



## 2016 Top Markets Report **Automotive Parts** Sector Snapshot

### New Technologies

Rapid technological advances are having profound effects on the global automotive industry. The impacts will alter the way humans and vehicles interact and can possibly fundamentally alter the light vehicle market itself.

Public policy has acted to spur sales of alternative fuel and zero emission vehicles, pushing an ongoing shift toward more diverse fueling and drivetrain technologies. At the same time, technological improvements in advanced drivetrain technologies are moving them to the mainstream.

Likewise, advanced computing, telecommunications, sensors and learning technologies are morphing the way people will interact with vehicles and how vehicles will interact with the environment. While most of these technologies will debut in advanced economies first, they will quickly spread to other regions.

#### **Advanced Engines, Drivetrains and Vehicle Construction**

Public policy is helping to push alternative fuels and fuel-related technologies by creating markets and mandating product availability. The policies often have a number of overlapping goals, including point and carbon emission reductions, employment, or improved energy security. Vehicle efficiency and carbon emission reduction regulations are becoming more stringent and, thereby, continuing to push manufacturers to increase their level of investments. Most have been focusing on reducing weight and advancing engine technologies.

Automakers are reducing vehicle weight through such things as advanced composites, high strength metals and smaller, more efficient electronics. By

reducing weight without reducing size, light weighting can improve vehicle efficiency while maintaining space for energy absorption, thereby maintaining levels of safety while also providing similar consumer utility. The advantages of light weighting for fuel efficiency are self-reinforcing. Reducing weight lowers the amount of energy needed to move and stop the vehicle for equivalent performance. Each decrease allows further decreases elsewhere. For instance a lower vehicle weight requires smaller brakes, allowing further decreases in the weight of brake components which further reduces weight.

Firms have also been focusing on increasing the efficiency of internal combustion engines. Achieving the same level of power in a smaller, lighter package contributes to the “virtuous cycle” of vehicle light weighting. In addition to the benefits of lighter weight, smaller engines also have lower internal friction, and in gasoline engines, they have smaller pumping losses. Companies are increasingly using turbochargers, advanced ignition, variable valve technology and direct fuel injection to increase the power at any given displacement and enable engine downsizing. They have been using advanced transmission technologies to help those engines run in their most efficient ranges while losing less energy transmitting the power to the road. Lowering the operating range of an engine (the difference between its fastest to slowest revolutions) generally allows engineers to achieve higher power and economy from a given engine displacement. Seven, eight or even nine speed transmissions allow engines to be designed for a smaller power curve than five or four speed transmissions. Continuously variable transmissions allow engineers to tune the engine for constant operation. Traditional clutches and torque converters either slip constantly or slip during the changing of gears, thus wasting engine power. Dual

clutch transmissions allow power to remain engaged, saving the energy usually lost to slipping.

## Fuels

Public policy has also been important for the expansion of markets for alternative fuels. Many nations globally mandate the use of biofuels in their fuel supply. The U.S. Renewable Fuels Standard requires EPA to set certain amounts within the U.S. fuel supply based on technology and availability. There are relatively few differences from a vehicle drivetrain technology and production standpoint, so costs are low on a per vehicle basis. There are, however, significant infrastructure costs and production constraints. Biomass-based gasoline and diesel fuels, which have essentially the same basic fuel properties of current petroleum-based fuels, avoid nearly all of those vehicle cost and infrastructure issues but continue to have high relative costs and face production constraints.

Low U.S. natural gas prices are leading to increased use of commercial fleet vehicles. Gas-based fuels present on-board storage packaging problems due to their low density. The low density currently necessitates relatively expensive and large high-pressure tanks, which have significant packaging issues, or liquefaction, which has boil off and insulation issues. Automotive conversions generally lose much of their trunk volume. The low density also leaves these vehicles with limited range. Natural gas vehicles also face considerable infrastructural barriers. Use of natural gas as a vehicle fuel is substantial in Germany, Argentina, Brazil, Venezuela, India, Pakistan and Iran.

Diesel is the main alternative fuel to gasoline worldwide with ubiquitous use in the commercial sector. Several European firms with significant investment in the technology have been focusing on expanding the market for diesel-fueled vehicles in the light vehicle sector. While it is still petroleum-based, the technology for its use is widely available, and increasing its use can reduce oil consumption. Diesel engines can provide 25 percent more fuel efficiency and more torque at lower rpm than gasoline engines, though emission reduction technologies can reduce that amount considerably. Due to thicker castings and higher quality components needed to withstand the higher pressures and torque of diesel combustion,

comparative diesel engines tend to be more expensive to produce and have higher upfront costs for consumers. The lower fuel costs from increased efficiency, however, can usually pay back those increased upfront costs over time.

Diesel engines account for approximately half of the European market, largely due to public policy, which included tax advantages that make diesel fuel cheaper versus gasoline in Europe. Diesels have not been popular in the United States, accounting for less than one percent of light vehicle sales, in part due to poor consumer perceptions regarding diesels caused by offerings from the 1980's. Emissions concerns were already leading to moves to end public policy support for diesel in Europe, but recent disclosures that Volkswagen had illegally cheated on emissions compliance in the United States has probably ended any hopes of greatly expanding the market globally. Other countries have opened investigations as well. In fact, Volkswagen has recently committed to expanding its electrified vehicle offerings. According to CEO Matthias Müller "The car of the future ... is electric."

## Electrified Vehicles

The increasing stringency of vehicle efficiency and carbon emission reduction regulations are also helping to push the manufacture of electric drive technologies, though other mandates and incentives are also playing a role. One of the main policies advancing electric drivetrains globally is the California Zero Emission Vehicle mandate. The mandate has forced manufacturers to market plug-in or fuel cell vehicles, improving the viability of those vehicles. California's mandates will begin to escalate in 2018, and by 2025, roughly 1 in 7 new vehicles (1.4 million) sold in California will be a plug-in or hydrogen fuel cell vehicle. Norway also has significant purchase incentives, including major tax reductions for plug-in vehicles. Due to those major incentives, plug-in vehicles are already roughly a third of new car sales in the country. China is also pushing electrification of its vehicle fleet with significant purchase incentives as well as incentives for the production of vehicles, including allowing the entrance of new manufacturers.

Many firms continue to explore hydrogen fuel cell vehicles. Fuel cells produce electricity through a chemical reaction. In this way fuel cells are electric

vehicles with a different energy storage system. Like plug-in vehicles, fuel cells offer low direct emissions in comparison to conventional vehicles. If pure hydrogen is used, the only direct byproduct is water vapor. This clean “tailpipe” has long been one of the chief reasons to pursue hydrogen fuel cell vehicles. Several automakers have been offering small numbers for public consumption. Limited fueling infrastructure and high costs, in part due to extremely low volumes, have prevented significant uptake.

While hybrid vehicles have been available for almost two decades and many manufacturers offer at least one model, only Toyota has been able to make them a significant portion of their sales. Hybrid power systems use their electric drive components to recapture energy and to augment their petroleum-fueled engine, allowing the engine to operate in higher efficiency ranges. Like most efficiency related technologies, the added costs of the technology are faced at the time of purchase while lower operating costs are seen over time. While hybrids provide substantial improvements in efficiency over internal combustion engine driven vehicles, greater reliance on electrical energy to drive vehicles could provide much greater gains in transportation efficiency and fueling costs.

Batteries and electric motors are highly efficient in their storage and use of electricity. Likewise, the large turbines at electrical power generation stations achieve much greater efficiencies than the internal combustion engines found in regular automobiles. Charging vehicles from the electrical grid allows them to benefit from the greater efficiencies of the large power generation stations and the fact that there are multiple fuels feeding the grid, causing substantial fuel price competition. The result is plug-in vehicles have lower emissions per mile using the average U.S. power generation mix of electricity than even typical hybrid vehicles. They are generally much cheaper to operate; until recently, however, the cost of batteries has made plug-in vehicles significantly more expensive. To provide vehicles with a similar purchase price, the vehicles generally had to have lower ranges (roughly 100 miles or less for battery-only vehicles). Alternatively, they have offered plug-in hybrids with even lower ranges (40 or less miles) that carry an internal combustion engine and associated systems with the additional packaging and cost constraints present.

Dramatic cost reductions over the last few years have significantly reduced all plug-in vehicle production costs. The reductions have been so large that plug-in vehicles appear to have already attained purchase cost competitiveness at the high end of the vehicle market with Tesla outselling all of its competition in the U.S. market. They appear close to achieving similar purchase cost parity with the middle of the market over the next few years. GM plans to bring to market its 2017 Bolt EV at a sales price of \$35,000 at the end of 2016. It will have an expected vehicle range of over 200 miles. This is roughly the U.S. average vehicle sales price, and vehicle-use surveys indicate the consumer utility at this range is high enough for most U.S. vehicle travel. Since the United States has some of the highest miles traveled rates in the world, the range should also cover most global usage. A number of other manufacturers are promising similar offerings by 2018. Likewise, the same technological advances that have led to lower cost and higher range in plug-in only vehicles has led to reduced costs and lower packaging constraints for plug-in hybrids.

Charging infrastructure is already significantly further advanced than all the other non-petroleum alternatives to petroleum. Nearly 50 percent of U.S. households have access to outdoor plugs, enabling a large potential market for early adoption. The load of a typical vehicle charging to cover normal usage is similar to a washing machine running overnight. As such, even standard 110 volt outlets can provide enough energy for 80 percent of trips via overnight charging. Nonetheless, improvements will need to be made to accommodate very large numbers of plug-in vehicles, and vehicle charging infrastructure is a constraint in markets without consumer-owned parking. There should be time to accommodate those changes. It takes roughly 15 years to turn over the U.S. vehicle fleet, so even if plug-in vehicles were to be 100 percent of 2016 sales, it would be 2031 before the fleet would be fully plug-in capable.

### **Other Technologies**

New technologies are increasingly merging the automotive market with other fields and industries. For instance, companies are beginning to provide electric grid stability services (helping maintain grid voltage levels) by increasing or decreasing the charging of groups of plug-in vehicles. Likewise, the line between consumer electronics and automobiles

is increasingly blurring. There are increasing levels of infotainment, electronics and telecommunications technologies being embedded in vehicles. Not only are automotive firms increasingly participating in the Consumer Electronics Show in Las Vegas, but GM first announced its new Chevy Bolt there, which indicates the level of influence that these changes are having. These changes include the integration of smartphone technology for both convenience and safety and the offering of internet hotspots in some vehicles.

The vehicles themselves are starting to communicate with each other, the road and, potentially, consumers. Enabling vehicle-to-vehicle communications allows automobiles to warn each other of otherwise unseen dangers. Allowing vehicle-to-infrastructure communication makes possible traffic signals that switch to green as traffic approaches. Vehicle-to-other-communication allows the vehicle to know the movement of individuals based on the smart phone in their pockets.

Vehicles are also beginning to drive themselves. Most firms already offer vehicles that provide a number of autonomous functions. These include adaptive cruise control systems that adjust speed to maintain safe following distances or active safety braking systems that detect and avoid crashes. The addition of improved sensor technologies, increases in computing power, more accurate maps and ongoing research are quickly closing the gap between these systems and full automation. The software in these vehicles will not be perfect, but the computers will not suffer from distraction and will have significantly faster reaction times than human drivers. They are expected to lead to dramatic reductions in accident rates. Showing how the vehicle and consumer electric markets are merging, Google, on the flip side of vehicle manufacturers, has logged over a million miles in its self-driving vehicle. The Silicon Valley start-up, Tesla, is already offering some of the most sophisticated vehicle automation options currently available in its

“Autopilot” highway driving and “Summons” self-parking feature suite.

Fully automated vehicles could completely change the automotive market. They could provide extremely low-cost on-demand transportation services, displacing most, if not all, taxi, bus, limo and truck drivers. They could dramatically reduce the number of vehicles needed for equivalent levels of service by, for instance, providing taxi or bus services during the peak commuting periods and offering package delivery services during off peak times with no driver rest requirements. This would mean a substantial contraction in vehicle and parts manufacturing in addition to the changes to the vehicle service markets. Autonomous vehicles can dramatically reduce the need for vehicle parking, making valuable city land available for other uses. With reaction times in milliseconds and communications with vehicles around them, they can enable increased throughput on roads and highways. They can also travel at much closer distances, enabling platooning to slip stream for reduced air drag on the highway and improve highway energy efficiency. They could also reduce interregional rail and air travel by making longer road travel less burdensome (and counteract possible congestion reduction benefits noted above).

#### Top Opportunities:

- Weight reduction technologies
- Advanced engine control technologies
- Turbos
- Advanced transmissions
- Vehicle accessory electrification technologies
- Sensors
- Advanced batteries and battery inputs
- Advanced electronics