Fuels Institute

# Tomorrow's Vehicles

*What will we drive in 2023?*

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## About the Fuels Institute

**The Fuels Institute**, founded by NACS in 2013, is a non-profit research-oriented think tank dedicated to evaluating the market issues related to consumer vehicles and the fuels that power them.

Led by a diverse Board of Directors and driven by a Board of Advisors, the Fuels Institute incorporates the perspective of interested stakeholders affected by this market, including but not limited to fuel retailers, fuel producers and refiners, alternative and renewable fuel producers, automobile manufacturers, environmental advocates, consumer organizations, academics, government entities and other stakeholders with expertise in the fuels and automotive industries.

The Fuels Institute commissions and publishes comprehensive, fact-based research projects that address the interests of the affected stakeholders. Such publications will help to inform both business owners considering long-term investment decisions and policymakers considering legislation and regulations affecting the market.

# Introduction

Innovation in the vehicles market is moving forward at a very rapid pace, but is that pace fundamentally changing the future composition of the fuels market? According to market forecasts completed for the Fuels Institute by Navigant Research, the answer is "yes," but only to a limited degree. Within the next 10 years, alternative fuel drivetrains will gain market share. However, traditional petroleum-powered internal combustion engines will continue to dominate.

The technological advances of new vehicles promise enhanced performance, improved fuel efficiency and reduced impacts to the environment, but consumers will be hesitant to purchase such vehicles unless the required fuel is readily available in their market at affordable prices. At the same time, the fuels market will hesitate to offer new products until there is sufficient demand (i.e., number of vehicles) to use these fuels. The two industries must develop together to convert consumers.

There is increasing interest in vehicles powered by electricity, natural gas, biofuels and fuel cells, supported by billions of dollars of investments in research and development, but which technology will win the hearts of the consumer and transform the transportation sector of tomorrow remains uncertain. Without coordination between the vehicle and fueling industries, successful market introduction of these new systems will be characterized by starts and stops, booms and busts and a protracted (and potentially economically painful) market development phase that may or may not result in consumer acceptance.

Individuals involved in the vehicle and fuels industries, as well as those considering public policies and the effect of change on consumers and environment, should make every effort to understand the potential direction of the market in order to properly prepare, initiate and respond to these developments.

In the summer of 2013, the Fuels Institute Board of Advisors recognized that evaluating the future transportation fuels market requires establishing a baseline from which to analyze potential changes. Often, evaluations of the vehicles market going forward are focused only on the sales of specific vehicle types. While this is informative, it does not tell the entire story. Decision-makers in both the vehicle and fuels industries must understand how the market might develop and what adjustments must be made to provide the ultimate value to the consumer.

To achieve this understanding, the Fuels Institute commissioned Navigant Research (hereafter referred to as Navigant) to provide a forecast of the vehicles market through 2023. This 10-year timeline was chosen because it provides valuable near-term insight to the market, capturing approximately two generations of vehicle development (assuming the time for a vehicle to transition from concept to production takes roughly five years), but is not so far into the future as to be rendered unreliable. Navigant leveraged its existing database and robust experience in the vehicles industry to provide a forecast of sales, inventories and fuel demand for a variety of light duty and medium/heavy duty vehicles based upon the fuel systems employed.

The Fuels Institute developed this report to provide decision-makers in related businesses and government agencies with valuable data to inform their deliberations and decisions. The Fuels Institute leveraged the findings of the Navigant forecast as well as other sources, including consumer surveys, market pricing analyses and government agencies.

The Fuels Institute believes that the market introduction of new vehicles and the fuels that power them must be coordinated. The first step towards achieving such coordination is to ensure that all participants have enough information to form opinions and begin evaluating strategies. This report is an initial look at the developing market – future Fuels Institute projects will look more closely at specific vehicle and fuel technologies under development.

## About the Navigant Research Forecast

This study was undertaken to understand how North American vehicle fuel consumption is likely to change through 2023 and how alternative fuel vehicles (AFVs) are likely to impact the consumption of gasoline and diesel. The forecasts for vehicles are based on economic, population, and historic demand trends as well as alternative drivetrain incremental costs, alternative fuel prices, and growth of ancillary markets such as refueling infrastructure. Fuel consumption forecasts utilize Navigant's established estimates for vehicle miles traveled (VMT) and fuel economy, which are sourced from industry research to generate consumption estimates for gasoline, diesel, compressed natural gas (CNG), liquefied natural gas (LNG), propane, ethanol and biodiesel.

The study conducted two forecasts: a base case evaluation, which was built on the established forecasts and updated trends, and an aggressive case evaluation, which considers alternative scenarios to forecast the potential number of registered vehicles on the roads. The aggressive forecasts included an assumption of higher gross domestic product (GDP) growth for the overall market and AFV markets. Within the AFV aggressive forecasts, higher gasoline and diesel costs are assumed. The combination of improved economic conditions (GDP growth) and higher petroleum fuel costs causes an increase in AFV adoption within the forecast model. While the overall number of vehicles is not anticipated to be meaningfully impacted by the aggressive forecasts (about 0.2% higher by 2023), the mix of alternative drive vehicles varies more significantly depending on the specific market. The study was also broken down into two segments: light duty vehicles (LDV) and medium and heavy duty vehicles (M/HD).

### Light Duty Vehicles

Light duty vehicle (LDV) annual sales and registration data forecasts are based on a combination of factors including population growth, GDP, GDP per capita, average new LDV prices, and incremental alternative fuel drivetrain costs. Vehicle prices were sourced from the National Automobile Dealers Association for the United States. LDV include all passenger cars and Class 1 and Class 2 light trucks (trucks weighing less than 10,000 pounds). Light duty trucks include some heavy duty pickup trucks, such as Chevrolet 2500 and Ford F-250, as well as most vans.

The base forecast data for the total LDV registrations is sourced from WardsAuto, which is an industry standard source for reliable North American data through 2010. The LDV registration for each year was calculated after 2010 using the following formula:

» Current Year LDV Registrations = Previous Year LDV Registration +
Current Year LDV Sales - (Scrappage rate x Previous Year LDV Registrations)

The aggressive forecasts for LDV annual sales are the result of increased GDP estimates. This factor was chosen in large part because economics have the greatest impact on the overall vehicle market. The gasoline and alternative fuel prices were not included in the overall LDV aggressive forecasts because it is difficult to parse out what the true impact high gasoline prices will have on overall sales. The GDP was increased by 1% over the base forecast in 2016 through 2020 and 1.5% from 2021-2023.

### Medium/Heavy Duty Trucks

The medium/heavy duty (M/HD) truck forecasts include buses and are sourced from a combination of Oak Ridge National Laboratory's (ORNL) *Transportation Energy Data Book*, the Energy Information Administration (EIA) and the American Public Transportation Association.

These sources provide sales data for traditional internal combustion engine (ICE) vehicles, as well as some alternative fuel vehicles (AFVs). Navigant is able to estimate forecast figures for truck sales by using linear growth offset by GDP growth and the overall LDV market growth rates. Within the individual weight classes, forecasts are revised based on qualitative data gathered during interviews conducted in the past year and expectations based on new fuel economy rules.

Similar to LDV forecasts, the aggressive forecasts for M/HD truck sales are the result of increased GDP performance. The GDP was increased by 1% more than the base forecast in 2016 through 2020 and 1.5% from 2021 to 2023.

## Medium/Heavy Duty Truck Classification Definitions

| Vehicle Class | Vehicle Weight (Pounds) | Examples |
|---|---|---|
| Medium Duty, Class 3 | 10,000 – 14,000 | Walk-in, box truck, city delivery, heavy duty pickup |
| Medium Duty, Class 4 | 14,001 – 16,000 | Large walk-in, box truck, city delivery |
| Medium Duty, Class 5 | 16,001 – 19,500 | Bucket truck, large walk-in, city delivery |
| Medium Duty, Class 6 | 19,501 – 26,000 | Type C school bus, beverage truck, single-axle |
| Heavy Duty, Class 7 | 26,001 – 33,000 | Refuse, furniture, city transit bus, truck tractor |
| Heavy Duty, Class 8 | 33,001and over | Cement truck, truck tractor, dump truck, sleeper truck tractor |

(Source: Oak Ridge National Laboratory)

### Fuel Economy and Vehicle Miles Traveled

The current and anticipated changes in fuel economy of LDVs, trucks, and buses are generally well known in the United States. The U.S. Environmental Protection Agency (EPA) and ORNL's *Transportation Energy Data Book* provide specific details on the U.S. market, and EPA enforced CAFE standards require benchmarked improvements for each automaker's fleet fuel economy. New vehicle sales are averaged into the existing vehicle stock for each year (as well as scrapped vehicles removed) to create the average fuel economy.

Annual light duty vehicle miles traveled (VMT) estimates are based on data provided by ORNL. Truck data is sourced from the EIA, ORNL and the National Transportation Library. For fuel consumption data, the number of vehicles registered is multiplied by the VMT to get the entire mileage driven by the vehicle stock. This is then divided by the fuel economy of the different vehicles to calculate an overall amount of fuel used. Natural gas and propane are converted into GGE. Gasoline, diesel, ethanol and biodiesel are measured in gallons.

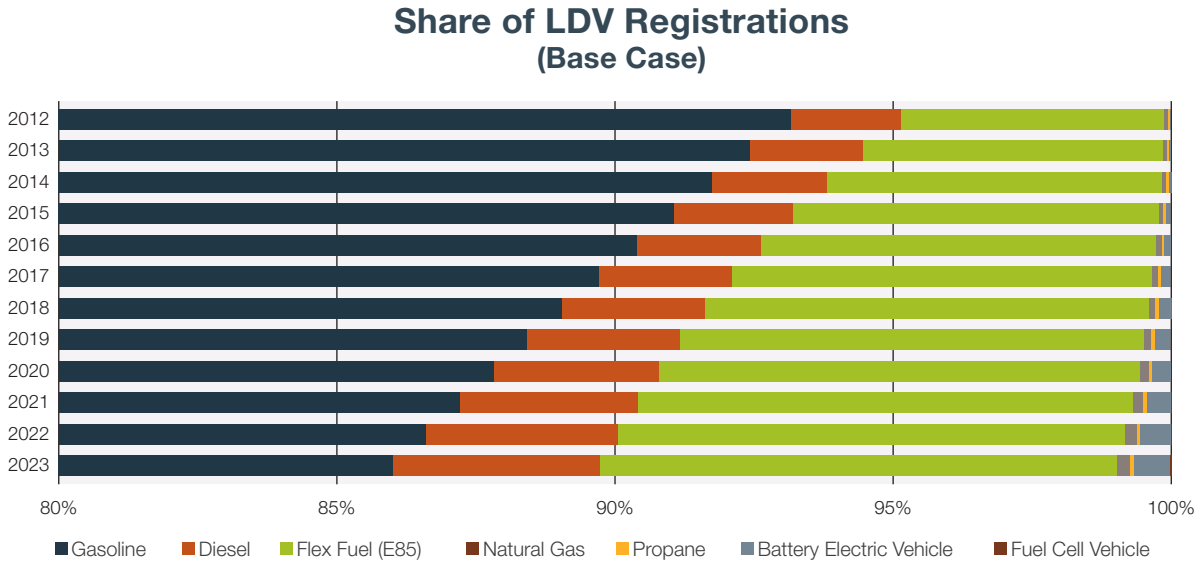
## Overall Vehicle Fleet

### Light Duty Vehicles

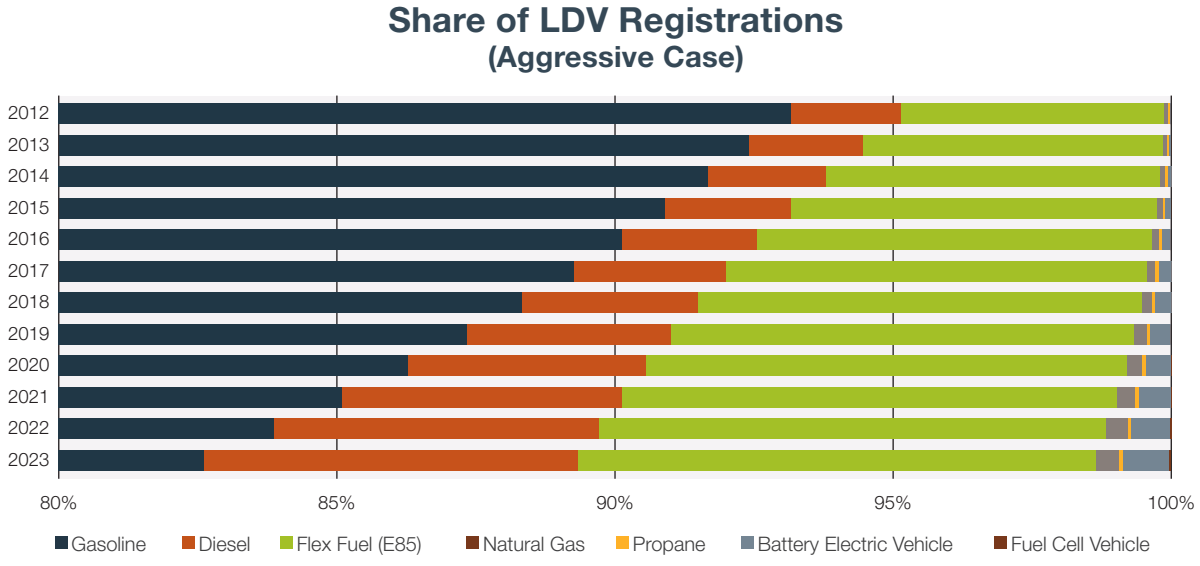
The North American light duty vehicle (LDV) market is and will continue to be heavily dominated by one primary engine type: the gasoline powered internal combustion engine (ICE). In fact, gasoline ICEs represented an overwhelming 93.2% of the entire light duty fleet in 2012. While other competing technologies will increase their presence in the market, they will combine to erode gasoline's market share by no more than 11% in the next 10 years.

Within the next decade, the total LDV market is projected to increase 13.0%, but the majority of this growth will originate in alternative power trains. The percentage of the LDV inventory (market share) represented by the gasoline ICE is projected to decline to 86.0% in the base case and 82.6% in the aggressive.

Diesel vehicles are partially responsible for this decline in gasoline ICE market share, with the percentage of LDVs equipped with diesel engines projected to increase from 2.0% to as much as 6.7% in the aggressive case. Flexible Fuel Vehicles (FFVs) likewise contribute to the drop in gasoline's market share, expanding from 4.7% of LDV registrations to 9.3% in both cases. The other fuel systems – natural gas, propane, battery electric vehicles (BEV) and fuel cell vehicles (FCV) — are projected to grow exponentially, but after starting from very modest market positions will still combine to contribute only 1.0%-1.4% of the vehicle pool in 2023.




(Source: Navigant Research)

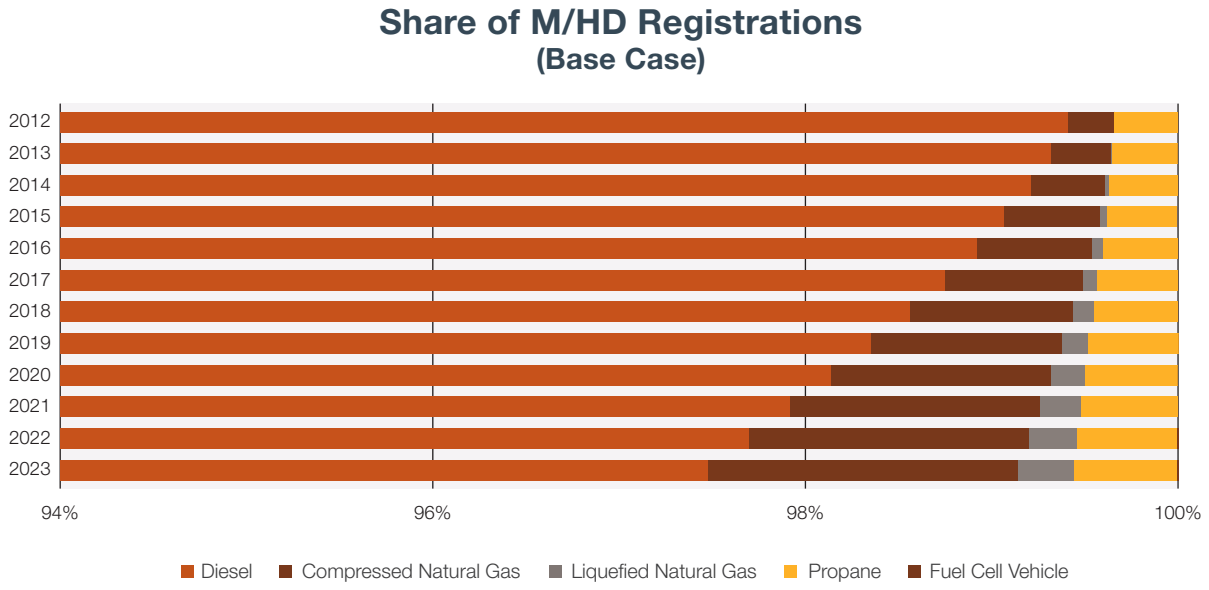



(Source: Navigant Research)

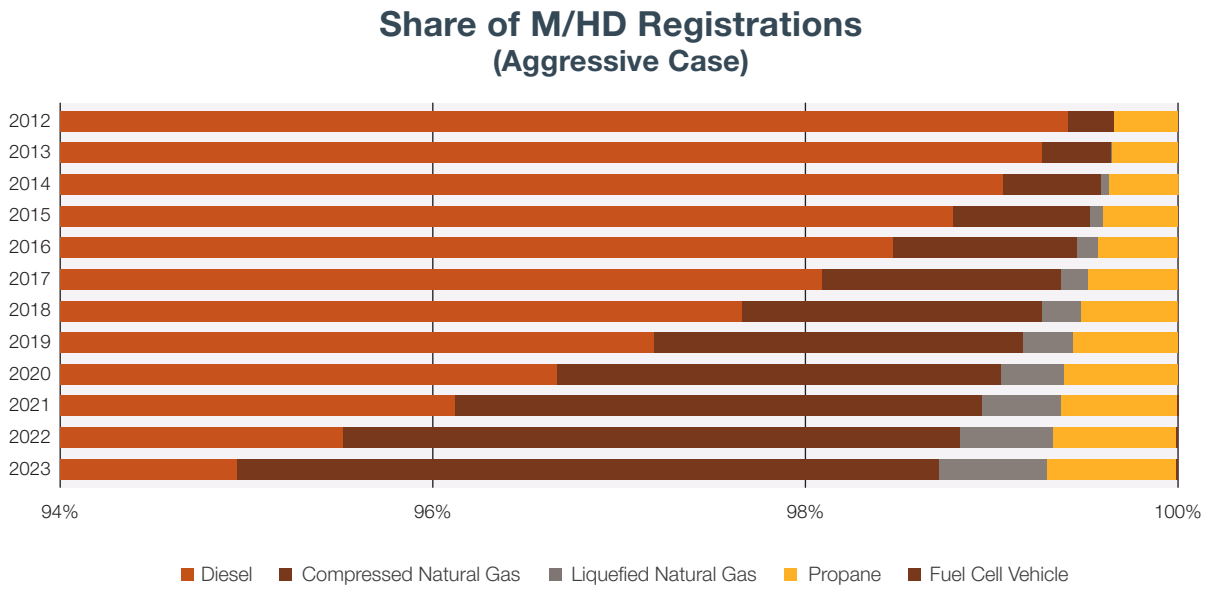
## Medium and Heavy Duty Vehicles

Like the light-duty vehicle market, the North American market for medium- and heavy-duty vehicles (M/HD) is dominated by one primary fuel – in this case, diesel fuel. In 2012, 99.4% of M/HD registered vehicles were powered by diesel and this unlikely to change much in the coming decade. Because M/HD engines must deliver so much power in order to move heavy loads, the choices for suitable alternative fuels are limited and the potential to diminish the market dominance of diesel fuel is likewise limited.

The inventory of M/HD vehicles over the next 10 years is forecast to increase 34%, with diesel vehicles continuing to represent at least 94.9% of these vehicles. This slight drop in market share is due to a significant increase in one of the few suitable alternative fuel power trains: compressed natural gas vehicles (CNG). The number of M/HD vehicles powered by CNG is forecast to increase from 0.3%-1.7% in the base case and 3.8% in the aggressive. Meanwhile, liquefied natural gas (LNG) and propane begin to gain some market share, but both remain below 1.0% in either scenario.



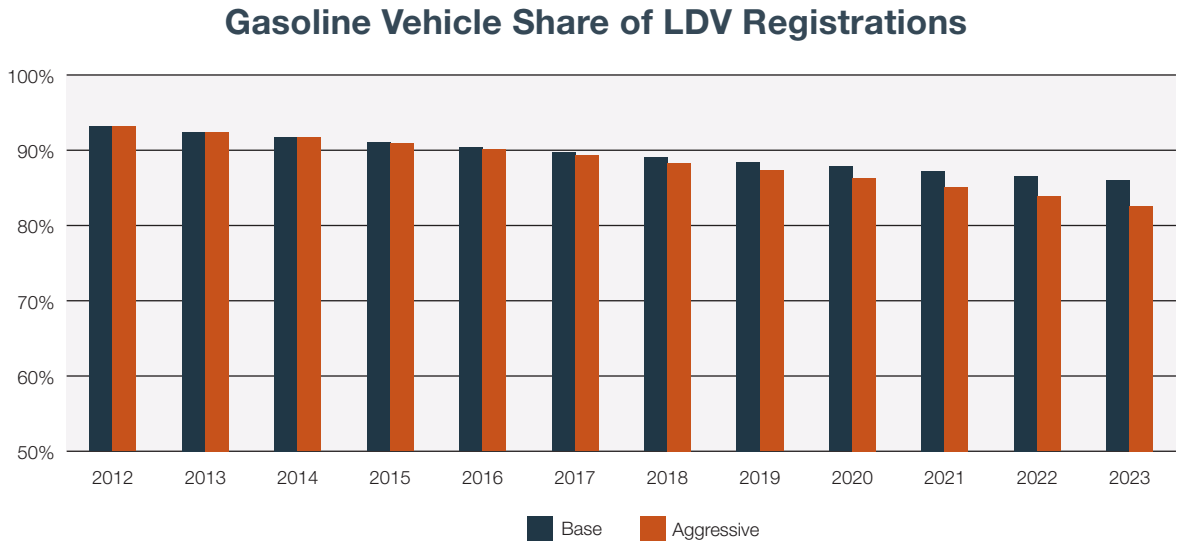

(Source: Navigant Research)




(Source: Navigant Research)

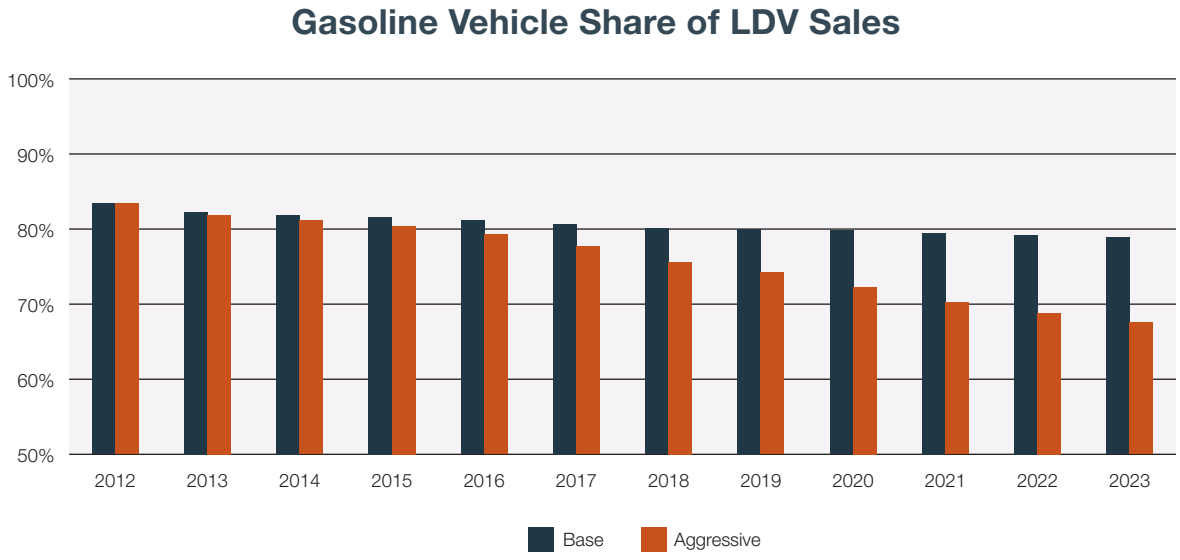
## Gasoline

Gasoline-powered vehicles are the dominant form of transportation in North America, representing 93.2% of LDV registrations. (In this forecast, gasoline vehicles include hybrid electric and plug-in hybrid electric vehicles where the battery supplements the internal combustion engine.) But the combination of higher fuel prices, mandatory vehicle fuel efficiency improvements, and the increasing popularity and availability of alternatives will cut into that market share over the next decade. Although the total number of LDVs registered in North America will increase by more than 13% according to Navigant, the total number of gasoline engine vehicles will increase less than 5%. Consequently, gasoline engines will represent a smaller portion of the LDV market, declining to 86.0% and 82.6% in the base and aggressive cases.




(Source: Navigant Research)

Driving the drop in gasoline market share is a forecast decline in gasoline-powered vehicles share of LDV sales. In 2012, gasoline vehicle sales represented 83.4% of all LDV sales. However, by 2023 these vehicles will represent only 67.6% of all LDV sales, according to Navigant in the aggressive case forecast (78.9% in the base). This would be a dramatic change in consumer purchasing behavior.




(Source: Navigant Research)

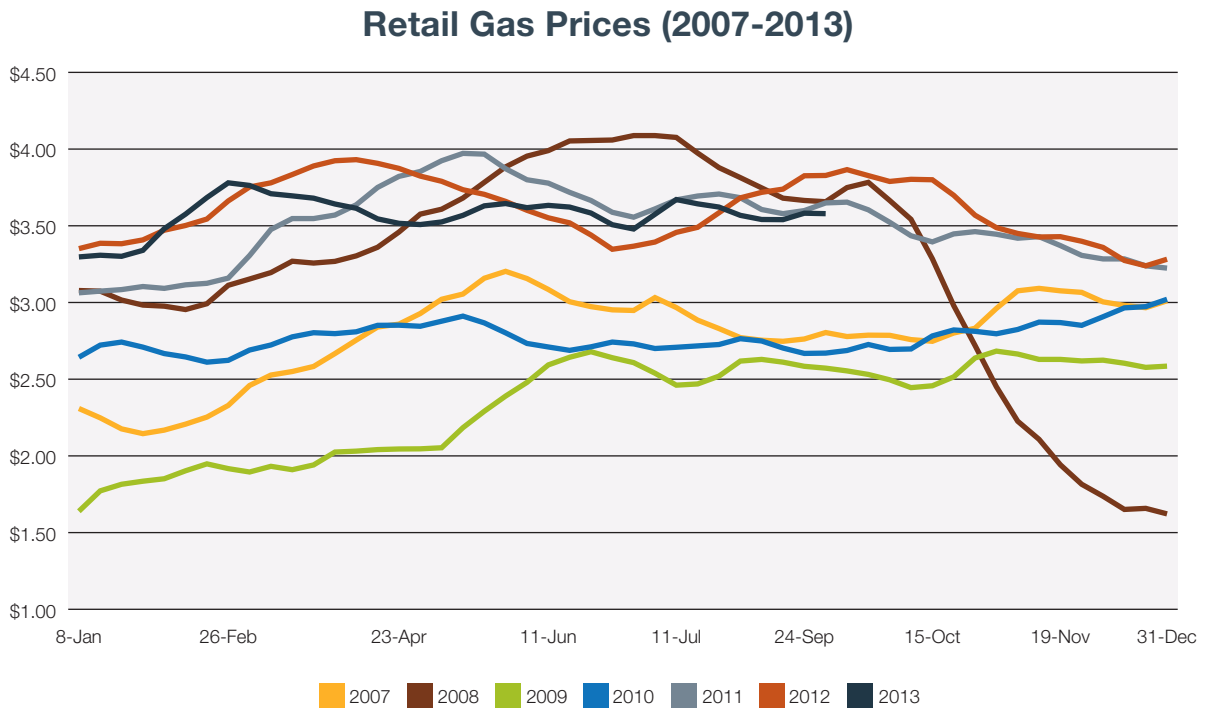
## Gas Prices Influence Vehicle Purchasing Decisions

What would contribute to such a change in behavior? One factor could be the retail price of gasoline. According to a consumer survey completed by NACS and Penn Schoen Berland in May 2013, 72% of consumers said that gasoline prices of $4.50 or less would be expensive enough for them to try to reduce how much they drive. When asked at what price would gasoline be so expensive that they would seek out an alternative to driving or drive drastically less, the majority (54%) said a price of $5.00 or less.

An historic rise in retail gasoline prices may be part of the reason why consumers are turning to alternative power train options more frequently. Although recent prices have not reached the self-reported consumer trigger points, consumers are witness to price changes every day and this can have an effect on consumer attitudes.

According to the Oil Price Information Service (OPIS), retail gasoline prices last came close to $4.00 in April 2012 when the average national weekly retail price hit $3.93. The EIA's Short Term Energy Outlook, released in September 2013, projects declining gasoline prices through 2014, with next year's annual average price of $3.43 lower than that in 2012 and 2013. Navigant does not forecast the United States crossing the consumer price thresholds of $4.50 or $5.00 found in the NACS and Penn Schoen Berland research until 2021 and 2023.

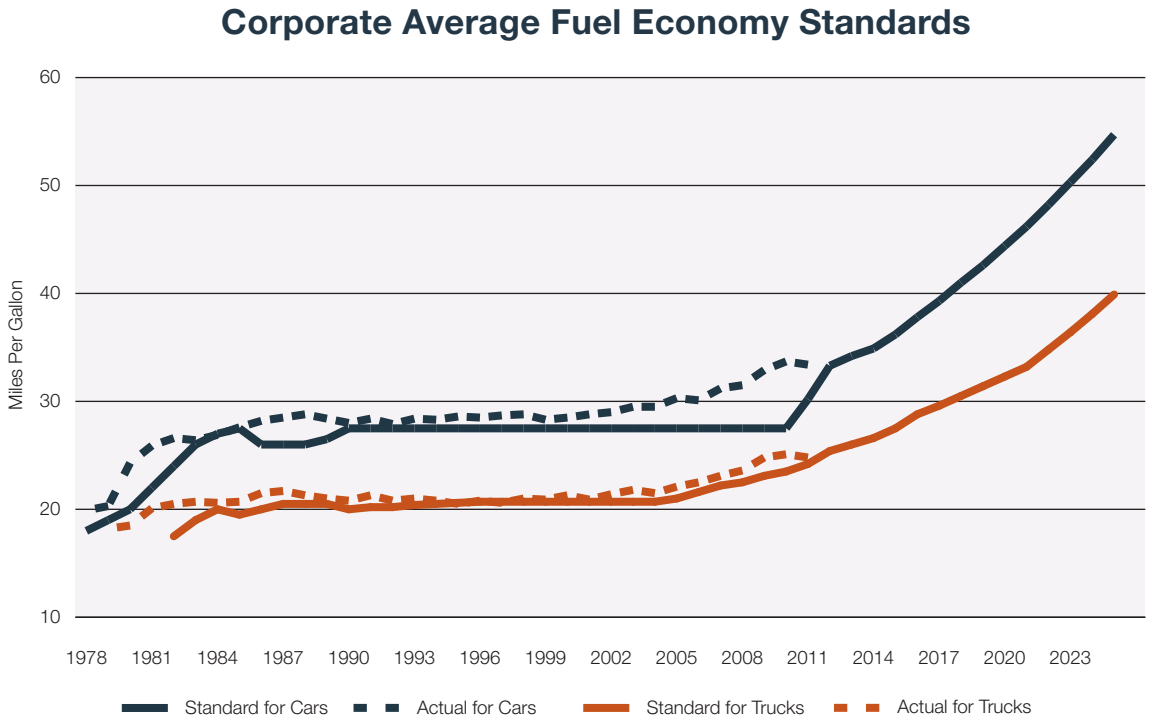
Despite indications that retail prices will not reach consumers' trigger points in the near future, it remains clear that retail fuel prices have a significant effect on the consumer's optimism and pessimism about the economy in general. Each month from January 2013 to September 2013, at least 84% of consumers report that fuel prices have some impact or a great impact on their feelings about the economy, as tracked by the monthly NACS and Penn Schoen Berland consumer surveys. Further, through September 2013, at least 53% of consumers have consistently expected fuel prices to be somewhat or much higher over the following 30 days. This attitude about fuel prices may influence vehicle purchasing decisions even more significantly than the actual price posted at the retail facility.




(Source: Oil Price Information Service: OPIS)

## Improved Fuel Economy Influences Vehicle Inventories

Another explanation for the decline in gasoline vehicle sales over the next ten years can be found in the Corporate Average Fuel Economy (CAFE) standards that require a significant increase in vehicle fuel efficiency. This required improvement in fuel economy is leading many automakers to consider alternative power trains that can facilitate compliance with these requirements. The combination of frustration with gasoline prices and the availability of alternative systems on auto dealer lots might help explain why consumers are beginning to consider non-gasoline vehicles more frequently.




(Source: U.S. Energy Information Administration)

The combination of market share deterioration and mandatory fuel efficiency requirements is projected to affect overall gasoline consumption. Since 2007, gasoline consumption has declined more than 6.0%, according to the EIA. This trend will continue with consumption declining an additional 19.2%-22.6% by 2023, according to Navigant.

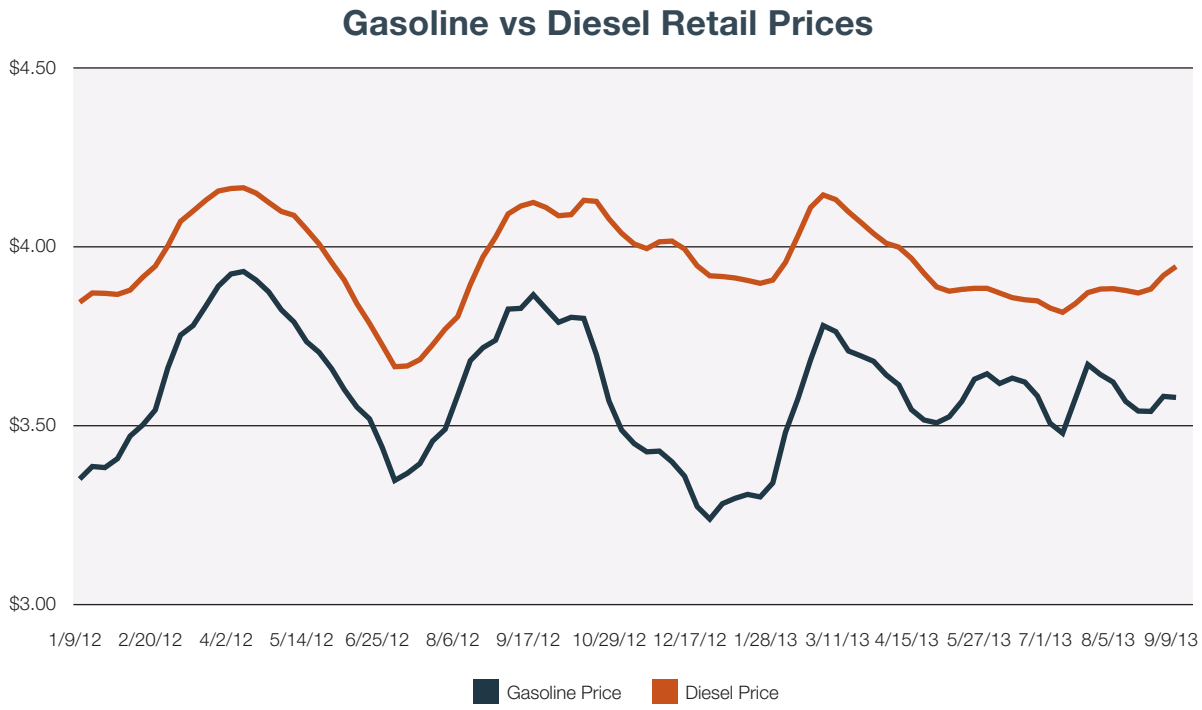
Consumers will continue to travel and EIA projects vehicle miles traveled to increase 12.7% by 2023. The decline in gasoline consumption can be explained partially through the improved fuel efficiency of the LDV fleet, but can also be partially attributed to the increase in consumer reliance on alternative engines and fuels.

## Diesel

Diesel engines might have the most to gain from the decline in market share for the gasoline ICE. Facing increased fuel economy requirements, many LDV manufacturers are turning to the improved performing modern diesel engine to boost their fleet averages. Depending on the configuration, diesel engines are capable of providing 20%-40% more miles per gallon than their gasoline equivalents. This could be why more auto manufacturers are considering introducing diesel vehicles to the U.S. market in the near future. The Diesel Technology Forum projects the U.S. LDV market will welcome more than 40 new models of diesel powered vehicles by 2015.

### Diesel Prices Inhibit Consumer Demand

To be successful in the market, the introduction of new diesel vehicles will have to overcome historically limited acceptance by consumers. One of the primary limiting factors is fuel price. In their May 2013 consumer survey, NACS and Penn Schoen Berland found that of the consumers who were unlikely to consider diesel powered vehicles, more than half (54%) said that fuel price was a determining factor. This is a rational response considering consumer sensitivity to fuel prices. Since January 2012, diesel prices have exceeded regular gasoline prices by a national U.S. average of 36.6 cents per gallon.



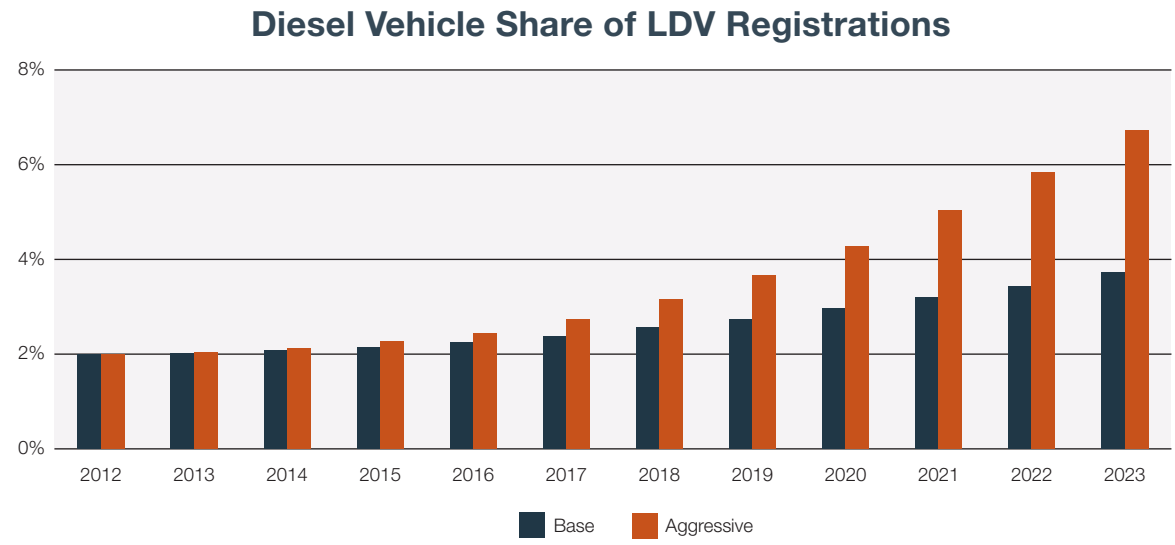

(Source: Oil Price Information Service: OPIS)

However, if consumers were to calculate the dollars per mile value of the fuels, considering the fuel economy boost they would receive from diesel engines, they would likely find greater value in diesel fuel. Since January 2012, the retail price of diesel fuel has been an average of 9.2% higher than gasoline. This is a cost, however, that often is overcome by the savings derived from the improved fuel efficiency of most diesel engines. Consequently, on a dollar per mile basis, diesel is often the more beneficial financial choice. But the constant reminder on retail fuel price signs that diesel fuel is more expensive is a clear deterrent to consumer acceptance.

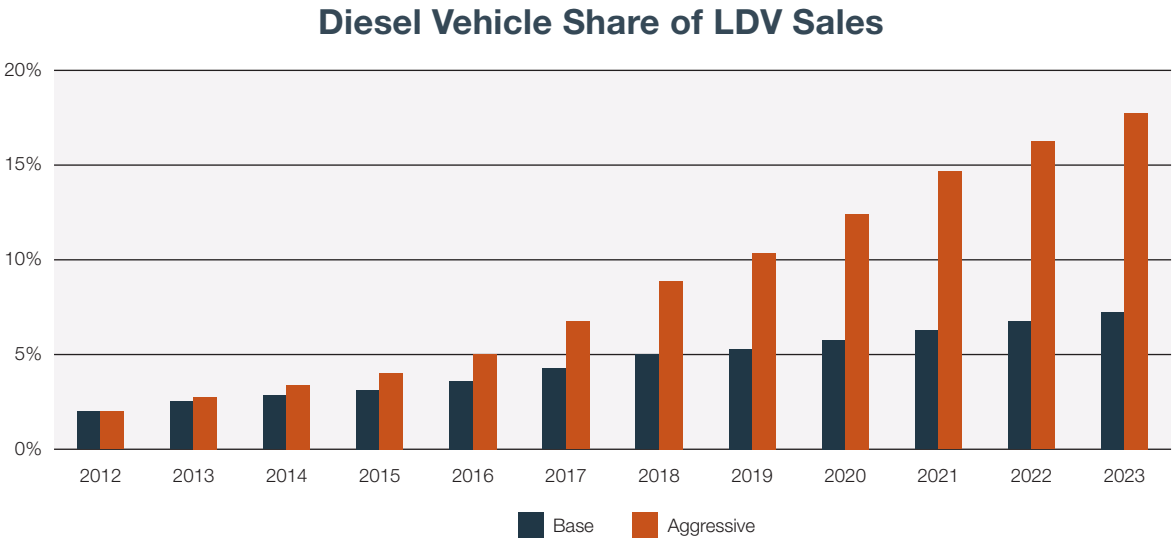
## Diesel Growth Powered by Fuel Economy

Despite this potential consumer reluctance, the consumer survey found many positives about the future of diesel fuel. Of those likely to purchase a vehicle in the next two years, 31% are very likely or somewhat likely to consider a diesel vehicle. Compare this to the current 2.0% market share of diesel LDVs and there is potential for strong growth for this power train. As further confirmation of the perceived value of the fuel, of the 31% who might consider a diesel vehicle, 59% noted the improved fuel efficiency as a reason for their consideration.

The combination of consumer interest in fuel economy and the U.S. government's mandatory CAFE improvements contribute to a bullish growth forecast for diesel powered LDVs. By 2023, inventories are projected to expand more than three-fold to 6.7% in the aggressive forecast, according to Navigant. Diesel LDV sales are likewise projected to accelerate, rising to represent as much as 17.8% of all LDV sales in the aggressive case. Even in the base case, diesel-powered vehicles can expect a robust future with inventories rising to 3.7% of all registered LDVs and sales representing 7.2% of all LDV sales.




(Source: Navigant Research)




(Source: Navigant Research)

As with alternative vehicles and fuels, retail availability will be an important contributor to the growth of diesel LDV sales. In fact, 30% of those unlikely to purchase a diesel vehicle cited the difficulty in finding diesel fuel at retail. Anecdotal information from fuel retailers indicates that this situation may be changing as more and more stations are being equipped to sell diesel fuel. In 2012, the EIA reported approximately 66,000 fuel retail locations sold diesel fuel, which would equate to more than 42% of all retail fueling locations. It is expected that this will increase in the coming years as more diesel LDVs enter the market.

## Medium and Heavy Duty Vehicles Dominate Diesel Market

The overall diesel market, however, will continue to be dominated by the medium and heavy duty (M/HD) fleet. Just as gasoline is the primary fuel source in the LDV market, so diesel is for the M/HD market. Of the total diesel consumption in North America, M/HD vehicles consumed 94.7% of it in 2012. This share of fuel consumption will decline over the next decade as diesel LDVs enter the market in greater numbers and as M/HD fuel economy improves significantly. Still, Navigant forecasts that the M/HD market will continue to command 92.1% and 86.0% of the diesel fuel market in the base and aggressive cases.

In 2012, diesel engines represented 99.4% of all M/HD registered vehicles. In the next 10 years, Navigant does not project this will change significantly as market share will only decline to 97.5% and 94.6% in the base and aggressive cases. The primary competition to diesel is projected to be natural gas.

## Flexible Fuel Vehicles (FFVs)

Flexible Fuel Vehicles (FFVs) seem poised to flex their muscles in the near term as inventories are projected to increase and economics are developing to make E85 potentially more attractive to consumers. FFVs are vehicles specially designed to operate interchangeably on gasoline or E85. E85 is defined by ASTM International as a fuel containing between 51% to 83% ethanol, with the balance made up of gasoline.

### Price Drives E85 Demand

The growth of the FFV market, and consumers' use of E85 fuel, is contingent upon the price of E85 compared to regular gasoline (E10) and the number of FFVs in the market. In the past couple of years, E85 sales have suffered from a lack of demand and a lackluster price compared to gasoline. Although the sample size for E85 reported prices is relatively small, OPIS reports that this sample of E85 prices has averaged 43 cents per gallon lower than gasoline since 2011. In that time, the average price spread has ranged from a low of 7.3 cents to 73.9 cents.

The average E85 discount is slightly less than that reported by consumers as necessary to encourage purchase of the fuel. In a May 2013 consumer survey, NACS and Penn Schoen Berland asked those consumers who drove an FFV at what price E85 must be offered relative to gasoline for them to consider buying E85. Averaging the open ended responses yielded a required price differential of 50 cents per gallon below gasoline. If the price matched the consumer's preferred price discount, more than half (54%) would be somewhat or very likely to buy E85.

At the end of 2013 there are some developing conditions that could cause the market to see a slight resurgence in the availability and consumption of E85. First, the relative value of E85 and its sale price is subject to change. The Renewable Fuel Standard (RFS), which sets mandatory volumes for renewable fuels to be blended into the fuel supply, is quickly outpacing the market's ability to comply by offering just E10. This is putting upward pressure on the price of renewable identification numbers (RINs), which are used by refiners to demonstrate compliance with the program.

As the value of RINs increases, fuel marketers who blend E85 could capitalize on the market, blend E85, generate a RIN, sell it to an obligated party and then use the value of the RIN to help offset the price of E85 and sell it for a more competitive price relative to gasoline. For example, if RINs are worth $1.50 per ethanol gallon, a marketer can reduce the cost of E85 by up to $1.245 (E85 can contain a maximum of 83% ethanol) in addition to leveraging the lower price of ethanol. (This situation could be nullified if Congress or the administration enact changes to the RFS and the value of RINs declines.)

This could help a retailer sell E85 at a price that compensates the consumer for the reduced fuel efficiency of the product (drivers of FFVs fueling with E85 experience fewer miles per gallon compared to fueling their vehicles with gasoline) and could be enough incentive to overcome the inconvenience of having to refuel more frequently. The Department of Energy estimates the average volume of ethanol in E85 at 74%. At this blend level, E85 delivers approximately 23% less energy than E10.

### Energy Content of Fuels

| Product | Est. BTU Content |
|---|---|
| Gasoline (0% ethanol) | 116,090 |
| Ethanol | 76,330 |
| E10 (Gasoline w/ 10% ethanol) | 112,114 |
| E85 (Average 74% ethanol) | 86,667 |

(Source: U.S. Department of Energy)

## Lack of E85 Stations Limit Consumer Demand

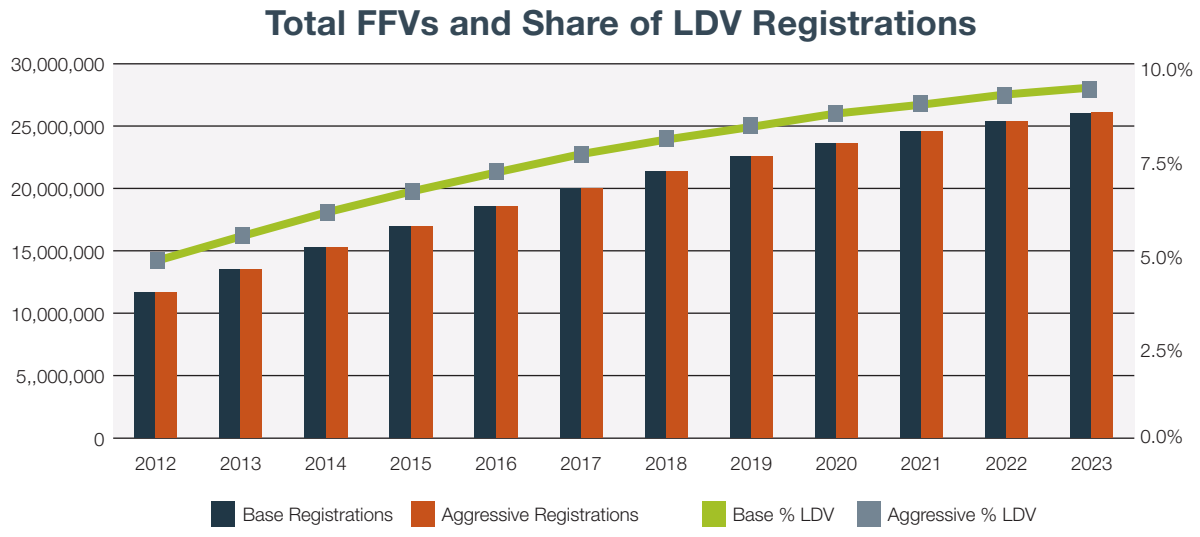
On the other side is potential demand. At the end of 2012, only 10.7 million FFVs existed in the United States, representing 4.7% of the light duty vehicle market. Of these 10.7 million vehicles, they consumed on average fewer than 20 gallons of E85 per vehicle for the entire year. The potential change in E85's cost structure could increase interest in the fuel, but demand still will be constrained by the number of FFVs on the road.

Some have argued that the lack of consumption is caused to some degree by the limited availability of E85 in the market. As of September 2013, the U.S. Department of Energy reports 2,338 retail stations selling E85 and open to the public with another 268 open for private access only. This represents only 1.5% of the 156,065 fuel retail facilities in operation in the United States in 2012, according to *NPN News*. Of these E85 facilities, nearly two-thirds (63.3%) were located in 11 Midwestern states: Iowa, Illinois, Indiana, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin. There are some reports, however, that indicate the number of stations could be significantly higher than those reported by DOE.

Demand and market economics are important criteria in the establishment of a retail infrastructure to sell E85, but another retailer consideration is equipment compatibility and capacity. To store and dispense E85, a retailer must ensure the fueling equipment is compatible with the fuel. Depending on the existing equipment, this investment can be minor or extensive. In addition, the retailer must dedicate an underground storage tank to handle the fuel. If the facility operates with only two such tanks, the retailer must decide whether to install a third tank or adjust the store's fuel product offering by replacing one product with E85. Such decisions are made based upon analysis of market demand factors.

A critical factor in demand is the number of FFVs on the road. Currently, for every FFV they produce automakers receive a credit toward meeting their fleet fuel economy requirements. However, beginning in model year 2016 these credits will begin to phase out, eliminating the primary incentive for producing FFVs. Unless consumer demand begins to pick up in response to more attractive E85 pricing and availability, some believe the days of increasing FFV production may be waning.

That might be, but Navigant is forecasting an aggressive increase in the number of FFVs on the roads over the next 10 years. In fact, the firm projects the number of FFVs registered in North American in 2023 to more than double 2012 registrations, reaching 26.0 million units. This will represent a market share of 9.3%. Sales are forecast to increase each year through 2018 and then begin to slowly decline throughout the remaining years of the forecast. This could be due to the fact that automakers are trying to capitalize on the CAFE credits before they completely expire by increasing production and sales in near-term and then simply maintaining production at those same facilities in subsequent years.




(Source: Navigant Research)

## Natural Gas

Few alternative fueling options are receiving as much attention by policy makers or public opinion leaders as is natural gas. The recent advances in North American natural gas production and the revised estimates of recoverable resources have driven prices lower and led to enthusiastic optimism concerning the future uses of natural gas. As industries begin to vie to leverage the abundant resources, the transportation market is often identified as an appealing use of natural gas and significant focus has been directed toward this market.

Despite the attention, there are many hurdles that must first be overcome before a robust market develops. Navigant reports that the sales of natural gas vehicles (NGVs) in the United States and Canada are almost entirely made to fleet customers due to the lack of ubiquitous infrastructure and limited vehicle availability. Navigant does not expect this dynamic to change during the next 10 years.

### Infrastructure Conversion Expensive and Time Consuming

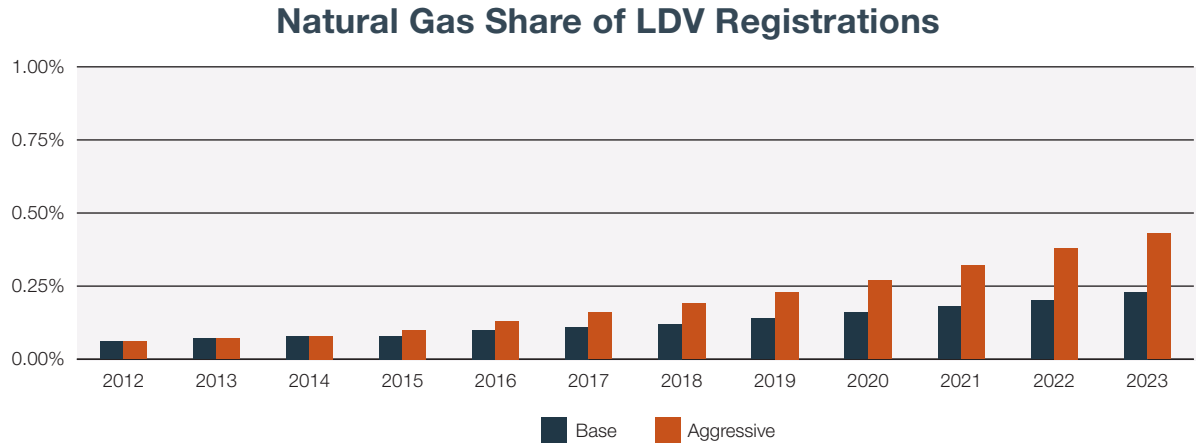
A contributing factor to this situation is the cost of infrastructure development. Installation of compressed natural gas (CNG) facilities at retail can cost $1.5 million compared to less than $500,000 for a petroleum retail facility; liquefied natural gas (LNG) stations can cost even more. This has led to slow deployment throughout North America, although there are several companies making significant investments to create a sustainable refueling system to support an increase in NGVs. But such a roll-out will take time.

Further, the cost of vehicle production or conversion can deter many owners from making the switch to a natural gas system. New OEM vehicles equipped to operate on CNG can be 10% - 40% more costly than their petroleum counterparts, while LNG versions can cost upwards of 60% more. Vehicle conversions can likewise cost several thousand dollars for LDVs and tens of thousands for M/HD vehicles. Vehicle owners must calculate the potential payback period of such conversion based upon anticipated fuel prices. Currently CNG is selling at retail for approximately 50% less than gasoline on an equivalent basis and even lower when compared with diesel fuel. EIA's 2013 Annual Energy Outlook reports, "Even after the substantial costs of liquefaction or compression, fuel costs for LNG or CNG are expected to be well below the projected cost of diesel fuel on an energy-equivalent basis." In a December 2012 article, *National Geographic* reported that EIA analysts project LNG will average 40% lower than diesel fuel for the next three decades.

### Consumers Are Open to Natural Gas Vehicles

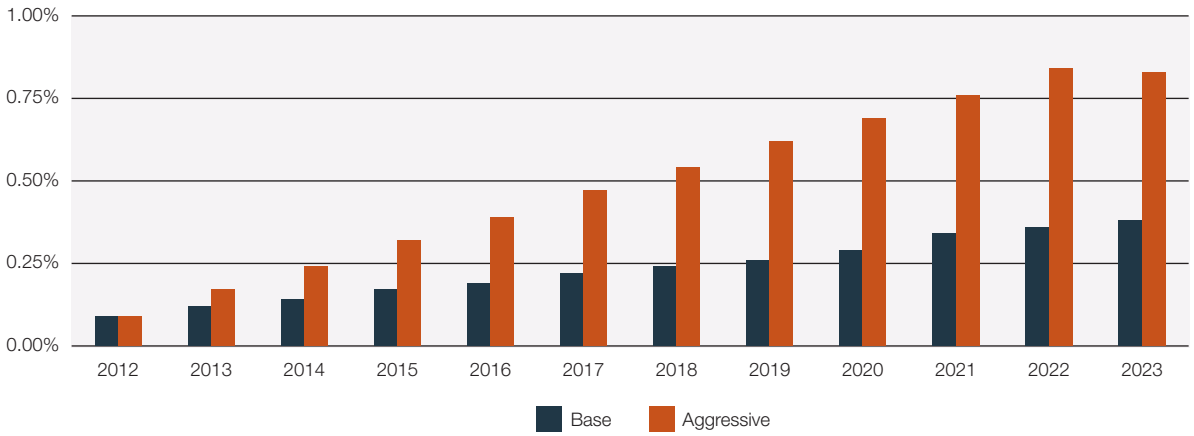
The interest in NGVs is not lost on consumers. In a March 2013 NACS and Penn Schoen Berland consumer survey, consumers indicated their willingness to consider natural gas as a transportation fuel. When asked how likely they would be to consider natural gas if vehicles and fueling were easily available, nearly three-quarters (73%) said they were somewhat or very likely to consider it. This indicates that consumers do not have an inherent distrust of the fuel and that there should be potential demand as this market begins to develop.

The growth of the market, however, is projected to move relatively slowly. In 2012, NGVs represented only 0.06% of registered LDVs. By 2023, this is projected to increase significantly but still represent less than half a percent (0.43%) of the market in the aggressive forecast. However, sales are projected to increase by at least 500% over the next 10 years and potentially increase by a factor of 11x in the aggressive case, according to Navigant.




(Source: Navigant Research)

## Natural Gas Share of LDV Sales



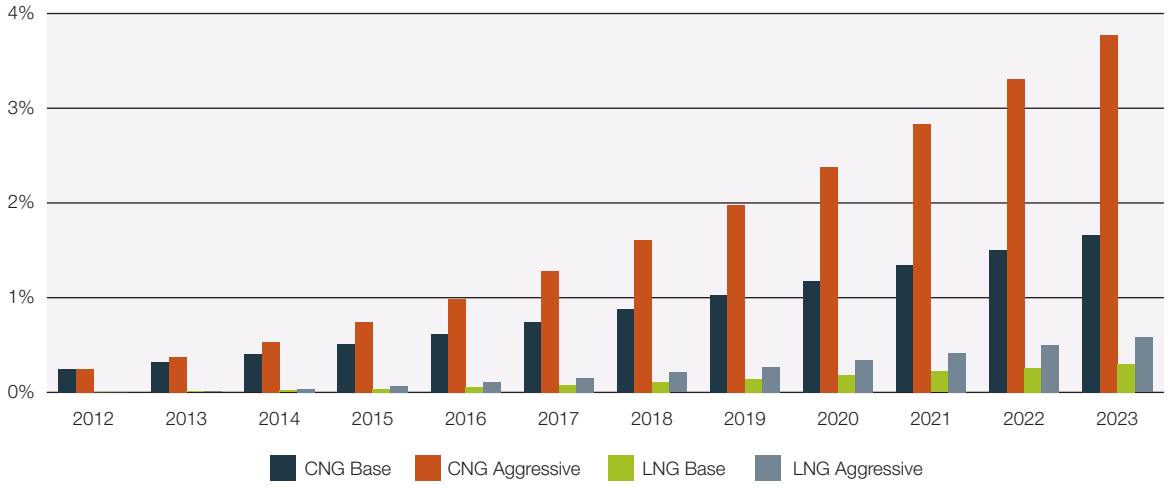

(Source: Navigant Research)

### Medium and Heavy Duty Market Show Most Growth Potential

The M/HD market is where NGVs are expected to show the greatest potential market expansion. In 2012, NGVs represented 0.25% of registered M/HD vehicles, almost exclusively as CNG. CNG vehicles are projected to increase their market share considerably, potentially representing 3.8% of registered M/HDs by 2023 in the aggressive forecast. The majority of vehicles leveraging CNG systems (approximately two-thirds) will be found in the Class 8 category of HD vehicles, where the lower cost of fuel combined with significant annual fuel consumption more quickly provide a return on vehicle investment.

By contrast, LNG vehicles had not yet taken hold in 2012, with only 207 registered vehicles reported by Navigant. However, significant growth is expected over the next decade and LNG vehicles are forecast to represent 0.30% and 0.58% of the M/HD market. Like CNG, however, the majority of vehicles (nearly three-quarters) leveraging LNG powertrains will be found in the Class 8 category.

## Natural Gas Share of M/HD Registrations




(Source: Navigant Research)

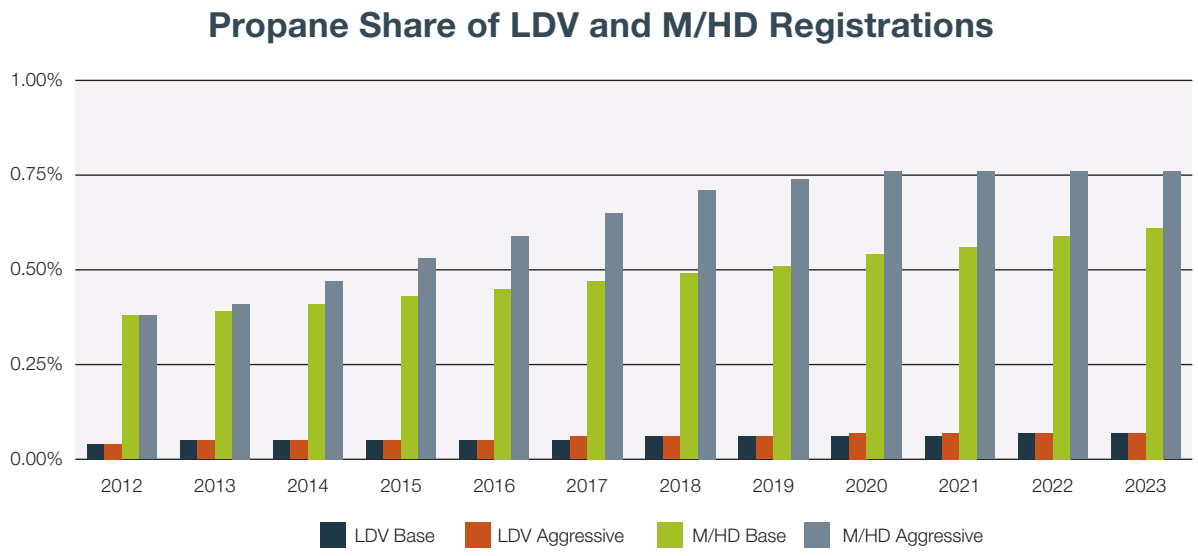
## Propane

Similar to NGVs, propane vehicles in North America are almost entirely sold to fleet customers due to infrastructure and vehicle availability. Navigant does not anticipate this to change significantly within the forecast period. While propane has been limited to LDV and MD trucks and buses, Navigant is expecting that after 2016 propane will be increasingly available to HD trucks as well. When it comes to smaller vehicles propane has an advantage over natural gas in the lower cost and smaller size of the onboard fuel system.

The propane vehicle market is largely overshadowed by NGVs in both the United States and Canada. Although the fuel prices of propane are highly competitive with CNG (and often lower), CNG vehicles are more widely available and propane is not yet available in HD trucks. Additionally, because propane is a byproduct of oil and gas production, natural gas as a vehicle fuel is thought to be more scalable than propane. Despite this, Navigant reports that propane has found a successful niche in the school bus market. The use of propane in school buses is a good example of how the clean nature of the fuel can be good for public relations and save school districts money. Slow and steady growth appears to be the future for propane as a vehicle fuel.

In 2012, propane LDVs represented just 0.04% of the market. Navigant does not forecast significant growth, with market share increasing to just 0.07% in 2023. Vehicle sales, however, are forecast to nearly double in the base case and more than triple in the aggressive case. Refueling infrastructure development will likely be restrained to service these specific fleet operations without significant investment in public access retail facilities.

In the M/HD market, propane already has a stronger market presence than its NGV competitors representing 0.38% of the market in 2012. This inventory is found in the medium duty classes (Class 3-6), with no vehicles found in Class 7 or 8. Navigant projects improved market share through 2023 with propane vehicles representing 0.61% and 0.76% of the market in the base and aggressive cases. Again, there is negligible presence of propane in the heavy duty segment, with nearly all of the market development occurring in the medium duty market.




(Source: Navigant Research)

## Battery Electric Vehicles

Among the alternative power train options under development, few have received as much attention from both federal and state government agencies as battery electric vehicles (BEVs). BEVs refer to those vehicles whose source of energy derives from a battery rather than the internal combustion engine. Accordingly, BEVs do not refer to traditional hybrid or plug-in hybrid vehicles in which a battery supplements an internal combustion engine or in which a battery is backed up by an ICE; rather BEVs are exclusively electricity driven and require plugging into the electricity grid to recharge the batteries (i.e., the Tesla Model S or Nissan Leaf).

The attraction of BEVs to government officials is the zero emissions characteristics of the vehicles. Requiring the on-board combustion of no fuels, these vehicles are essentially silent and contribute nothing to the direct-emissions of criteria air pollutants or greenhouse gases. (Indirect emissions created by electricity generation are a source of debate concerning BEVs, but government policies that encourage the adoption of BEVs are primarily focused on the direct emissions of the vehicles. Addressing indirect emissions are the subject of other government programs.) Government incentive programs range from tax credits for the purchase of BEVs to single passenger access to carpool lanes on the highways.

The attraction to consumers of BEVs is the efficiency of the vehicles. By enabling the consumer to avoid purchasing "expensive" commercial fuel products and recharge their vehicles at home, BEVs present consumers with an affordable alternative. Many BEVs are marketed as delivering up to 100 miles-per-gasoline-gallon-equivalent, which is a very attractive attribute for the consumer when compared to a 2012 fleet average fuel economy rating of less than 25 miles per gallon.

But BEVs come with their own unique challenges. Recharging current battery technology takes a long time, ranging from a couple of hours with a commercial grade Level 2 charger to more than eight hours with a common household outlet. In addition, range is limited with most BEVs boasting a maximum mileage of less than 100 miles per charge, compared with more than 300 miles for most ICE vehicles.

For consumers who do not have access to a secure electric outlet to recharge their vehicles at home, the options are limited. While the network of public recharging stations in the nation is growing (DOE reports 6,571 in the United States as of September 2013), they remain limited and the time frame required to recharge a vehicle does not necessarily instill confidence in consumers. These facilities are more likely to be used for supplemental charging by consumers who are able to provide the primary charge capacity at their residence or place of work.

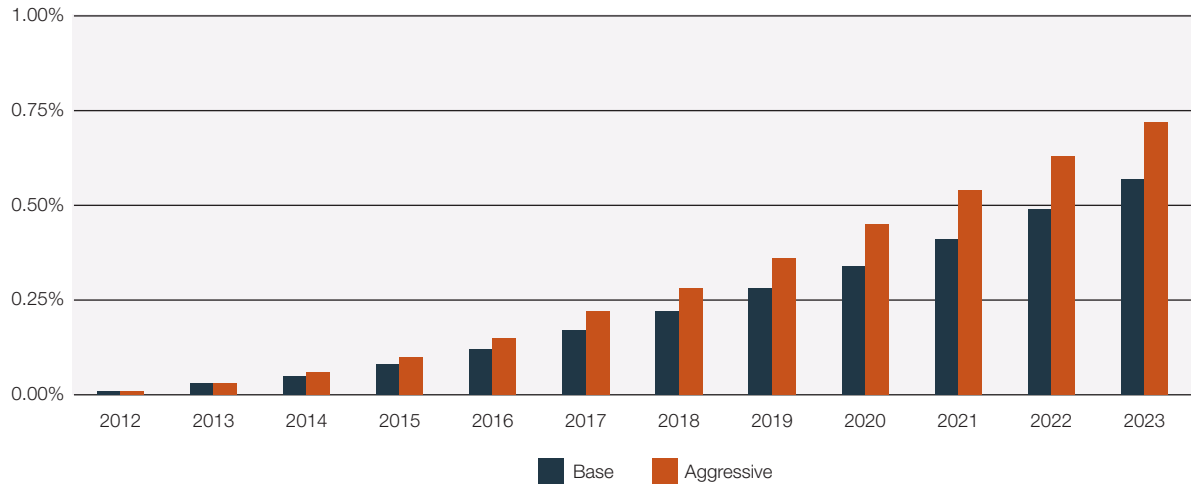
Despite these limitations, the attraction of BEVs remains. In its 2013 Annual Energy Outlook, EIA was extremely optimistic about the growth of this vehicle market, although the majority of market growth occurs after 2025. Navigant similarly forecasts limited growth in this segment over the next 10 years.

Navigant's forecast for the number of BEVs registered in North America is based on a number of key assumptions including: increasing vehicle model availability, government influence on the market, increasing vehicle range and decreasing prices, increased gasoline and diesel costs, and the overall LDV market and economics. In the base forecast, Navigant expects that 14 BEV models will be available by 2015, increasing to more than 25 by 2020. In addition, the segmentation of BEV availability is expected to widen during the forecast period to include more light trucks.

Within both the base and aggressive forecasts, Navigant is assuming that the current level of incentives will remain in place to 2020. While BEVs are not anticipated to see significantly lower prices through 2020, the cost savings from vehicle and battery production efficiencies will be dedicated toward improving the battery energy density, vehicle range, and charge times. After 2020, Navigant is expecting these cost savings to be passed through to the consumer in the form of lower vehicle prices to compensate for a reduction in government purchase incentives.

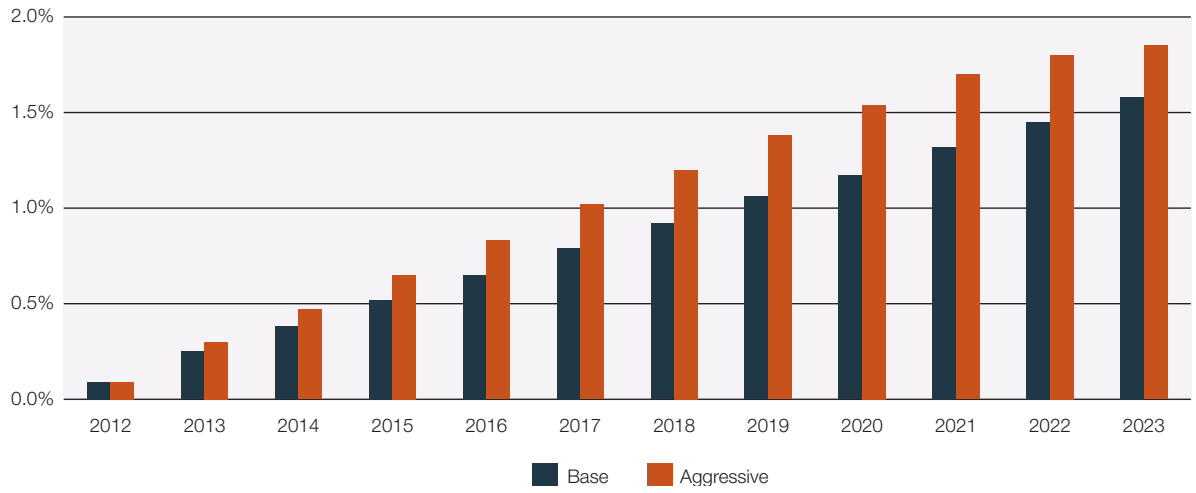
Navigant does forecast a relatively strong increase in LDV market share for BEVs, building from just 0.01% of the market in 2012 to 0.57% and 0.72% in 2023 in the base and aggressive cases. This improvement in market presence is supported by a forecast 22- to 26-fold increase in BEV sales over the next decade.

## BEV Share of LDV Registrations




(Source: Navigant Research)

## BEV Share of LDV Sales




(Source: Navigant Research)

## Fuel Cell Vehicles

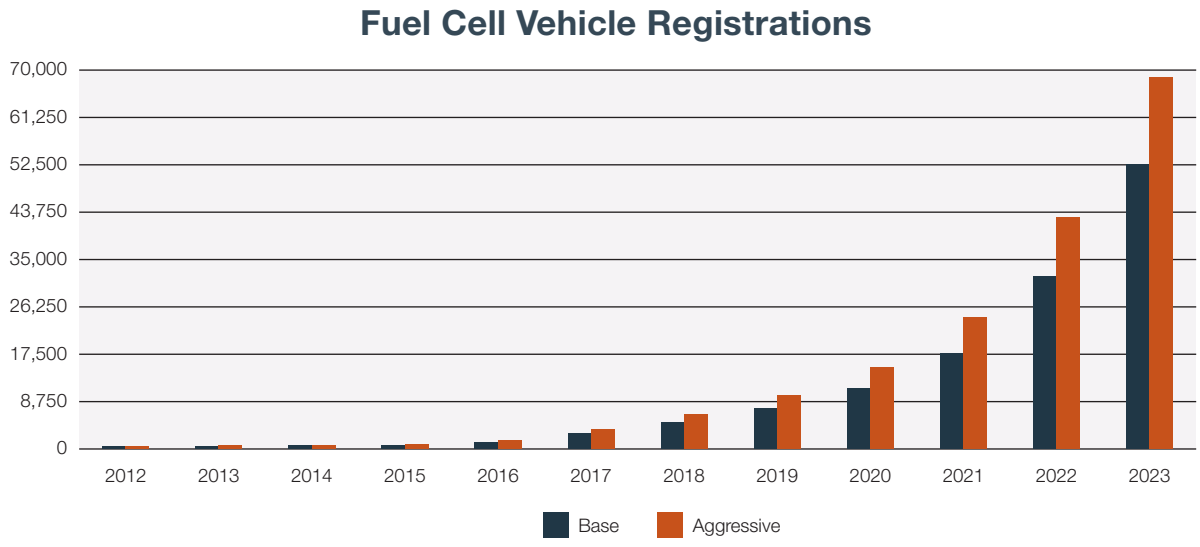
Fuel cell vehicles (FCVs) are electric vehicles that use an external fuel source, like hydrogen, to create an on-board chemical reaction to generate the electricity that powers the vehicle. Fuel cell technology for LDVs remains in a pre-commercial stage. Hyundai is currently leasing vehicles in Europe with plans to expand to the United States in 2014, while Honda and Daimler are already leasing in the United States. A few other auto manufacturers such as Toyota and General Motors (GM) have demonstration models. For several years, the industry's target date for commercialization has been 2015. Daimler recently pushed back its commercialization target to 2017, due in part to infrastructure roll outs in California.

Nonetheless, auto manufacturers continue to pursue FCVs as part of their portfolio. FCVs provide the ability to offer a zero emissions vehicle (ZEV) in a larger platform than a BEV, with a range comparable to an ICE, and in a vehicle that can be refueled in three to seven minutes. A major driver for auto manufacturers is the ZEV mandate in California and other states. As long as these policies remain in place, it is likely that manufacturers will continue to invest in fuel cell technology.

FCVs have largely overcome the technical barriers to commercialization, but the key issue is getting vehicle cost down to no more than $50,000 – the stated target for several automakers. Daimler has said that it is targeting a price equal to that of a diesel hybrid. This early price premium will limit the demand for FCVs.

Beyond cost, infrastructure is the other major barrier for FCVs. Original equipment manufacturers (OEMs) have indicated that an FCV driver must have a fueling station no more than five miles from his or her home. While California is moving ahead on infrastructure roadmaps, the progress has been slow. If stations are not in place, manufacturers will severely restrict the number of vehicles they roll out in 2015. For this reason, Navigant has a very conservative sales projection for 2015-2017, as it seems unlikely infrastructure roadmaps will be met. As a result, this market is not projected to take off until after 2020. In the aggressive forecast, Navigant assumed that the FCV infrastructure roadmap in California is met and other states move toward infrastructure roadmaps as well.

Navigant forecasts exponential growth in the FCV market, but from a 2012 starting point of approximately 500 vehicles. By 2023, Navigant projects North American FCV registrations will eclipse 50,000 and approach 70,000 in the base and aggressive cases. This still only represents a market share of 0.02% in either case. The potential for FCV growth will likely not be realized until years beyond the extent of this forecast, but the attraction of these vehicles in terms of environmental performance, vehicle performance and consumer interface will continue to inspire investment by vehicle manufacturers.




(Source: Navigant Research)

## Summary

The growth in alternative drivetrain vehicles is accelerating in the next decade, but significant market share for anything other than petroleum-powered ICE vehicles will take longer to develop.

For the LDV market, gasoline ICE vehicles will continue to dominate the market, although overall market share could decline to as low as 82% of vehicle inventories in 2023. In the M/HD market, diesel ICE vehicles will remain supreme, representing at least 94% of the market. Meanwhile, diesel fuel will begin to capture more of the LDV market, potentially commanding nearly 7% of the market while FFVs capable of operating on E85 could expand to more than 9%.

Despite this continued dominance of petroleum based vehicles, alternatives are gaining traction. Government programs supporting the development of BEVs will inspire consumer gravitation to these vehicles, resulting in as much as a 26-fold increase in sales. Yet infrastructure and vehicle limitations remain, constraining overall market share to less than 1%.

Natural gas is the current hot topic throughout industry and investments in vehicles and refueling infrastructure are increasing. Growth is projected to be strongest in the M/HD sector rather than among LDVs, with CNG showing the greatest potential for growth over the next 10 years, potentially growing to nearly 4% of the M/HD market by 2023.

Meanwhile, continued investments in the development of FCVs will likely not show appreciable market penetration until after the forecast period, but it is clear that some progress will be made in the next 10 years. And propane will likely remain a niche market with its greatest use found in the M/HD sector.

The market is changing, albeit slowly. Consumers seem to be more open to alternatives than ever before for a variety of reasons, including economics and the environment. Certain hurdles must be overcome for any of the competing alternatives to successfully gain market share. These include the reduction of vehicle cost, conveniently available refueling infrastructure, expanded vehicle range and overall consumer familiarity with and confidence in the new technology.

All of these hurdles can be overcome in time, but it will require strategies spanning multiple industries to ensure that the consumer realizes the full benefit of the new technologies. Ultimately the consumer will determine what fuels and vehicles will dominate the market of the future. What is clear today is that their choices are becoming more varied. From the alternative fuel vehicles to better performing ICE vehicles, consumers have more options than ever and where they choose to invest their money will determine the future.

# List of Acronyms

| | |
|---|---|
| **AFV** | Alternative Fuel Vehicles |
| **BEV** | Battery Electric Vehicle |
| **CAFE** | Corporate Average Fuel Economy |
| **CNG** | Compressed Natural Gas |
| **DOE** | U.S. Department of Energy |
| **EIA** | U.S. Energy Information Administration |
| **EPA** | U.S. Environmental Protection Agency |
| **FCV** | Fuel Cell Vehicle |
| **FFV** | Flexible Fuel Vehicle |
| **GDP** | Gross Domestic Product |
| **ICE** | Internal Combustion Engine |
| **LDV** | Light Duty Vehicles |
| **LNG** | Liquefied Natural Gas |
| **M/HD** | Medium and Heavy Duty Vehicles |
| **NACS** | National Association of Convenience Stores |
| **NGV** | Natural Gas Vehicle |
| **OEM** | Original Equipment Manufacturer |
| **OPIS** | Oil Price Information Service |
| **RFS** | Renewable Fuel Standard |
| **RIN** | Renewable Identification Number |
| **VMT** | Vehicle Miles Traveled |
| **ZEV** | Zero Emissions Vehicle |

# List of Figures

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