less was conducted in October 2019, this time focusing on the more challenging segment of the market — regional haul. NACFE defined this as a return to base operation with the routes remaining within a 300-mile radius of the domiciled location. Ten fleets participated running various distinct duty cycles including out and back, hub and spoke and multiple drops. NACFE used Geotab and LinkeDrive data to display each of the 135 days of driving to detail the duty cycles and environmental conditions during the Run. Figure 15 shows two of those graphics showing an out and back and a multistep day of driving.

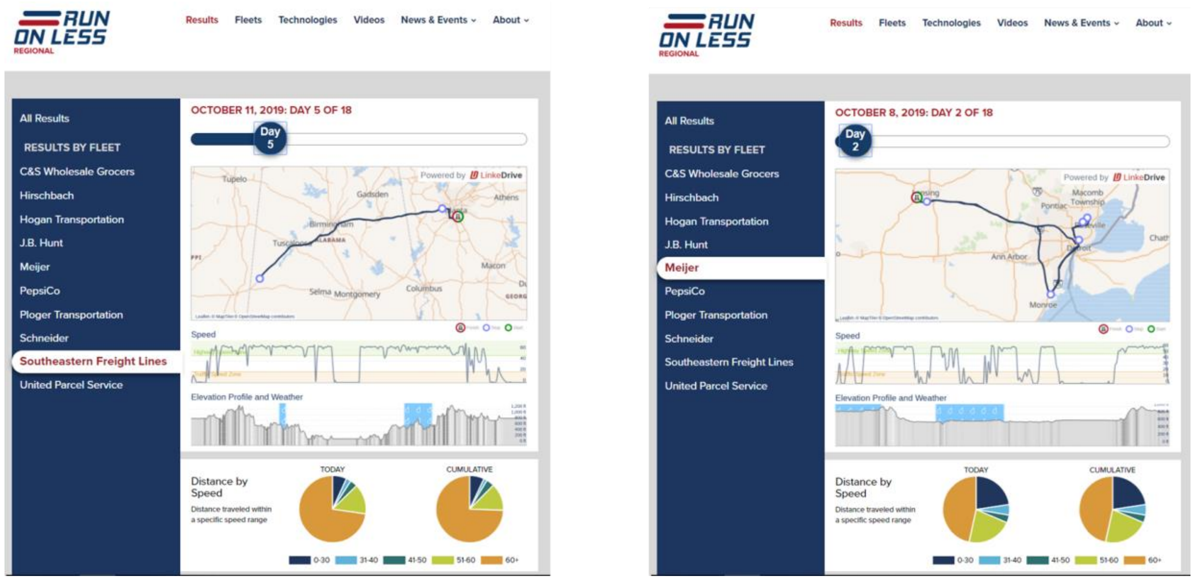


Figure 15: NACFE Run on Less Regional Duty Cycles

The 10 trucks averaged 8.3 MPG; that included one of the trucks powered by compressed natural gas, which did quite well for a CNG tractor. The remaining nine diesel trucks averaged 8.7 MPG. If all the 800,000 trucks operating in North America in regional applications were at this level of performance, over $9 billion dollars would be saved.

During Run on Less Regional, NACFE instrumented the trucks with dataloggers to better calculate the actual payload moved during differing segments of each day's drive. This calculation is incredibly difficult to measure consistently and NACFE will continue its efforts to better understand payload. Much was learned during the month with over 30 videos, fleet details and data that can be viewed at www.runonless.com.

6.3 Benchmarking MPG

There have been other efforts to improve the fuel efficiency of moving goods with large trucks. The US Department of Energy helped fund four SuperTruck 1 teams to build prototype tractors and trailers that would double freight efficiency. Four teams created equipment that reported fuel economy in the 10 to 12.5 MPG range. Results of these truck program demonstrations were reported by the teams at the DOE Annual Merit Reviews in 2015 and 2016 (DOE, 2015 & 2016).

Figure 16 provides a comparison of the various benchmarks of Class 8 tractor-trailer performance mentioned so far in this report. (Figure 16) Shown are:

- The national average of all U.S. Class 8 tractor-trailers at 5.97 MPG in 2017,
- The NACFE Annual Fleet Fuel Study fleetwide average of 7.27 MPG in 2018,
- The Department of Energy SuperTruck 1 trucks ranging from 10 to 12.5 MPG.
- The Run on Less 2017 performance of 8.5 to 11.5 MPG,
- The NACFE AFFS latest model year truck range from 7.2 to 9.5 MPG in 2018, and
- The Run on Less 2019 Regional results of about 6.5 to 9.6.

There continues to be a multitude of developments underway that are sure to continue the performance increases in efficiency of these trucks. Such efforts include the Shell Starship initiative, DOE SuperTruck2 effort, which now includes five teams, the developments underway for commercial battery electric vehicles, hydrogen fuel cell electric vehicles, diesel hybrid trucks, and on and on.

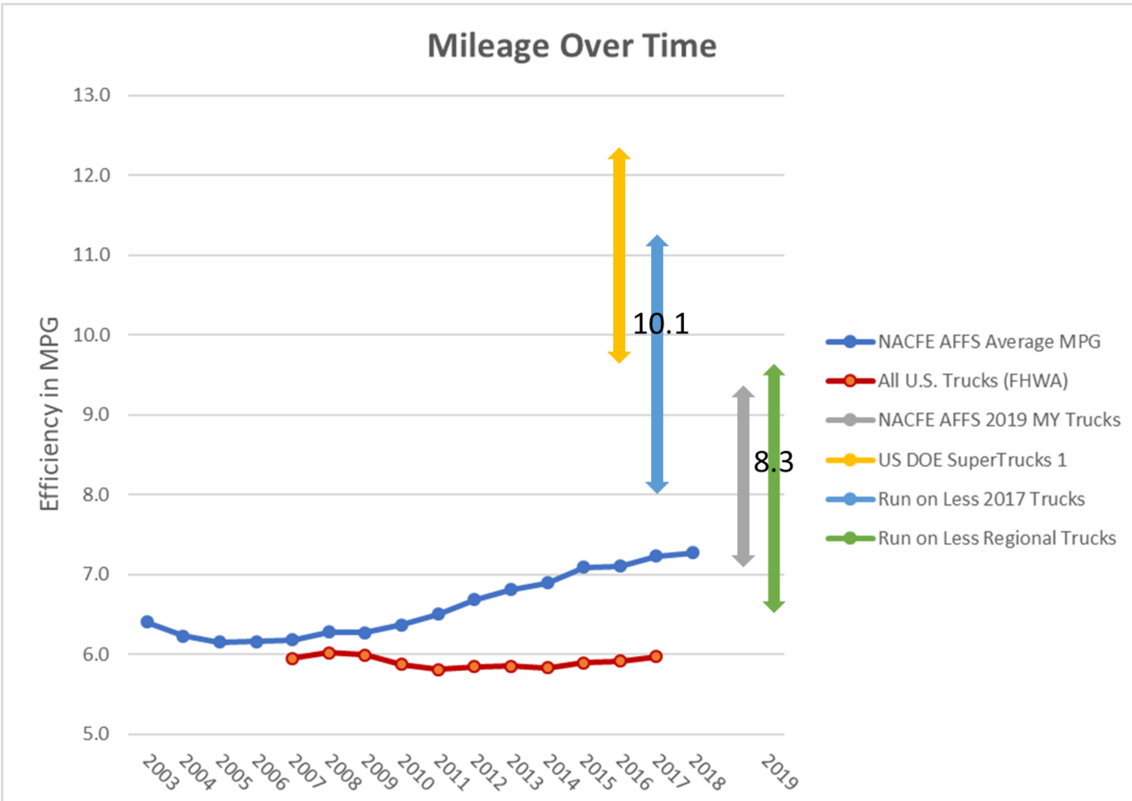


Figure 16: Mileage Comparisons

6.4 Why Not Ton-Miles per Gallon?

NACFE uses miles per gallon as the common performance metric in these studies as it is provided by fleets through their IFTA reporting and published by the United States government. It is also a commonly referenced metric as it is relatively easy to measure. As discussed in depth in NACFE's Run on Less report, the conditions that contributed to the MPG really matters. These include such items as payload carried, speed driven, wind and other environmental conditions as well as the elevation change of the journey. Many projects are beginning to use Ton-Miles per Gallon as a metric which considers the payload hauled by the truck during a given freight hauling segment. The recently completed Starship project by Shell and Airflow Truck Company (Figure 17) is an example where this freight ton efficiency metric was heavily used.

Figure 17: Shell Starship (Photo: Shell)

It is difficult to determine the actual loads in any given route, let alone, day or year, and in some situations a load will cube out, the trailer fills with freight, before reaching a maximum weight limit.   Given these challenges, NACFE will continue to use MPG as the primary metric for the Annual Fleet Fuel Study. The group will continue to understand the amount of goods hauled, either in tons or cubic dimensions and share findings whenever possible.

7 2019 Key Insights

As in previous years, the 2018 study team was interested in the meanings behind the data in this study and offer the following insights.

7.1 Fleet Focus on Fuel Economy

Fleets have many challenges when operating their business, such as driver recruitment and retention, equipment maintenance and cost, equipment spec'ing for driver amenities, increased capital cost for new equipment, safety, complying with regulations, and many others. In the 2017 AFFS report, we discussed how lower fuel prices of the past few years, that were discussed earlier in this report, may have helped contribute to a diminished fleet focus on fuel economy.

In 2017 and 2018, truck tonnage hauled by carriers in the United States increased dramatically (ATA, 2019). (Figure 18) This increase in demand challenged the fleets to procure new trucks at a very high level to keep up with demand. In July order levels were the highest of all time, where fleets ordered over 52,000 Class 8 tractors (ACT Research, 2018). This also has put extra stress on driver retention and attraction. Fleets can only haul the tonnage (increase their capacity) if they have both the equipment and the drivers.

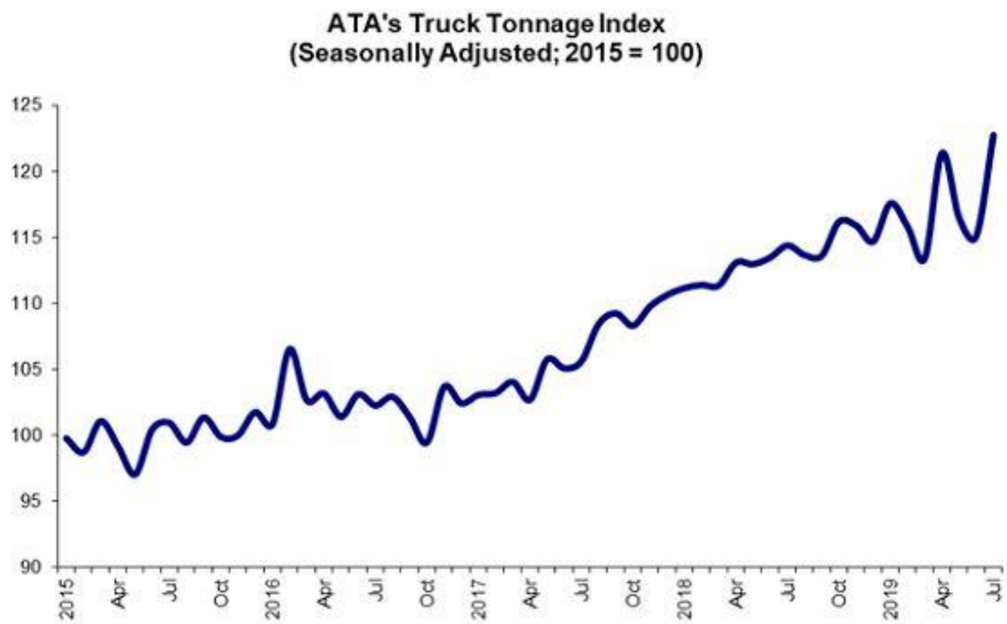


Figure 18: Truck Tonnage Increase in 2017 and 2018

ATRI conducts another annual report in conjunction with its cost per mile study, where the fleets are surveyed on critical issues in the trucking industry (ATRI Top Ten, 2019). For the third year, NACFE has tabulated the top 10 issues identified in this study in each of the last 12 years. Fuel supply/fuel price made the top 10 list in all years between 2007 and 2013 and was the number one issue in 2008. But with the lowering of fuel prices, this topic dropped off the list by 2014. As of the most recent study, issues related to drivers were the dominant concerns in the industry. The top five and even a few of the bottom five concerns directly relate to driver satisfaction and productivity. The stress on the industry to increase capacity while satisfying drivers is obviously a challenge for carriers.

Table 4: ATRI Trucking Industry Issues

ATRI Top Industry Issues	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
Driver Shortage	1	1	7	3	2	3	4	3	5	6	3	2
Hours of Service	2	3	2	1	1	1	2	2	4	5	5	1
Driver Compensation	3											
Detention / Delay at Customers	4											
Truck Parking	5	4	4	5	6	6	8					
Driver Retention	6	5	8	4	4	7	7					
ELD Mandate	7	2	1	6	5	5	6					
CSA	8	6	6	2	3	2	1	4	2			
Infrastructure/Congestion/Funding	9	9	9	9	7	9	10	6&7	7	4&8	6&7	4&6
Economy	10		5	8	9	4	3	1	1	1	2	
Regulations		7	3						3	2	4	5
Driver Distraction		8	10	10	10							
Driver Health/Wellness		10		7	8	10	9					
Fuel Supply/Fuel Price						**8**	**5**	**5**	**6**	**3**	**1**	**3**
Tort Reform								8			9	7
On-board Truck Technology								9	8	10	10	
Truck Size and Weight								10	10	9		10
Environmental Issues									9	7	8	9
Truck Driver Training												8

This lack of focus on fuel economy is likely not as significant with the fleets that have chosen to participate in this study, but some of the fleets stated in interviews that other issues have more management attention in 2016, 2017 and 2018 than in prior years. Even if the adoption of technologies on their equipment increases or remains the same, a lack of focus on fuel economy and freight efficiency can have negative consequences.

Some of these fleets also mentioned the importance of the proliferation of more technology choices; that is evident in the fact that the number of technologies in this study increased from 69 in 2015 to 85 the past few years. New options are emerging that are mitigating the challenges with earlier ones, next generations of current technologies are being released and brand-new solutions are emerging. This is all helping fleets find the best technology for their needs but can also be very confusing. One fleet leader stated, “This can create a deer in the headlights moment for many fleet managers and with fuel pricing down, they may decide to do nothing, and maintain but not increase their adoption of fuel economy solutions.”

7.2 Factors Influencing Adoption

NACFE spends a great deal of time out with the industry, sharing thought leadership and gaining input at more than 50 trucking events a year. Over the past few years, the group has been constantly interviewing fleets concerning their adoption of fuel savings/freight efficiency improving technologies and operating practices. It has become increasingly obvious that fleets are motivated by more than just the current cost of diesel. Figure 19, shows four factors that combined support fleets having aggressive efforts to burn less fuel, save money and create less emissions.

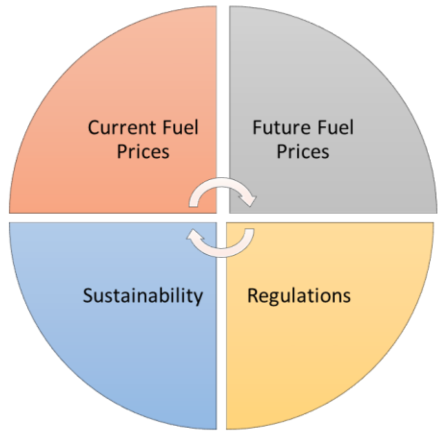


Figure 19: Factors Influencing Fleet Decisions on Saving Fuel

Obviously higher current fuel prices at the pump drive fleets to take action to move goods using less fuel, but given the volatility of that pricing, fleets also worry about what future fuel prices might be. When a tractor is purchased, most of the fuel that will be burned in that asset is fixed given the specification of the equipment for 10 and 15 years, respectively. Even during times of relatively low fuel prices, purchasers must understand how decision today will impact costs for many years in the future.

Greenhouse gas regulations although not a direct requirement on fleets, do impact the equipment that they must purchase to move goods. Being proactive with the truck, engine and other component manufactures as they build equipment to meet the rules helps fleets purchase the features that the manufacturers must build. And finally, public demand for companies to operate in a more sustainable manner has reached all organizations including all carriers. Whether a consumer facing brand moving their own goods or a carrier with a less familiar name, companies are taking action on sustainability.

8 Tech Adoption and the Greenhouse Gas Phase 2 Rule

On August 16, 2016, U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) jointly published the final rule for Phase 2 of Greenhouse Gas regulations for commercial vehicles, Classes 3 to 8. The rule finalized reductions in fuel use by requiring truck, engine, and trailer manufacturers to produce equipment that emits lower emissions via improved fuel economy (EPA, 2016).

The International Council for Clean Transportation (ICCT) represented both the Phase 1 and Phase 2 stringency in Figure 20, where the bottom two blue lines represent the tractor and trailer configurations that match the equipment in this AFFS. The lines show that over the 20 years from a base of 2010, Class 8 sleeper tractor-trailers are expected to improve their fuel efficiency by about 45%.

Figure 20: Greenhouse Gas Phase 2 Stringency (ICCT, 2016)

For the Annual Fleet Fuel Study reports published in 2017 and 2018, NACFE compared the past history detailed in this study to the EPA/NHTSA predicted levels of adoption for years 2021 through 2030. This provides an approximate 25-year adoption experience for many of these technologies. See Figures 21 and one example of the technology curves for a specific set of technologies in Figure 22, below.

Given that the federal governments predictions were a one-off forecast conducted in 2015 for the final rulemaking, it is not worthwhile to continue this comparison. Please review the prior NACFE AFFS reports for information on the mapping of past adoption performance with possible future Greenhouse Gas phase 2 levels.

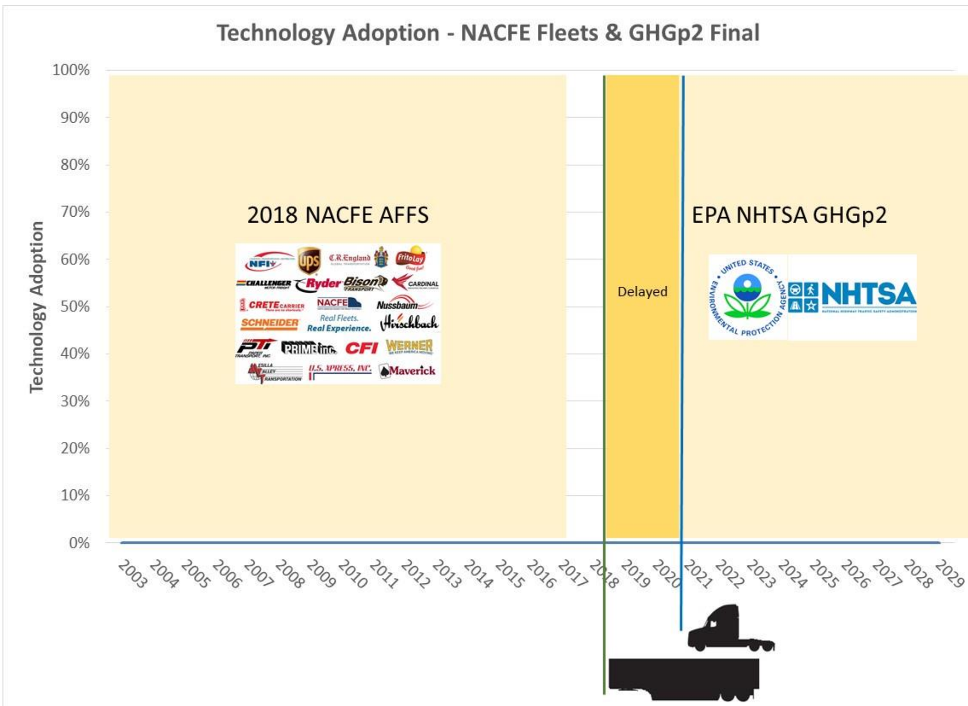


Figure 21: NACFE AFFS and GHG

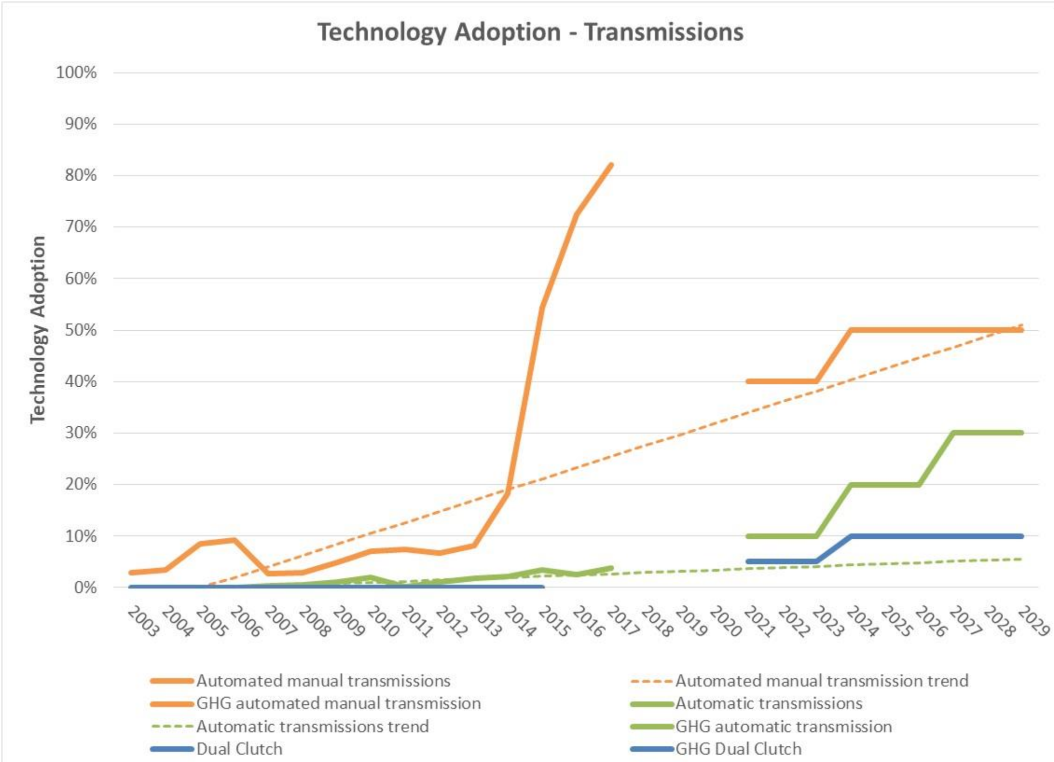


Figure 22: Transmissions Adoption - Fleets and GHG Forecast

9 NACFE 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 will spur additional investment, particularly by fleets that may be lagging the overall industry when it comes to certain widely adopted technologies. However, while conducting this research, it became clear that some technologies are still only being adopted by the most progressive or innovative fleets despite their showing strong potential for achieving cost-effective gains in fuel efficiency. To facilitate the wider industry's trust in and adoption of such technologies, NACFE and RMI began delivering a series of 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 NACFE for the reports). This information from manufacturers, end-user fleets, tractor and trailer builders, and others such as government and non-government organizations is aggregated 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 https://nacfe.org/current-technology/

As of the release of this report, the group has finished in-depth work on available technologies, Figure 23, such as tire pressure systems, 6x2 axles, idle reduction solutions, electronically controlled transmissions, optimizing engine parameters, low rolling resistance tires, downspeeding, lightweighting, maintenance for fuel economy, tractor and trailer aerodynamics, and low viscosity engine lubricants. Emerging technologies including two-truck platooning and variable engine-driven accessories as well as an in-depth look at determining efficiency have also been completed. The group recently provided an update on idle reduction solutions and 6x2 axles including the emergence of liftable pusher 6x2s and competed a confidence report on Solar on Tractors and Trailers. NACFE is in the process of reviewing and updating all of the Confidence Reports in 2020 and 2021. Contact Mike Roeth (mike.roeth@nacfe.org) to get involved in this important work.

Figure 23: NACFE Confidence Reports

10 Value of Technology Adoption

Each technology has a unique total cost of ownership and return on investment. NACFE's Confidence Reports provide insight into each technology's primary benefits and consequences, and in most cases, organize 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 cost thousands of dollars, but 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 24 shows an example of such a matrix from the recently published

Confidence Report on solar solutions (NACFE, Solar, 2018). These illustrations locate the technology in question on a grid comparing simple payback in years (value) with 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 have a short payback and are proven to impact their operations in a very positive manner. Technologies to the top and left of the matrix are those for which there isn't a significant amount of information available, but what data is available suggests they would be very good for most fleets. As more information becomes available to the NACFE team these ratings and the information on online will be updated.

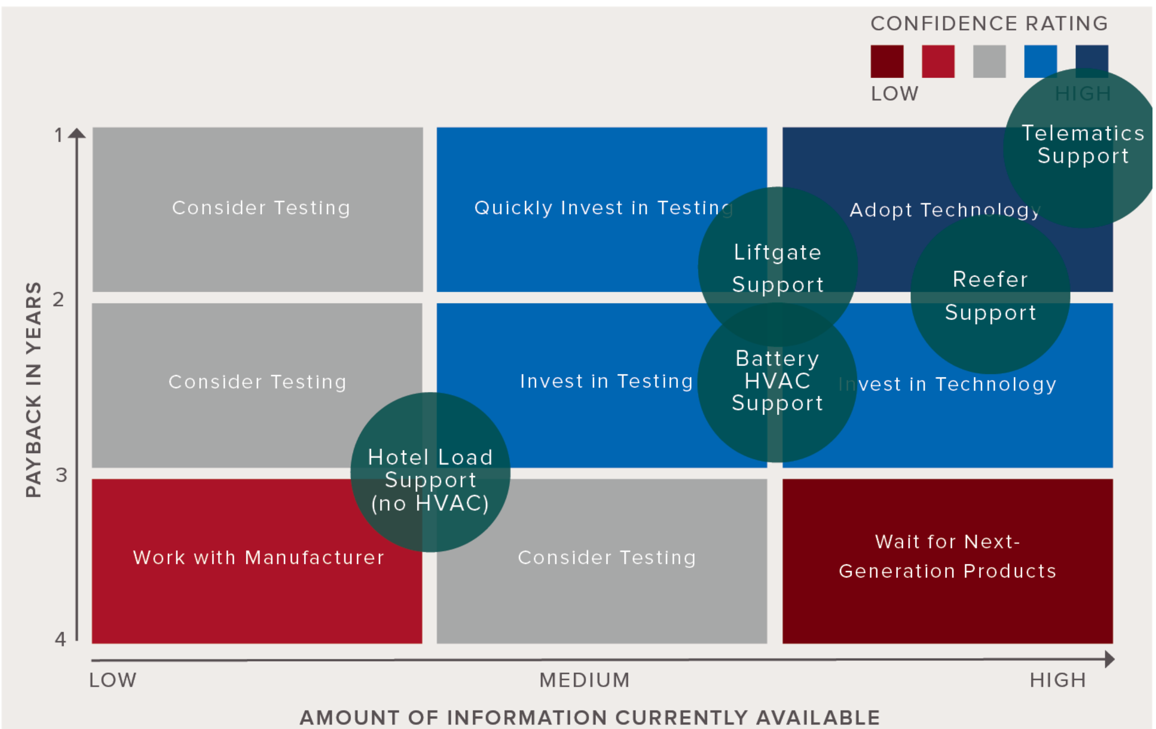


Figure 24: Confidence Matrix for Solar (NACFE, Solar, 2018)

11 Conclusions

The results of this annual survey clearly reflect a growing use of fuel-saving technologies and practices and 2018 provided another interesting set of data. Following are the high-level conclusions reached by the study team this year.

- *Multiple factors are influencing fleet adoption.*
- *Fleets continue to adopt fuel-saving technologies.*
- *Manufacturers accelerated delivery of technologies.*
- *There is still a significant gap to best-of-the-best fleets..*

11.1 Multiple factors are influencing fleet adoption.

New factors have emerged that influence decisions by fleets to improve efficiency including the current cost of fuel, potential future cost, federal and local regulations and increasing public demand for more sustainable operations.

11.2 Fleets continue to adopt fuel saving technologies.

They are implementing technologies on their tractors and trailers improving overall adoption to 45%. Specific technologies adopted vary by fleet duty cycle, business models, fleet size and other factors.

11.3 Manufacturers accelerate delivery of technologies.

Manufacturers are delivering more advanced generations of existing technologies to quicken the payback and mitigate the challenges of adoption. Other advancements come both as novel technologies that provide the same function in a different way and new technologies that address areas not considered in the past. 2018 also provided more new trucks that comply with Phase 1 of the federal GHG rule, and manufacturers are also developing technologies to meet GHGp2 starting in January 2021.

11.4 A significant gap to best-of-the-best still exists.

The average fleetwide performance of 7.27 MPG improved year-over-year, 2018 compared to 2017, along a rate of 2.0% per year since 2011. It is expected that this level could reach somewhere between the 8.3 and 10.1 MPG demonstrated during the two Run on Less by NACFE best-of-the-best demonstrations.

12 Closing

NACFE (in conjunction with RMI) conducts a series of workshops that allow fleets, industry suppliers dealerships, governments, NGOs and others 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 NACFE 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.

NACFE would like to thank the participating fleets for offering such important information to the rest of the industry. This study provides a benchmarking opportunity for participating fleets to continue to improve their operations and increase freight efficiency. If you are interested in joining this study, please contact NACFE at mike.roeth@nacfe.org. For other fleets the details in this study will provide a roadmap for your consideration of technologies and practices to help reduce fuel costs.

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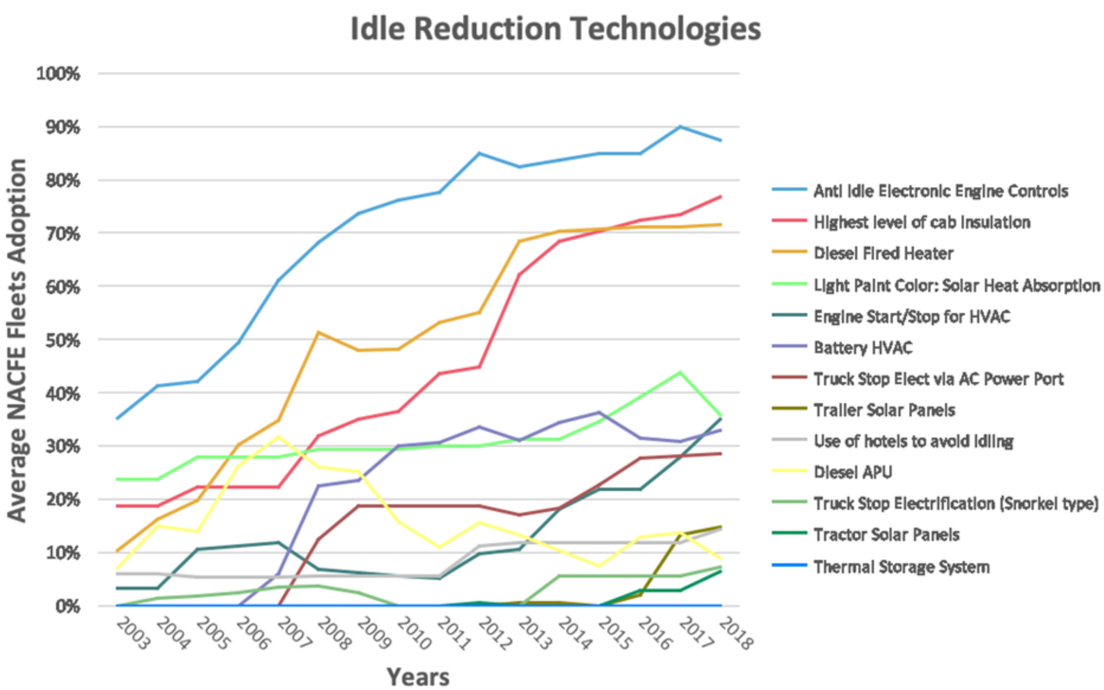
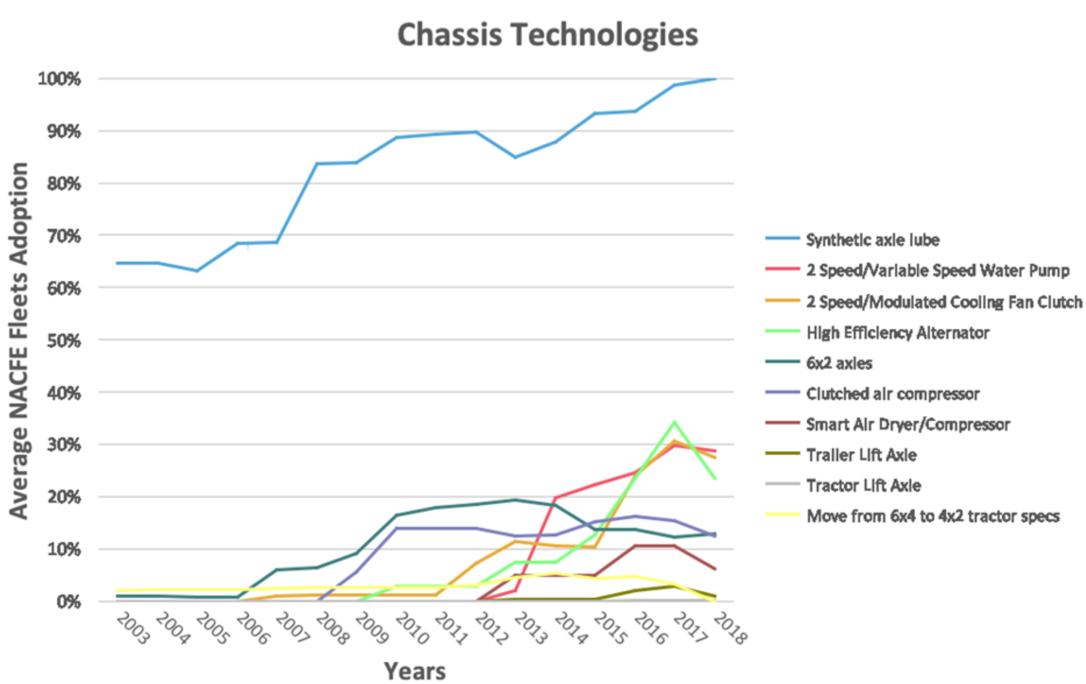
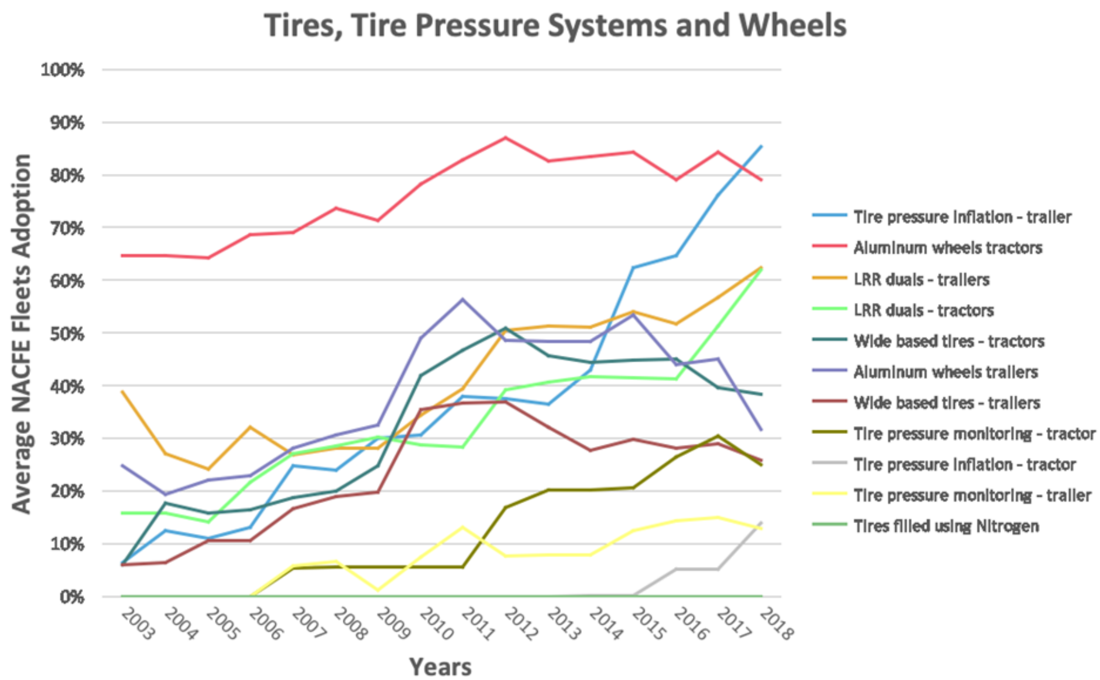
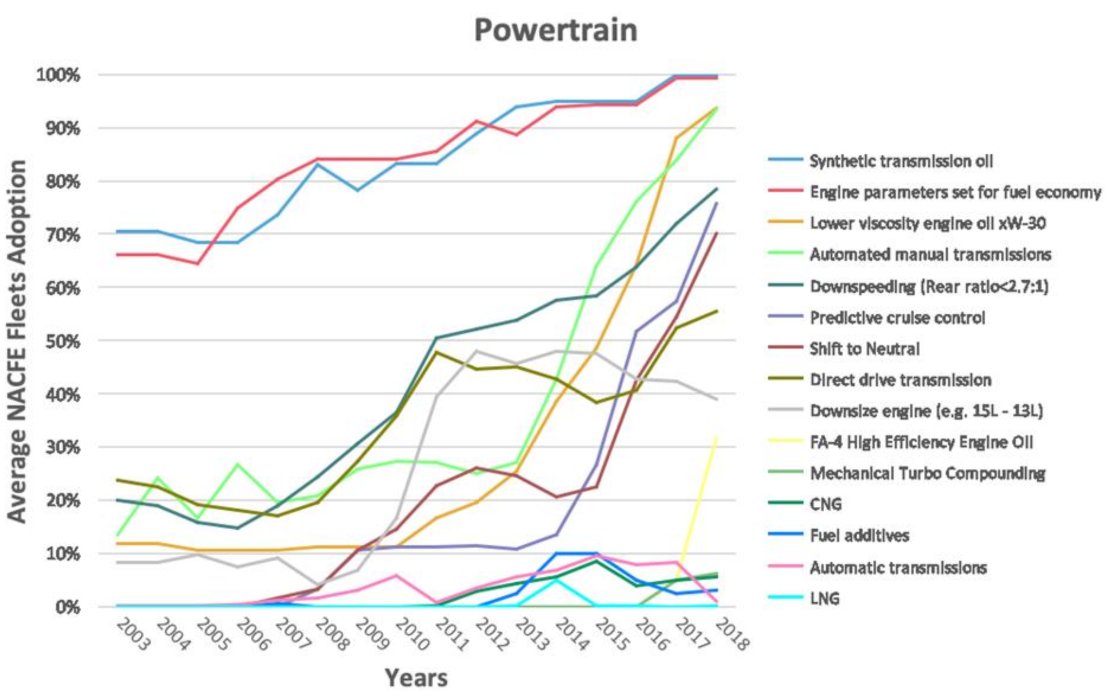
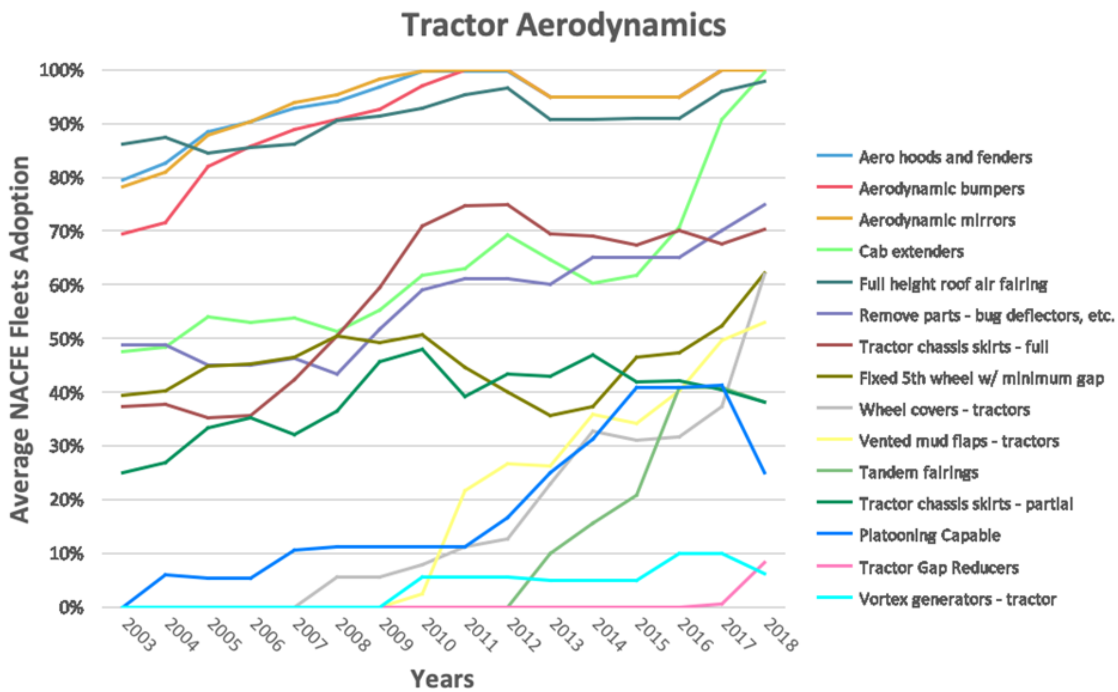
14 Appendix

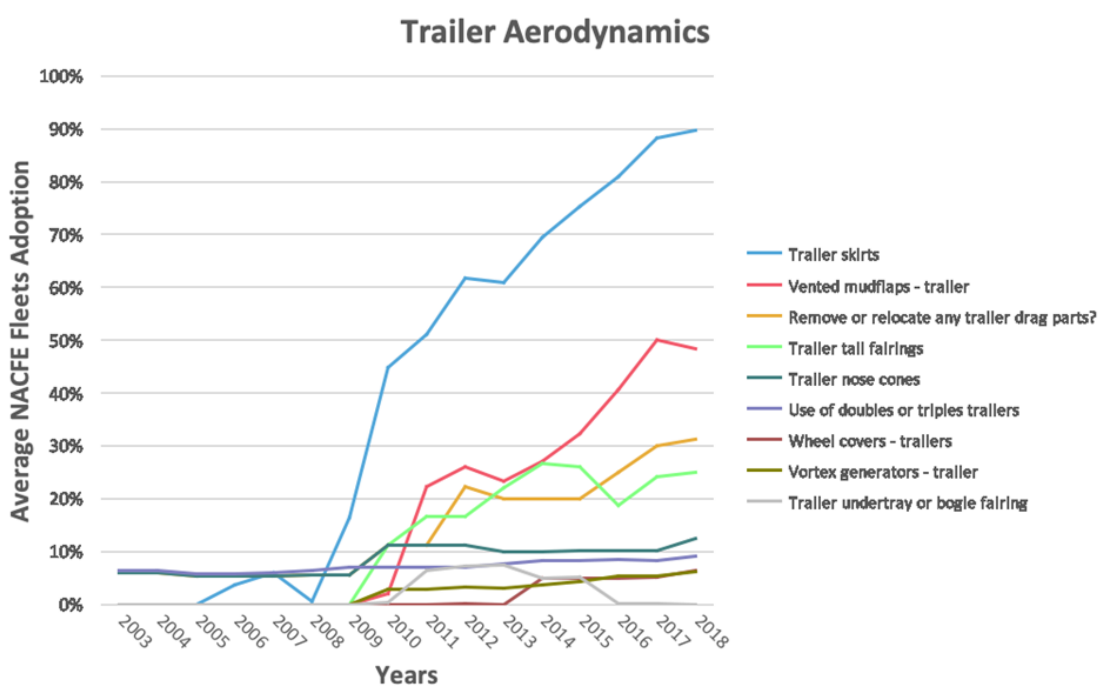

Idle Reduction Technologies
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Anti Idle Electronic Engine Controls
Highest level of cab insulation
Diesel Fired Heater
Light Paint Color: Solar Heat Absorption
Engine Start/Stop for HVAC
Battery HVAC
Truck Stop Elect via AC Power Port
Trailer Solar Panels
Use of hotels to avoid idling
Diesel APU
Truck Stop Electrification (Snorkel type)
Tractor Solar Panels
Thermal Storage System

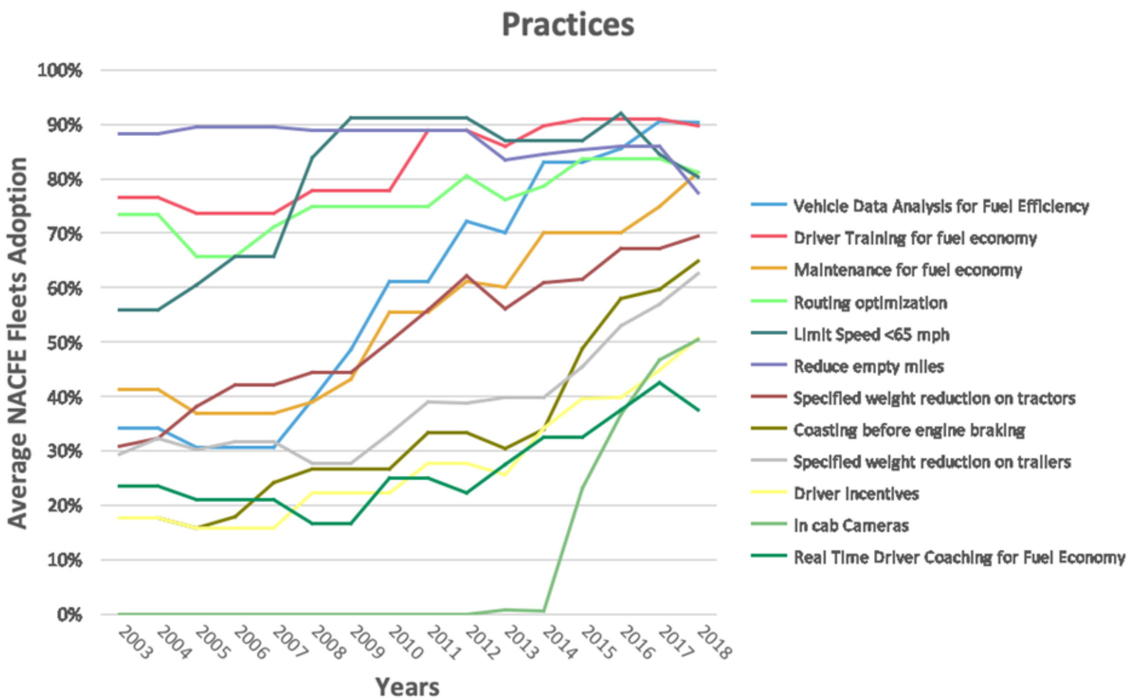

Chassis Technologies
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Synthetic axle lube
2 Speed/Variable Speed Water Pump
2 Speed/Modulated Cooling Fan Clutch
High Efficiency Alternator
6x2 axles
Clutched air compressor
Smart Air Dryer/Compressor
Trailer Lift Axle
Tractor Lift Axle
Move from 6x4 to 4x2 tractor specs


Tires, Tire Pressure Systems and Wheels
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Tire pressure inflation - trailer
Aluminum wheels tractors
LRR duals - trailers
LRR duals - tractors
Wide based tires - tractors
Aluminum wheels trailers
Wide based tires - trailers
Tire pressure monitoring - tractor
Tire pressure inflation - tractor
Tire pressure monitoring - trailer
Tires filled using Nitrogen

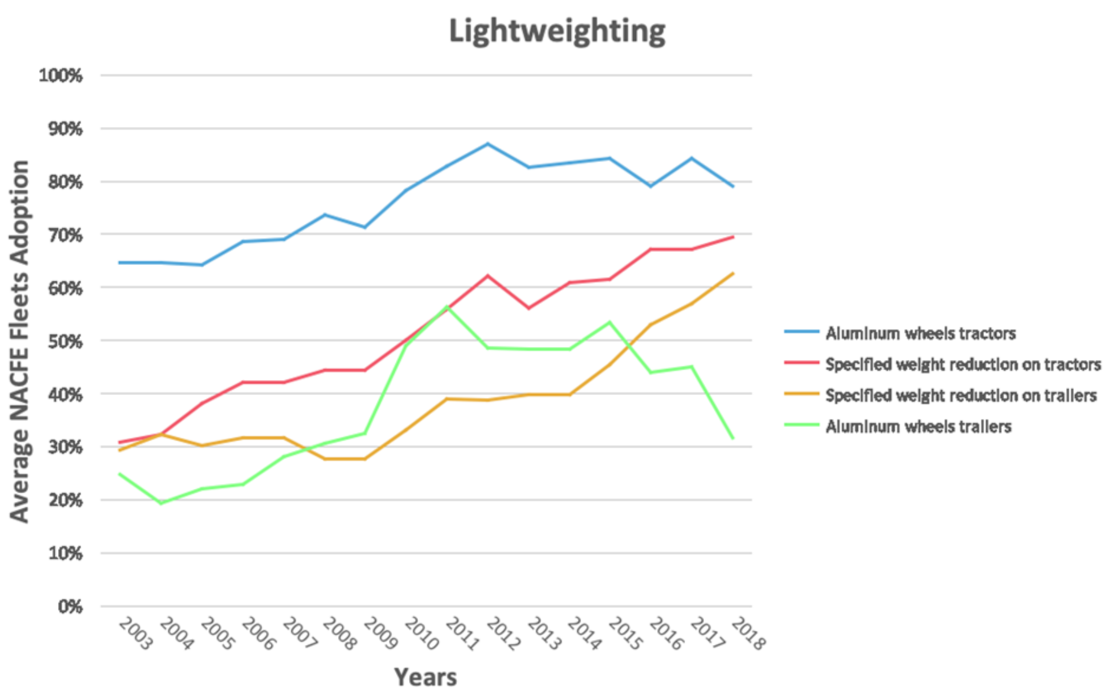

Powertrain
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Synthetic transmission oil
Engine parameters set for fuel economy
Lower viscosity engine oil xW-30
Automated manual transmissions
Downspeeding (Rear ratio<2.7:1)
Predictive cruise control
Shift to Neutral
Direct drive transmission
Downsize engine (e.g. 15L - 13L)
FA-4 High Efficiency Engine Oil
Mechanical Turbo Compounding
CNG
Fuel additives
Automatic transmissions
LNG


Tractor Aerodynamics
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Aero hoods and fenders
Aerodynamic bumpers
Aerodynamic mirrors
Cab extenders
Full height roof air fairing
Remove parts - bug deflectors, etc.
Tractor chassis skirts - full
Fixed 5th wheel w/ minimum gap
Wheel covers - tractors
Vented mud flaps - tractors
Tandem fairings
Tractor chassis skirts - partial
Platooning Capable
Tractor Gap Reducers
Vortex generators - tractor


Trailer Aerodynamics
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Years
Trailer skirts
Vented mudflaps - trailer
Remove or relocate any trailer drag parts?
Trailer tail fairings
Trailer nose cones
Use of doubles or triples trailers
Wheel covers - trailers
Vortex generators - trailer
Trailer undertray or bogie fairing



Practices
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Years
Vehicle Data Analysis for Fuel Efficiency
Driver Training for fuel economy
Maintenance for fuel economy
Routing optimization
Limit Speed <65 mph
Reduce empty miles
Specified weight reduction on tractors
Coasting before engine braking
Specified weight reduction on trailers
Driver Incentives
In cab Cameras
Real Time Driver Coaching for Fuel Economy



Lightweighting
Average NACFE Fleets Adoption
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Years
Aluminum wheels tractors
Specified weight reduction on tractors
Specified weight reduction on trailers
Aluminum wheels trailers

