

The future of the car

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64 MPH



ENERGY

The race to make a cleaner car

p.14

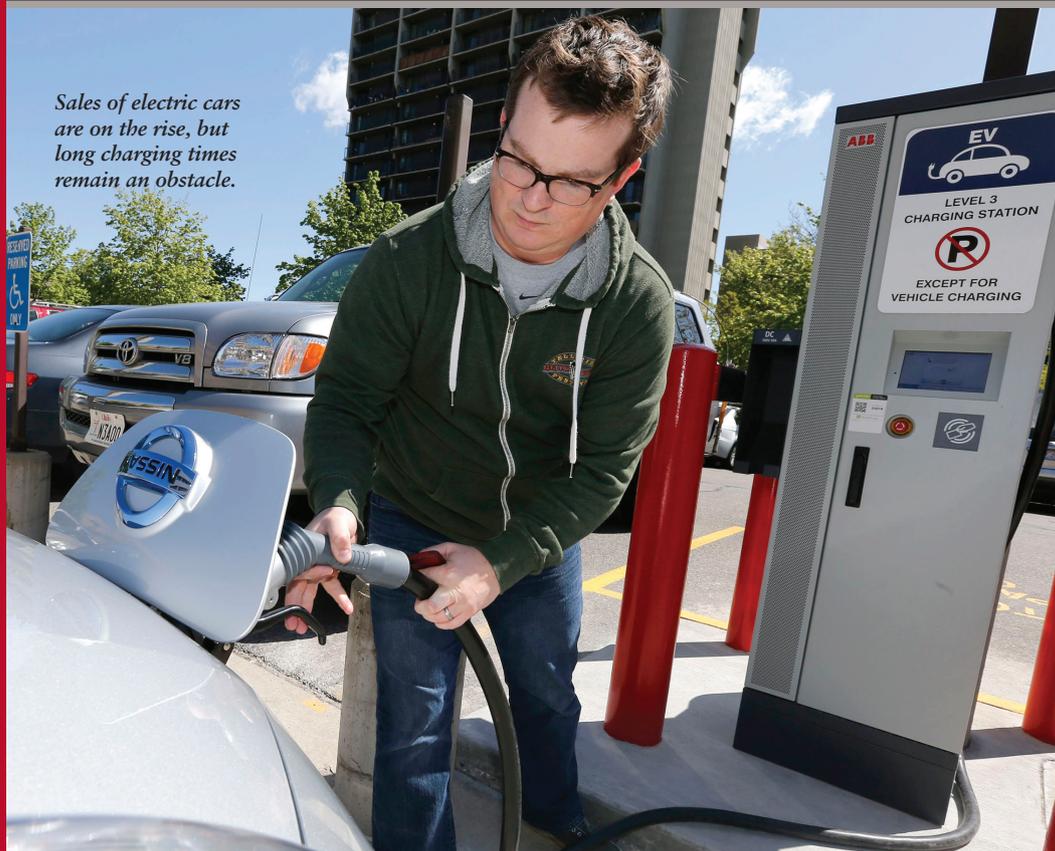
BRIEFING

When will driverless cars hit the road?

p.16



Sales of electric cars are on the rise, but long charging times remain an obstacle.



but not enough to take a long road trip or an overnight excursion. Tesla's much-heralded Model S sedan can travel well over 200 miles between charges, but its \$70,000 base price turns off the vast majority of car shoppers. And despite electric vehicles' recent surge in popularity, they still account for less than 1 percent of U.S. vehicle sales.

Batteries remain the main obstacle. While you can fill a traditional car with gas in just a few minutes, a Nissan Leaf hooked up to a public "quick charger" requires more than 30 minutes to fully recharge—a figure that increases to four to six hours when the car is plugged in to a 240-volt outlet like the one you might have installed in your home. Worse, batteries wear out over time, so that an electric car's range deteriorates as the car gets older. Replacing the battery pack could easily exceed \$5,000.

Automakers continue to

explore other alternatives. Some companies, such as Toyota, consider hydrogen fuel-cell technology, which converts hydrogen into electric power without any harmful emissions, to be the most promising next-generation fuel source. "We're viewing hydrogen propulsion as the future for the next 100 years," said Nihar Patel, Toyota's North American vice president of business strategy.

A Toyota hydrogen vehicle will come out next year, says Patel, available in limited quantities to customers in California. But like other hydrogen cars offered in small numbers by rivals like Honda and Hyundai, it comes with a few drawbacks, including a high manufacturing cost and a near-total lack of infrastructure support. In fact, there are only about a dozen hydrogen-refueling stations in the entire country, and the majority are confined to Southern California. But for drivers in that area, Toyota's hydrogen fuel-cell vehicle boasts something electric cars just can't offer: a 300-mile range and a refueling time of only three minutes.

Still, critics deride hydrogen as unsuitable for the mass market because it would require a huge global investment to get the new technology off the ground. Perhaps the most vocal hydrogen naysayer is Tesla founder and chief executive Elon Musk, who recently said hydrogen "makes no sense" for automotive propulsion—a statement echoed by Nissan chief executive Carlos Ghosn, who asked, "Where is the infrastructure? Who is going to build it?" Toyota will help to build a few dozen hydrogen-refueling stations in the U.S. over the next few years, but Patel concedes the lack of infrastructure puts the technology at a disadvantage.

"We may not get hydrogen going in my lifetime," Patel says. "But if you want an 80 percent reduction in greenhouse gas emissions by 2050, hydrogen is going to have to play a very large role."

Other alternative-energy sources have been explored and dismissed as impracticable. Auto experts say solar power isn't feasible as a sole power source for vehicles because of the heavy weight of current solar panel technology, the relatively small surface area of a car's roof, and—most important—the unreliability of regular sunshine. However, solar power could be a key supplemental power source in the future. Even today, a few new car models offer optional roof-mounted solar panels that can power accessories within the vehicle.

The road ahead

BY DOUG DEMURO

In the century since mass-produced automobiles began rolling off Henry Ford's assembly line, the car has revolutionized American life, radically changing the way we work, live, and travel. But even as the car has come to be synonymous with freedom, it has brought with it a host of serious problems, including a dangerous reliance on fossil fuels, increased congestion in urban areas, and tens of thousands of traffic fatalities each year.

Today, the automobile is undergoing some of the most profound changes in its history. Though cars were once simple conveyances to get from Point A to Point B, many today might be better described as "computers on wheels," with the ability to park themselves, automatically slow down and speed up with traffic, and hit the brakes before an impending collision. Vehicles packed with high-tech amenities are also becoming cleaner, with fewer emissions and better fuel efficiency. Many experts suggest that this high-tech revolution is just beginning, and that the next three decades will bring sweeping changes to the car as we know it.

"Technological advancements are radically changing the automotive industry," said Rick Hanna, global automotive sector leader for PricewaterhouseCoopers. "Companies are evaluating every aspect of their business."

Some of the most dramatic changes are taking place under the hood, in response to rising gasoline prices and stricter fuel economy regulations. In 2012, major automakers agreed to nearly double their fuel economy standards to 54.5 miles per gallon by 2025.

For some automakers, electric vehicles are a key part of that greener strategy. Although there wasn't a single plug-in vehicle on the market just five years ago, Americans purchased 96,000 such vehicles in 2013 alone—nearly double the 2012 sales figure.

But electric cars still have a long way to go before they replace gasoline-powered vehicles. The most popular fully electric car, Nissan's five-door Leaf hatchback, can travel just 84 miles between charges—more than sufficient for most daily routines,

Biofuels—clean-burning fuels derived from algae or plants like corn, sugarcane, and oil palms—have been considered one of the most promising alternative-energy sources in recent years. But so far, the technical hurdles and expense of generating the fuels have dampened the initial enthusiasm that the energy sources could replace fossil fuels on a mass scale.

Who's in the driver's seat?

Although experts disagree on exactly what will be under the hood in the decades to come, they nearly all agree that you probably won't be in the driver's seat.

A growing number of companies—as varied as traditional automakers like General Motors and tech giants like Google—are developing driverless vehicles, which aim to completely remove human beings from the driving experience. “Your car should drive itself,” Google executive chairman Eric Schmidt famously said in 2010. “It's a bug that cars were invented before computers.”

The benefits of a driverless car are obvious. It will save you time: You can finish that presentation on the way to work, rather than the night before, giving you an extra hour or two with your family. A driverless car also won't make “human errors” like falling asleep at the wheel or running a red light, which could lead to fewer collisions and road deaths. Still other benefits will improve efficiency: Driverless cars would communicate with one another, decreasing congestion and thereby boosting gas mileage.

Driverless cars are already being tested in several states, but that doesn't mean they are consumer ready. “The public seems to think that all of the technology issues are solved,” says Steven Shladover, a researcher at the University of California at Berkeley's Institute of Transportation Studies. “That is simply not the case.”

One problem is weather. Although Google's driverless cars have worked flawlessly around the tech company's headquarters in sunny Mountain View, Calif., the cars rely heavily on road lines for orientation—and that means they'll encounter problems in snow or hard rain. And since Google's prototypes require detailed maps for direction, a route change—a construction zone that temporarily sends you to the other side of the road, for instance—could cause a substantial disruption. Objects that a human being might easily respond to, like a police officer directing traffic with hand signals, remain difficult for the car's computer sensors to process.

As a result, experts disagree about when driverless cars will first start to appear in dealerships. Nissan's Ghosn has said that his company is on track to introduce a “groundbreaking technology,” called autonomous drive, by 2020. Others are more cautious; Ralf Herrtwich, director of advanced engineering for Mercedes-Benz's parent company, Daimler AG, suggests the technology is more likely still a decade or more from mainstream release.

Driverless cars also face a number of hurdles before the courts give them the green light. The National Highway Traffic Safety Administration is taking a cautious approach, stating that it is conducting its own research “so the agency has the tools to establish standards.” There's no telling how long that will take.

But public acceptance might be even more difficult to earn, largely because the idea of a self-driving car may seem too futuristic to generations of Americans who grew up driving themselves.

“It's the fear of robots,” said Bryant Walker Smith, a fellow at Stanford's University Center for Automotive Research. “There's something scary about a machine malfunctioning and taking away control from somebody.”

Still, most engineers hope that driverless cars could eventually overcome those challenges. The car that you're driving in 30 years might just be driving you.



Charging-station sign

THE TALKING CAR

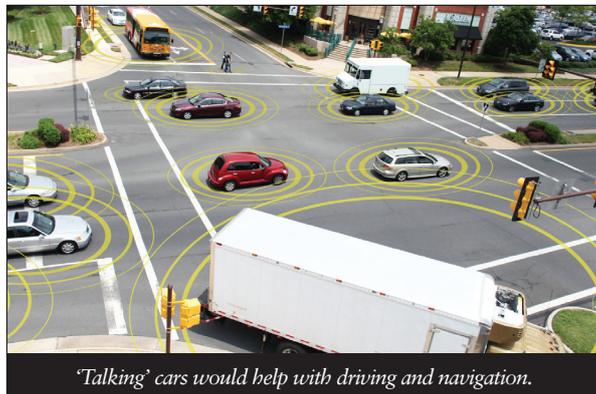
One promising high-tech auto feature in development is “vehicle-to-vehicle” (or V2V) communication, which would allow cars to virtually “talk” to one another to relay safety and traffic information. Imagine, for instance, if your car could connect with other nearby vehicles to decide when it's safe to make a left turn across oncoming traffic.

Right now, V2V communication is in its earliest stages. Most experts agree that early applications of the technology wouldn't take over functions for drivers but rather would alert them to potential hazards ahead so they can react more quickly. “V2V has the potential to help drivers avoid 70 to 80 percent of crashes that involve unimpaired drivers,” says Department of Transportation Secretary Anthony Foxx.

V2V communication could also have a major impact on traffic problems, as “talking cars” could uniformly slow down to avoid serious delays and prevent gridlock. And even if cars aren't driving themselves in 30 years, vehicles that talk to one another could dramatically reduce injuries and deaths on the road—especially if they offer some level of automation, such as slowing down or taking an alternate route long before a human driver detects an upcoming problem.

Not only will cars be talking to one another in the years to come, but they'll also be talking more to you. Augmented reality windshields—systems that display a wide range of information in front of a driver—are already in testing. Automakers say the technology would help with driving and navigation, by having the windshield flash if it detects an upcoming object in the road or display directions by highlighting the road where you should drive. Some automakers are also testing systems that could provide you with information about nearby landmarks or let you know if the restaurant you're passing has any reservations left.

The technology might sound far-fetched and even dangerous, but automakers insist it's coming soon. “Everyone is working on this,” says Tom Seder, chief technologist for human machine interface at General Motors, who notes that the goal is to “make driving more interactive.” Automotive safety engineers say the technology could actually help keep drivers' eyes on the road rather than on their smartphones or dashboard apps. But that may introduce other means of distraction. “There is potentially no limit to what could be displayed on the windshield,” says Johann Jungwirth, chief executive of Daimler's Mercedes-Benz Research and Development North America.



“Talking” cars would help with driving and navigation.



Briefing: Self-driving cars

Automakers say driverless cars will hit the market within a decade. But there are plenty of speed bumps along the way.

Why are cars going driverless?

Safety and efficiency. About 90 percent of the 10 million car accidents in the U.S. every year are the result of human error. By removing the human from the driving equation, autonomous cars—which don't run a red light, drink and drive, or text at the wheel—would make the roads markedly safer. They'd also make driving—and all those former drivers—more efficient. Cars that can drive closer together at steadier speeds would eliminate traffic jams, improve fuel efficiency, and lower emissions. And people who formerly spent hours commuting would get whole chunks of their day back. Rather than spending hours driving to and from work, people could spend commutes finishing work projects, reading, sleeping, catching up with friends and family, or doing any other number of activities.

How do the cars work?

There are three key components to the driverless car. One is a global positioning system, similar to the technology in a modern car's navigation system, which feeds the car's computer directions and other location information, based on highly detailed 3-D maps. Lasers and sensors mounted on the roof and bumpers also help identify nearby objects like other vehicles, pedestrians, cyclists, and signage. Finally, software inside the car puts it all together, analyzing the data and making probability-based predictions about what's going to happen next. Google has programmed its self-driving car to be the ideal driver, stopping for pedestrians and giving way to other vehicles in accordance with right-of-way rules.

Is the technology ready?

Google has racked up 700,000 accident-free autonomous miles with its driverless car—and some automakers, like Nissan, say they're rapidly developing the technology for public use by the end of the decade. But although

the technology has made impressive strides, plenty of hurdles remain. Driverless cars can't read hand signals, for instance, which means they won't react properly to a crossing guard or a police officer who's directing traffic. They're also sensitive to changes in location, and maps must be preprogrammed before a drive. And then there's the issue of weather: Because driverless cars rely heavily on monitoring road lines for navigation, they may not work well in snow or dense fog. "Weather is a challenge," said Katelin Jabbari, communications manager at Google. "Though we're working on improving this, in the meantime, our cars recognize when they have limited visibility and will make the safe decision not to drive." But though these technological obstacles are significant, they're nothing compared with the legal issues.

What are the legal hurdles?

Even with self-driving cars, accidents will be inevitable. But who would be at fault? Is the manufacturer to blame for a traffic fatality, or is it the designer of the software powering the car? If laws are rewritten to place blame on automakers and software firms, those companies would bear a huge legal risk, giving them little incentive to develop the cars for public use. The National Highway Traffic Safety Administration is at work creating basic regulations for self-driving vehicles, but those rules could be years away. In the meantime, decisions about whether to allow driverless cars on the road are up to the states. A handful, including California, Florida, and Nevada, have

legalized driverless cars for "experimentation purposes," but none has addressed broader legal or moral questions.

What moral questions?

Self-driving cars would lack something humans still possess: common sense and the ability to react to unexpected events. Say an obstacle fell into the road and you had only a split second to swerve either into a school bus or into a parked car. How do you program a machine to make this type of decision? There will be times when driverless cars are faced with moral dilemmas, from mundane lawbreaking (if there's an object in the road, is it OK to cross a solid line to go around it?) to more-serious matters that could cause injury or death. Driverless car manufacturers will have to decide how to handle these issues, effectively engineering the car to "choose" when to break the law.

Will people even want a driverless car?

It's hard to say. A University of Michigan survey this year of people in the U.S., U.K., and Australia found that although a majority of respondents in each country believed there were major benefits to self-driving cars, they also had high levels of concern about the safety and security of the vehicles. That

may be why many automakers are currently focused on creating "half autonomous" vehicles that could help ease the transition, by allowing people to get comfortable with the technology through a mix of machine driving and human driving. But car companies understand that it will be an uphill battle to get Americans to give up the wheel. "It's the United States of America, after all," says Mickey Cornelius, senior vice president of the Traffic Group consulting firm in Baltimore, "People here love to drive their cars."

Paving the way

Most U.S. roads are capable of handling driverless car technology. Signage is largely standardized for speed limits, school zones, and one-way streets. Driverless cars are also adept at detecting even faded lane lines if the weather is good. The biggest challenge is the lack of detailed 3-D maps for the navigation systems. Maps for Google's driverless car have been prepared for only a few thousand miles of roadway. But the company is well on its way to filling the data gap. Chris Urmsen, director of the Google car team, wants the cars on the road by the time his 11-year-old son turns 16. "It's my personal deadline," he said.