

**Testimony of John Eichberger,  
Executive Director, the Fuels Institute,  
before the  
House Energy and Commerce Committee's  
Subcommittee on the Environment  
at a hearing entitled,  
"The Future of Transportation and Fuels,"  
March 7, 2018**

## Summary of Testimony

- The vehicles and fuels market will change, but absent significant influence from an external factor (such as government policy) it will likely take decades before major shifts in the composition of the vehicles on the road or the fuels that power them will be achieved.
- If every vehicle sold today were equipped with a new technology, it would take about seven years before the new feature is present in more than 50% of the vehicles on the road—and that is assuming 100% immediate and persistent market adoption.
- Even when assuming a very aggressive rate of growth in the sale of battery electric vehicles and plug in hybrid electric vehicles (at 26% annual growth 2017–2025 and 20% annual growth 2026–2035), these vehicles would combine for 42.9% of all LDVs sold in 2035. Yet, because of the overall size of the market, their combined share of registered LDVs by that time is only 10.4%.
- There are several external factors that affect these growth trajectories, including:
  - If oil prices go above \$80 per barrel, retail fuel prices could accelerate consumer interest in alternative vehicles, including electric vehicles.
  - Global announcements to ban some internal combustion engines (especially in China) could hasten the drop in battery prices and incent the auto industry to increase electric vehicle production, thereby influencing the domestic market.
  - If fleets can realize a substantial decrease in annual operating expenses by shifting to electric vehicles, their bulk purchases could accelerate market transition and signal to consumers that these vehicles are viable options.
  - Urbanization introduces new complexities for personal mobility at a time when younger generations are moving to cities and are more open to alternative transportation paradigms. Electric, autonomous on-demand mobility services could become a less expensive and sought-after alternative to personally owned vehicles in some markets, but the system is unlikely to gain national reach in the near term.
  - Advancements in the efficiency of internal combustion engine design, potentially paired with a change in fuel specification, promise to benefit consumers by delivering more miles per dollar, thereby could slow the pace at which consumers may seek out alternative powertrains, like electric vehicles.
- Disruptive events must deliver compelling consumer value, reducing costs and friction in the market to such an extent that it leads to an improved quality of life. Absent such value, consumers are unlikely to rush to abandon traditional systems unless required to do so by an external force. Currently anticipated transportation options do not seem to offer such compelling value to result in transformative, disruptive change in the vehicle and fuels market. Consequently, change is likely to be incremental and take extended time.

## Statement of John Eichberger

Chairman Shimkus, Ranking Member Pallone, members of the Subcommittee, thank you for inviting me to share my perspective with you today regarding “The Future of Transportation Fuels and Vehicles.” My name is John Eichberger and I am the Executive Director of the Fuels Institute. It is my pleasure to share with you my thoughts on the fundamental factors that might shape the future of the market.

### About the Fuels Institute

The Fuels Institute, founded in 2013 by NACS (the trade association representing the international convenience and fuel retailing industry), is a 501(c)4 non-profit research organization focused on publishing peer-reviewed, unbiased research evaluating issues affecting the fuels and vehicles market today and in the future. Led by a diverse Board of Advisors, the organization does not advocate and has no vested interest in how the market develops. Research is commissioned to answer questions that decision-makers in the industry and government might have by providing data and perspectives that can lead to more informed decisions. In addition to publishing unbiased research, the Fuels Institute fosters cross-sector collaborative dialogue and provides common-sense analysis to the issues of the day. A list of our Board of Directors, Board of Advisors and contributing corporate partners and associations is available on our website and is reproduced in each published report.<sup>1</sup> A comprehensive list of our research published to date is available<sup>2</sup>, and a monthly newsletter containing market analysis in blog-form<sup>3</sup> is also available.

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<sup>1</sup> <http://www.fuelsinstitute.org/about.shtm>

<sup>2</sup> <http://www.fuelsinstitute.org/research.shtm>

<sup>3</sup> <http://www.fuelsinstitute.org/news/fuelsforthought/index.shtm>

## **Disclaimer**

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## **Overview**

When evaluating the future of the transportation market, the headlines and forecasts that predict a rapid change in market structure and behavior can be overwhelming. It is important to take this type of information and view it within the context of the existing market to better understand the validity of the predictions. If I could leave you with one message today it would be this: The market will change, but absent significant influence from an external factor, such as government policy, it likely will take decades before major shifts in vehicle composition and the fuels that power them will be achieved.

This is not to dismiss advancements in vehicle technology or powertrain diversification; it is simply a recognition of the size and scope of the current market, the amount of time vehicles remain in service and the nature of human behavior.

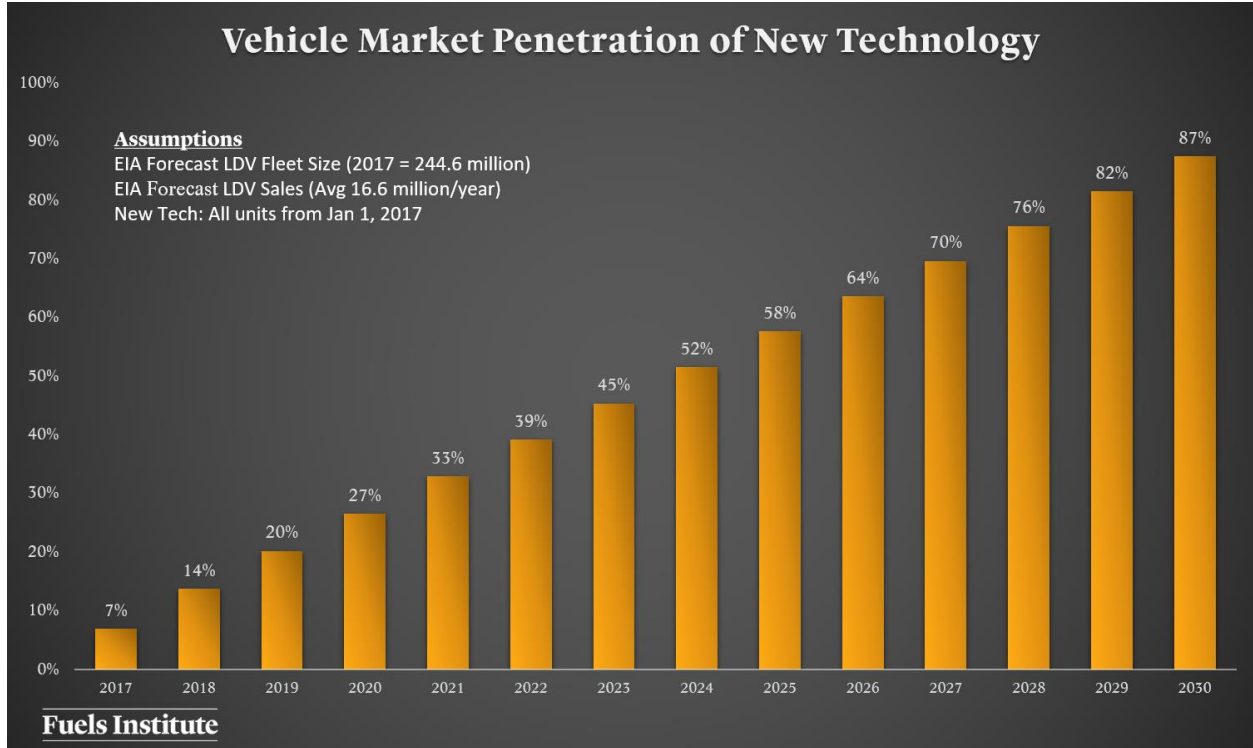
Currently, there are nearly 250 million light-duty vehicles (LDV) registered in the United States. The U.S. Energy Information Administration (EIA) projects that an average of 16.6 million vehicles will be sold each year through 2030, and according to EIA's projections for the size of the fleet, approximately 6% of vehicles on the road will be scrapped each year.<sup>4</sup> What this means is that it will take time before a new technology penetrates the market in a meaningful way. In fact, using these statistics as the foundation, Figure 1 plots the rate of market penetration if a new feature were to appear in 100% of the vehicles sold as of January 1, 2017. As you can see, it would take about seven years before the new feature is present in more than 50% of the vehicles on the road—and that is assuming 100% immediate and persistent market adoption.<sup>5</sup> By way of comparison, total sales of battery electric vehicles (BEVs) and plug in hybrid electric vehicles (PHEVs) combined represented just 1.1% of LDVs sold in 2017.

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<sup>4</sup> <https://www.eia.gov/outlooks/archive/aeo17/>

<sup>5</sup> <http://www.fuelsinstitute.org/news/fuelsforthought/2017/Jun2017-2.shtm>

Figure 1. Vehicle Market Penetration of New Technology



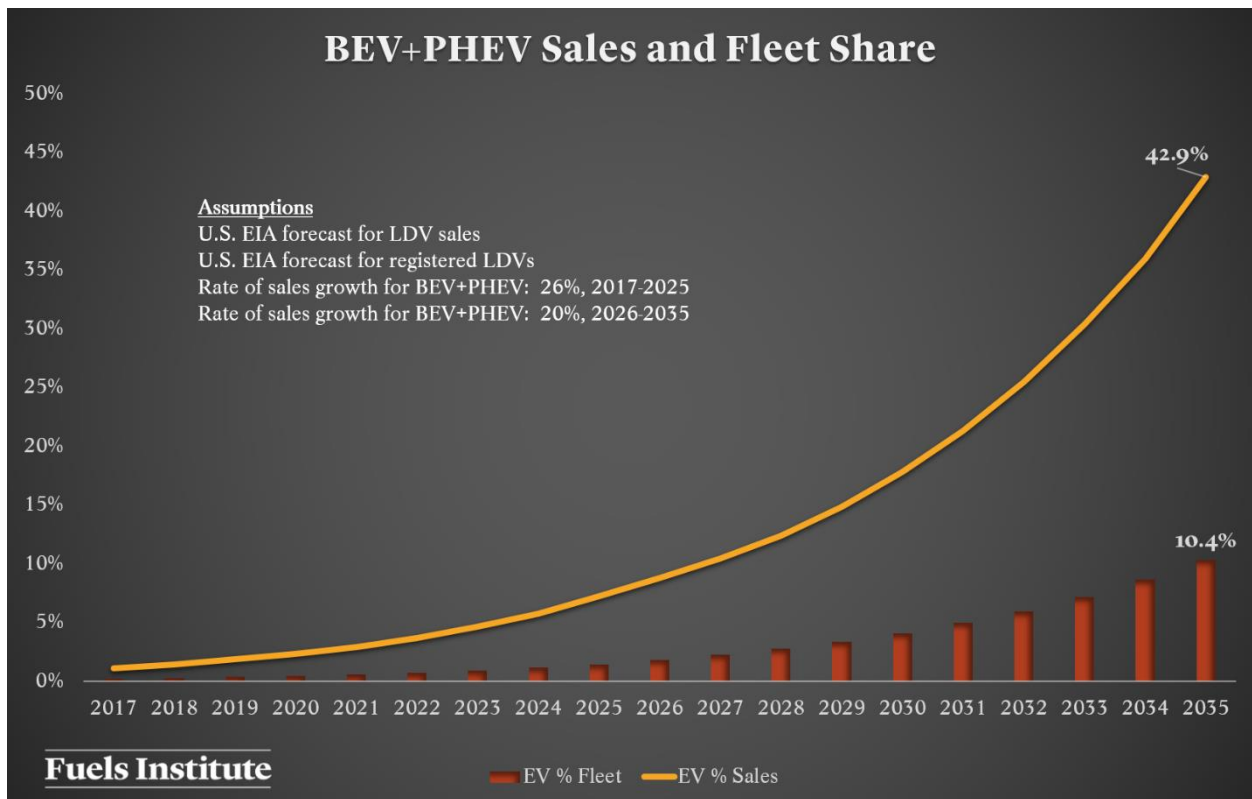
Source: Fuels Institute

Yet the rate of sales growth for these electrified powertrains has been impressive: 26% more BEVs and PHEVs were sold in 2017 than 2016, according to WardsAuto. I believe strongly that these powertrains (BEVs more so than PHEVs) will eventually represent most vehicles on the road, but where I disagree with many headlines and aggressive forecasts is the timing of that eventuality. I believe this future is several decades away because the rate of market conversion is much slower than the rate of vehicle sales growth.

To demonstrate, Figure 2 uses the same EIA data as Figure 1 and plots the share of LDV sales and registered LDVs for BEVs and PHEVs. For this illustration, the 26% rate of growth in BEV/PHEV sales recorded in 2016-2017 is extended annually through 2025. After then, however, because the overall market will have increased to a significant number rendering year-

over-year sales increases more difficult to achieve, the annual rate of growth is decreased to 20% through 2035. This remains a very aggressive forecast and results in BEVs and PHEVs combining for 42.9% of all LDVs sold in 2035. Yet, because of the overall size of the market, their combined share of registered LDVs by that time is only 10.4%. It should be noted also that in 2035, despite selling 7.5 million BEV and PHEV units, the United States will still incorporate into its existing fleet an additional 10 million units of traditional powertrain vehicles.

**Figure 2. BEV+PHEV Sales and Fleet Share**



Source: Fuels Institute

## Factors That Might Affect the Rate of Market Transition

Figure 2 represents what I would consider to be a very aggressive rate of change in the composition of vehicle sales, yet it still affects only a modest change in the overall functioning of

the market. Nearly 90% of vehicles on the road will continue to be powered by liquid fuels in 2035, despite the growth in electrification. But there are external factors that could influence this projection, which may include:

- A sustained increase in crude oil prices
- Global regulatory developments
- Fleet vehicle purchases
- Urbanization, generational shifts and mobility as a service
- Advancements in the efficiency of internal combustion engines

In the following pages, I will explore how each of these factors could change the future of the vehicles and fuels market.

### **Crude Oil Prices**

According to EIA, since 2010 crude oil prices have contributed on average 60% to the retail price of gasoline.<sup>6</sup> When oil prices rise, so do retail gasoline prices and that generates enhanced consumer sensitivity to prices. According to NACS, at the beginning of 2018, after multiple years of relatively low prices, two-thirds of consumers continue to select their fuel retail outlet based on the posted price of fuel, and 38% still say they might drive as much as 10 miles out of their way to save 5 cents per gallon.<sup>7</sup> However, when gas prices are higher, consumer sensitivity is higher and translates into greater interest in alternative fuel vehicles.

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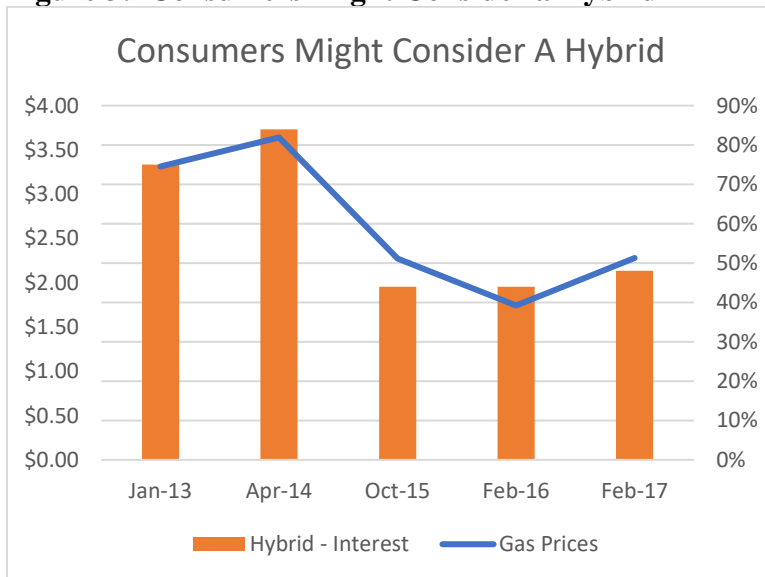
<sup>6</sup> [https://www.eia.gov/petroleum/gasdiesel/gaspump\\_hist.php](https://www.eia.gov/petroleum/gasdiesel/gaspump_hist.php)

<sup>7</sup> Upcoming release in March 2018 issue of *NACS Magazine*



Since 2013, the Fuels Institute and NACS annually ask consumers whether they are in the market to purchase a vehicle in the next few of years and, if so, whether they would consider certain alternative fuel/powertrain vehicles. As Figure 3 demonstrates, when retail fuel prices were above \$3.50 in 2014, 84% of consumers said they would consider a hybrid vehicle. However, when fuel prices dropped to below \$2.00 at the time of the survey in 2016, the percent of consumers who would consider a hybrid dropped to 44%. This level of sensitivity to gas prices and overall interest in alternative vehicles was demonstrated in overall sales of hybrids. Figure 4 shows that when fuel prices dropped, not only did interest in hybrids decline but actual sales did too—from 3.2% of all LDVs sold in 2013 to 1.9% in 2016.<sup>8</sup>

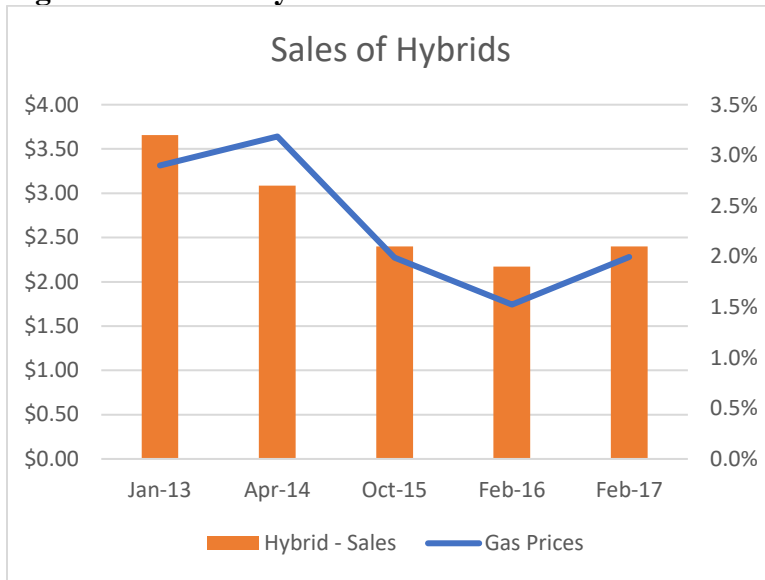
**Figure 3: Consumers Might Consider a Hybrid**



Source: OPIS, Fuels Institute, NACS

<sup>8</sup> [www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Consumers-and-Alternative-Fuels-2017](http://www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Consumers-and-Alternative-Fuels-2017)

**Figure 4. Sales of Hybrids**



Source: OPIS, WardsAuto

While most forecasts are not projecting oil prices to eclipse \$80 per barrel again anytime soon, if this situation were to develop the impact on retail fuel prices, and consequently interest in alternative vehicles, could be significant. Every time Brent oil has been priced above \$80 since 2011, the national average retail price of gasoline has been above \$3.00.<sup>9</sup> A sustained market position of these levels could encourage consumers to consider an alternative fuel vehicle that would deliver more miles per dollar.

## Global Regulatory Developments

The automobile industry is global, with most automakers seeking to strengthen their economies of scale by introducing flexible vehicle architecture to satisfy multiple markets throughout the world. This means that activities in other countries could have residual impact on the United States. For example, recent announcements by several governments—including China, India,

<sup>9</sup> Brent oil price data sourced from U.S. EIA; retail fuel prices sourced from OPIS Retail Fuel Report

United Kingdom, France, Germany, Norway and even domestically in California—to ban internal combustion engines and mandate a transition to electric vehicles could have a profound impact on the manufacturing decisions of global automakers. Although most of these announcements exclude hybrid vehicles from proposed bans, the implications of such policies could be significant. For example, in 2016, Chinese consumers purchased 31.3% of the world’s LDVs, which puts China in a position to exert significant influence on the automotive industry. Further, OPEC projects China and India combined will represent nearly 40% of global gross domestic product (GDP) by 2060. This is an economic power block that cannot be ignored when considering the future of the automotive industry.

To consider whether these nations will remain committed to their stated policy objectives, let’s look at China. The Chinese government is stable and likely to remain in power for several decades, suggesting we might expect consistent policy throughout this timeframe. Further, China has a parochial interest in promoting electric vehicles since it currently produces a substantial share of the world’s BEV batteries, and controls significant shares of the world’s cobalt and lithium reserves. Should China proceed with a ban on internal combustion engines and a mandated transition to electric vehicles, battery costs for BEVs could decline rapidly due to increased production volume, and that automakers considering Chinese market opportunities will increase BEV production. This combination of lower costs and increased production could inspire larger deliveries of BEVs to the United States. The greater availability of potentially more affordable BEVs could increase the rate of consumer adoption of these alternative powertrains.

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In addition to these announcements, 159 nations have signed on to the Paris climate accords and are working to reduce overall emissions to meet their agreed-upon targets. To date, 60 nations are implementing some sort of biofuels program, 40 have a greenhouse gas reduction or fuel efficiency program, 20 contain jurisdictions that have enacted some sort of ban or limitation on internal combustion engines, 13 have established zero-emission vehicle zones, and nearly all have enacted fuel sulfur controls.<sup>10</sup> As nations continue to press forward with global commitments and local government focus their efforts to address air quality, policymakers will look at other markets for guidance and experience. This could result in additional initiatives considered within the U.S. that could disrupt the market trajectory.

### **Fleet Purchases**

Fleet operators represent the potential to inject momentum for change through volume and by example. The Rocky Mountain Institute believes that fleet operators could reduce annual operating expenses by approximately \$1,000 per vehicle.<sup>11</sup> For a fleet manager, who might be in the market to purchase 100 vehicles in a year, this could deliver \$100,000 benefit to his bottom line—a powerful incentive to consider an electric vehicle. Given that modern BEVs can deliver more than 200 miles per charge, recharge in less than an hour and sell for a comparable price as an equivalent internal combustion engine, there is strong potential for fleets to purchase BEVs in larger quantities, contributing to an accelerated market penetration.

Because of a stronger presence of BEVs in the market, fleet adoption could signal to individual consumers that BEVs are viable. Human behavioral sciences suggest that consumers are drawn

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<sup>10</sup> [www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Global-Initiatives](http://www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Global-Initiatives)

<sup>11</sup> <https://www.rmi.org/insights/reports/peak-car-ownership-report/>

to items they are familiar with and used by their peers. If consumers witness fleet operators, who drive more miles per year than most consumers, opting for a BEV, they may be more inclined to consider a BEV. Hence, more rapid fleet adoption of BEVs could have a domino effect that would accelerate market conversion and support consumer adoption.

### **Urbanization, Generational Shifts and Mobility as a Service**

Where people live, who lives there and how they get around can have a profound influence on the composition of the transportation market.

First, younger consumers in the United States behave substantially different than their predecessors. For example, younger consumers are much more inclined to consider an alternative vehicle. In fact, a 2017 Fuels Institute survey found that 66% of consumers age 18-34 would be willing to consider a BEV as their next vehicle, compared with just 47% of consumers age 35-49.<sup>12</sup> But perhaps more interesting is that since 1982, the percent of consumers age 20-29 who have a driver's license declined by 10% to just 81.5% of the cohort.<sup>13</sup> These trends are indicating a significant shift in consumer behavior relative to car ownership and driving.

Compounding this shift in behavior for the younger generation is the overall urbanization of society. The percent of Americans living in metropolitan areas has increased from 56% in 1950 to 84% in 2010. Since 1970, the percent of those age 20-34 who are living in these markets has increased from 33% to 40%, and the trend is continuing.<sup>14</sup> Americans are living in more

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<sup>12</sup> <http://www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Consumers-and-Alternative-Fuels-2017>

<sup>13</sup> [www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Driver-Demographics](http://www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Driver-Demographics)

<sup>14</sup> [www.fuelsinstitute.org/ResearchArticles/Urbanization%20Brief.pdf](http://www.fuelsinstitute.org/ResearchArticles/Urbanization%20Brief.pdf)

concentrated, urban environments, which introduces unique mobility issues such as cost of insurance, parking, congestion and overall convenience.

Capitalizing on this trend have been ride hailing services. With mobility through an urban environment becoming more challenging, and with younger consumers less inclined to drive, mobility has gained significant traction. Most analysts agree that the typical American drives his or her vehicle approximately 5% of the time. The remaining time for that vehicle is spent absorbing resources for insurance, parking and depreciation. Using an on-demand mobility service can be attractive to many as an alternative to such burdens of vehicle ownership.

Deloitte research suggests that 23% of Americans report using a ride hailing service at least once per week, and this number jumps to 44% for Generations Y and Z. Of those in Generations Y and Z who use a ride hailing service, 64% question their need to own a car in the future.<sup>15</sup>

Members of these generations know a market that included electric vehicles and do not have historic concerns about the technology. They are also looking for an alternative to driving and are accepting of new technologies and services.

Rocky Mountain Institute suggests that autonomous, electric vehicles could reduce costs of on-demand mobility services to such an extent that such services could become less expensive than owning one's own car.<sup>16</sup> RethinkX published a paper predicting that mobility services would be 10 times less expensive than owning a car.<sup>17</sup> And Deloitte predicts that by 2040, total LDV sales

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<sup>15</sup> Ryan Robinson, Deloitte, presentation at Fuels Institute Annual Meeting, May 2017, Denver, CO

<sup>16</sup> <https://www.rmi.org/insights/reports/peak-car-ownership-report/>

<sup>17</sup> <https://www.rethinkx.com/transportation>

could drop to about 11 million per year, of which only about 4 million will be personally owned and driven vehicles, with the remaining a mix of on-demand services and personally owned autonomous vehicles.<sup>18</sup>

In November 2017, Bob Lutz, former Vice Chairman of General Motors, wrote an op-ed in which he predicted that electric, autonomous on demand mobility services would soon dominate the transportation sector. In fact, he predicts that the compelling value (in terms of economics and safety) would result in legislation removing the right of Americans to drive their own vehicles within 20 years.<sup>19</sup>

I personally do not subscribe to forecasts in which on-demand mobility will supplant personally owned vehicles within 20 years, or even within 50 years, but the prospects for this type of mobility solution gaining roots in certain markets and then growing in the near term cannot be ruled out. Local governments and planning commissions are seeking ways to address traffic congestion, to reduce the need for more parking spaces and to enhance the overall value of mobility. It is possible that these concepts could find their way into near- and long-term city plans, and it is nearly a foregone conclusion that electric and autonomous vehicle technology will be available when such plans are enacted. There is an opportune intersection occurring within the next 10 years where these vehicles will be capable and affordable, consumers will be ready and willing and the needs of these local governments will be acute enough to warrant new mobility paradigms gaining traction.

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<sup>18</sup> Ryan Robinson, Deloitte, presentation at FUELS2017, Fuels Institute Annual Meeting, May 2017, Denver, CO

<sup>19</sup> [www.autonews.com/article/20171105/INDUSTRY\\_REDESIGNED/171109944/industry-redesigned-bob-lutz](http://www.autonews.com/article/20171105/INDUSTRY_REDESIGNED/171109944/industry-redesigned-bob-lutz)

While the overall impact on the market cannot be projected because the number, scope and market reach of these programs is unknown, the Rocky Mountain Institute suggests that there are 26 potential early market adopters of such services with a potential market capitalization value of \$120 billion.<sup>20</sup> Hence, there are dozens of companies investing in the development of capabilities and business opportunities for delivering a shared, autonomous and electric mobility solution, which only enhances the potential.

### **Advancements in Internal Combustion Engines**

Most external factors that could affect the market that have been addressed thus far would serve to accelerate the pace of market transition away from traditional modes of transport. But despite the public announcements of automobile manufacturing companies of their intent to transition to electrified fleets, engineers have remained diligently at work to improve the internal combustion engine. This is not a contradictory situation, however. Electrification does not necessarily mean BEV and PHEV, as most auto company announcements include hybrids, which operate primarily on an internal combustion engine. And, if my projections for the rate of market conversion are close to reality, the need for enhanced efficiency in a 100+ year-old technology is critical because it will continue to dominate the fleet for decades to come.

In this space, automotive engineers are doing remarkable things to improve vehicle efficiency. They are using high strength steel to reduce weight, increasing the number of gears in transmissions, testing aerodynamics in advanced wind tunnels, and they are changing the engine. Many are using techniques that change intake valve timing to reduce the fuel-air mixture is

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<sup>20</sup> <https://www.rmi.org/insights/reports/peak-car-ownership-report/>



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ignited in the cylinder. Because this improves efficiency but reduces power and performance, automakers are pairing this approach with hybrid systems or turbo boosts, which ensures the driver receives the power necessary but reduces fuel consumption when possible.

In addition, two companies (Nissan and Mazda) have taken internal combustion engine design to a new level. Nissan has introduced an engine (VC-Turbo) that will adjust the compression ratio (CR) of the piston stroke to accommodate performance needs. When more power and torque are necessary, the CR can drop to as low as 8:1. This is not the most efficient mode, but it delivers power when needed. When more efficient operation is desired, the CR can increase to 14:1. Pairing this technology with a turbo boost ensures adequate performance throughout the drive cycle and reports indicate potential efficiency improvements of more than 20%.

Meanwhile Mazda will introduce an engine (SkyactiveX) next year that features a compression ignition gasoline system. Mimicking a diesel engine, this system compresses the fuel-air mixture almost to the point of auto-ignition and then uses a spark assist to ensure optimal timing of combustion. The spark assist protects against knock, but the compression system improves overall thermal efficiency. I have read reports suggesting efficiency gains of 20% to 40% with this engine.

Other automotive engineers are focusing on the optimization of an engine design to maximize efficiency with a high-octane fuel. Auto engineers, biofuel producers, petroleum producers, the Department of Energy's Co-Optimization of Fuels and Engines (a joint effort of 11 national

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laboratories; I serve as External Advisory Board member)<sup>21</sup> and others have spent years evaluating the relationship between octane and engine design to determine that significant improvements in overall efficiency, performance and emissions can be obtained if internal combustion engines are designed to operate specifically on a higher octane fuel and do not need to accommodate alternative, lower-octane products. The Fuels Institute will be releasing a study in late spring evaluating the production capabilities of fuel producers to produce sufficient volumes of specific high-octane fuels and the market's ability to deliver such fuels to consumers. Preliminary results indicate there might be a trade-off between the most cost-efficient production options and the most cost-efficient distribution and retailing options. Much of the discussion to date has centered around the potential role for ethanol in such a market.

Each advancement in the efficiency of the internal combustion engine extends its life in the market and that of liquid fuels. Automakers are focused on achieving the emissions reductions and vehicle efficiency targets set forth by government and will use the technologies available to comply in the most cost-efficient manner possible. This may include electrification at some point, but it must include engine advancement as well.

### **Conclusion**

The vehicle and fuels market is dynamic, with many stakeholders engaged in multiple initiatives designed to deliver compelling value to the consumer. Media outlets continue to rally around corporate and government announcements, new research papers and thought-leader statements that pronounce disruption to the traditional model of transportation and energy. Yet, when we

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<sup>21</sup> <https://www.energy.gov/eere/bioenergy/co-optimization-fuels-engines>

look beyond the headlines and the hype, the market that is supposedly subject to disruptive and radical change won't get there in the next few decades without considerable external prodding.

The fundamentals of the market demonstrate that meaningful change will take time. Changing today's transportation system will not be like introducing a car engine to replace the horse and buggy, or the introduction of the smartphone to ultimately replace a wallet and personal computer. The major difference is this: Each example of a major, successful disruptive event delivered compelling, immediate and tangible value to consumers that improved their quality of life in some real way. What transportation paradigm shift could do that?

Currently, I do not see overwhelming evidence that the consumer is inclined to drive a significant pace of change, so it falls to external forces to influence the pace of change. In the absence of aggressive policies or market forces inspiring an acceleration in market transition, it is most likely that the internal combustion engine will remain the dominant powertrain in the U.S. vehicle fleet for the next several decades. And although BEVs will continue to gain market share, perhaps at a very fast pace, and alternative mobility solutions are likely to emerge in certain regions and markets, the fundamental structure of the market will evolve slowly.