



Market Intel

Pathways for clean vehicles and fuels, advanced technologies, mobility and autonomous rides, and multi-modal transportation

Heading text

EV Market Report

Will we see transformation of ground transport by 2030?



A white paper exploring forecasts that historic changes are coming fast in global auto sales, plug-in vehicles beating traditional engines, autonomous vehicles going mass market, and whether automated mobility services could be a bridge for adoption of new technology

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Will we see transformation of ground transport by 2030?

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In this white paper:

Will we be riding to work in electric, autonomous, shared vehicles a decade from now? Will the traditional internal-combustion engine auto manufacturing industry be clearly transformed into a new age?

Expectations have been put in place that this decade will be as historically significant as the birth of mass production automobiles — when Henry Ford’s company put the first Model T in production in 1908 and watched it reach the 15 millionth unit 19 years later.

But will the 2020s be likely to see these historic shifts fall into place, with the year 2030 typically used in forecasts and emissions reduction goals as the benchmark for adoption?

What would it look like?

That benchmark could include:

.....steadily declining new vehicles sales;

.....younger consumers choosing autonomous, electric, shared ride services over owning their own personal vehicles;

.....electric vehicles becoming more important to automakers and vehicle owners than cars and trucks powered by internal combustion engines;

.....autonomous vehicles clearing regulatory hurdles and starting production;

.....connected car features playing a significant role over the next decade;

.....and mobility services leading the way in traffic- and smog-congested cities.

Good questions to answer, and topics to explore. Let’s start with the the first one.....

Where global car sales are heading over the next decade



New vehicle sales increased in June 2019 in China, the world's largest auto market, but that came during a 14 month period where 13 of them were in decline. July saw the decline fall back into place.

Rising trade tensions and tariffs, a slowdown in China's booming economy, and implementation of stricter emissions rules, have had their impact. Much of the the June sales boom was fueled by dealers cutting prices way down to clear inventory and prepare for exhaust controls coming to new vehicles. LMC Automotive estimates 2019 will see a second straight annual drop in China. India has seen sales decline at an alarming rate this year, with automakers cutting production and putting plans on hold to increase capacity. Analysts worry that U.S. auto sales reached their historic peak and will continue to see decline this year. Germany's Center for Automotive Research says that the global auto market is about to take its biggest hit since the financial crisis of 2008, with sales declining by more than four million units at the end of this year.

There are concerns over a global economic slowdown potentially dragging out the current sales decline, yet global sales growth is far from being over. Studies by McKinsey, IHS Markit, Bank of America and Merrill Lynch, and AutoForecast Solutions, predict a return to growth in new vehicle sales worldwide. Should these studies be taken seriously? Yes, as they do tap into auto executive interviews on their product pipelines in the coming years, and opinions expressed by shareholders.

Where studies see the trend heading

A McKinsey report forecasts global new vehicle sales will return to an increase, but not at the steep rate we'd seen over the past five years. That was at 3.6 percent per year, and it should decline and level out around 2 percent annual growth rate by 2030. Consumers are buying a lot of new vehicles, many times for the first time ever. China, India, Brazil, and a few other countries with emerging economies, are expected to see economic growth return with consumers moving to growing metro regions with strong job demand and more need for transportation beyond metro trains and buses.

The McKinsey study expects that the decline and leveling out will come from macroeconomic factors and the rise of new mobility services such as ride hailing, car sharing, and eventually by automated shared rides.

“New mobility services may result in a decline of private vehicle sales, but this decline is likely to be partially offset by increased sales in shared vehicles that need to be replaced more often due to higher utilization and related wear and tear. The remaining driver of growth in global car sales is the overall positive macroeconomic development, including the rise of the global consumer middle class. As established markets are no longer expanding, growth will continue to rely on emerging economies, particularly China and India,” according to the McKinsey study.

These findings have been echoed in other market reports, with many including electric vehicles in the numbers. A dominant topic of conversation among industry panelists last month at the 54th annual CAR Management Briefing Seminars in Michigan, was the speed in which key markets around the world will adopt EVs and increasing levels of autonomous mobility. Cybersecurity was another key concern, with fear of hackers being able to take over vehicles and shut down the grid, being reiterated by speakers.

AutoForecast Solutions and IHS Markit released studies forecasting overall new vehicle sales growth to continue through at least 2026. Electric vehicles are supposed to replace internal combustion engines in large numbers by 2030, but IHS Markit sees that taking much longer — reaching only 7.6 percent of the total by 2025. Another previous forecast has been set aside, with the young Millennial generation actually buying cars like their parents did and keeping them longer.

Global plug-in vehicle deliveries reached 2.1 million units for 2018, 64 percent higher than for 2017 and 2.4 percent of the world's overall 86 million units sold last year. The International Energy Agency's New Policies Scenario expects that by 2030, global EV sales will reach 23 million for that year and the stock of owned EVs will exceed 130 million vehicles (excluding two and three-wheelers). That's under one forecast analysis including the impact of announced policy ambitions by several governments; the IEA scenario includes another potential outcome where the number shoots up to 43 million and the stock coming to more than 250 million. Either predicted scenario would cut oil demand substantially.

China saw its first drop in recorded EV sales in July. Monthly global sales fell 14 percent with declines in China and North America during that month. Reductions in EV subsidies and a cooling economy impacted the China market. Another top auto market, India, is struggling to get consumers and rickshaw drivers to convert over to EVs and meet goals the government had laid out.

For now (and in another study), the IEA sees oil being king and the US playing a leading role over the next six years. That comes from rapid growth in the shale industry. By 2024, the US will export more oil than Russia and will come close to Saudi Arabia's exports.

Other advanced fuels, such as renewable natural gas, will offset the advantages stable fuel prices offer petroleum suppliers when it comes to fleets. Affordable gasoline and diesel, and concern over incentives diminishing, are expected to keep EV sales at bay in the US for now with fleets and consumers. Traditional ICE vehicles with good fuel economy, strong crash safety ratings, and a full spectrum of features and connectivity, are leading the way for now. As for new vehicle purchases, it appears that major markets won't see their numbers go way down over the next decade. It will take longer before alternative modes and energies will be fundamentally and historically altering the industry.

Buyer Demographics: What generation is most likely to lead the mobility transformation?



General Motors CEO Mary Barra is confident her company will be taking a leading role in mobility services of the future. For those less interested in owning a car, or having to drive and park it everywhere, what about sharing an autonomous Chevy Bolt through your local Maven outlet? Just tap into your mobile app and have it show up in front of your workplace.

The big question becomes: Who will be the customer?

Millennials (about 23 to 38 years old in 2019) broke open barriers by waiting longer to buy their first car — and becoming rabid fans and riders with Uber, Lyft, Zipcar. There have been other on-demand mobility services in meal delivery, groceries, and other needed services for extremely busy people ready and willing to pay.

Some things are changing — with Millennials in the US buying property less than the two generations ahead — Generation X and Baby Boomers. They're moving to cities

and seeing rent, lease payments, and property values shoot up. They'd also lived through the Great Recession, and are carrying concerns over another bout of economic turbulence coming up.

But when it comes to buying cars, Millennials are becoming a lot like previous generations, though they are interested in trying out electrified models — battery electric, plug-in hybrid, and hybrid. And Millennials still make up the lion's share of Uber and Lyft riders; though the next generation is taking its share of rides, too.

Generation Z — teenagers through age 23 — are still a bit young to determine what sort of economic impact they'll be having on car sales and other markets. One thing they do have in common with Millennials is being challenging in the workplace. It's very typical to talk to managers in their 40s through 60s and hear complaints about getting them to do their jobs as they've been asked to do — very different from their experience. Supervisors advise that you think a bit differently about where the "youngsters" are coming from. They do tend to be talented, hard-working employees, but it might take a bit longer — and employers are advised to help them find their own sense of purpose and meaning in their work.

A recent survey study by Allison+Partners suggests that changing definitions of transportation and an influx of new mobility solutions are paving the way for the birth of the "mobility culture."

Gen Z has even less interest in getting their driver's licenses than previous generations. They see cars as yet another appliance they'll need to have access to someday that ranks up their with smartphones and gaming machines like Xbox. In the study, they said autonomous vehicles make a lot of sense, and 60 percent of them believe they'll be using self-driving cars by 2030.

Owning their own prestigious car — whether that be a Tesla or a Lexus — doesn't matter as much, or make as much sense. Coming of age as the recession finished up, and smartphones became the new norm, pragmatism is the benchmark. The Allison+Partners study concluded that Gen Z will be the first generation in large numbers to get rides from Waymo, Maven, Uber, Lyft, and the next iteration of offerings from Tesla, Volvo, Audi, BMW, Toyota, Honda, and other makers rolling out new options in connectivity, automation, electrification, and safety — along with mobility services of their own.

Mobility won't be taking over by 2030, with new vehicle sales continuing to see growth in global markets — and concerns over safety and reliability will take several years to be alleviated, especially for autonomous vehicles. But the transformation appears to be occurring, with Gen Z taking the lead.

Will EVs transform the auto industry by 2030?



A *Science* magazine article (“The coming electric vehicle transformation,” Oct. 25, 2019) states that: “Electric vehicles are poised to transform nearly every aspect of transportation, including fuel, carbon emissions, costs, repairs, and driving habits.”

That will come from planned mandates coming up soon, that if enacted, include Norway wanting to have all its vehicles be battery electric or plug-in hybrid by 2025; Netherlands banning all gasoline and diesel vehicles by that year; Germany banning internal combustion engines by 2030; and France and Great Britain ending gasoline and diesel car sales by 2040. Not to mention China’s subsidies moving sales of new energy vehicles and Europe and the US seeing strong EV sales. What’s the tipping point? Battery technology, which have a host of challenges to overcome, according to the author.

I would say that two developments will likely slow the pace of EV sales growth we’ve seen over the past nine years, and extend the timing of when we see them make a substantial global impact. One is China cutting its generous subsidies, and the other

being a battle between the Trump administration and California’s clean car standards (see news section for more on the battle).

EV sales are declining for now, but how long will that last?

The chart below takes a look at the past decade of battery electric and plug-in hybrid sales since the launch of the Nissan Leaf and Chevrolet Volt in late 2010. A few points stand out while reviewing the short history of mass market production-level electric vehicles.

Calendar Year	US Plug-in Vehicle Sales	Percentage Growth YOY	China Plug-in Vehicle Sales	Percentage Growth YOY	Worldwide Plug-In Vehicle Sales	Percentage Growth YOY
2011	17,425	NA	8,159	NA	50,000	NA
2012	52,607	200.02%	12,791	56.77%	125,760	151.52%
2013	97,507	85.34%	17,642	37.92%	212,986	69.35%
2014	122,438	25.56%	74,763	323.77%	320,713	50.57%
2015	116,099	-0.51%	331,090	342.85%	550,297	71.58%
2016	158,614	36.61%	507,000	53.13%	777,497	41.28%
2017	199,826	25.98%	777,000	53.25%	1,227,117	57.82%
2018	361,307	80.81%	1,256,000	61.64%	2,018,247	64.47%
2019	329,528	-8.79%	1,210,000	-3.65%	2,209,831	9.49%

Sources: *InsideEVs*, China Association of Automobile Manufacturers, and Argonne National Laboratory

EV sales trends since 2011: The US was the market leader until 2015, when “new energy vehicle” subsidies began flowing in China and more electric vehicle product offerings entered that market. European countries also began seeing more acceptance of the technology and more EV models to consider. Norway continues to be No. 3 in global EV sales with its extensive government support in subsidies and charging infrastructure. Japan has been in the top five countries for cumulative EV sales.

Two thousand fifteen was the outlier year for US sales, with one of the factors being the Chevrolet Volt dropping in sales as the new next-generation Volt with range boosted from 38 miles to 53 started showing up at dealerships late in the year. Other market trends that pulled EV sales down were low gas prices, fewer incentives, and a broader market shift away from cars and toward SUVs and pickup trucks. But global EV sales kept their upward trajectory, leaping 71.58 percent in 2015 over 2014.

China is by far the leading sales market, with the US following in second with about a quarter of China's EV sales in the past two years. China's NEV sales data includes passenger vehicles and heavy-duty commercial vehicles such as buses and sanitation trucks. China's new energy vehicle mandate and its generous subsidies have brought the purchase prices down substantially. Building out its charging infrastructure has helped, too, as has the launch of a long list of NEVs built and sold by Chinese automakers and joint ventures between foreign automakers and local automakers.

Battery electric vehicles are leading by far in key global markets over plug-in hybrid electric vehicles. Last year, BEVs had 66.8% of the US plug-in vehicle market. By December 2018, the stock of new energy vehicles sold in China since 2011 saw 79.4% as BEVs. In Europe during 2018, the sales numbers were closer, with BEVs in the lead by over 40,000 units — 223,284 BEVs and 182,768 PHEVs.

As for popular models, here were the top 10 global sellers in 2019:

1. Tesla Model 3 — 300,075 units sold
2. BAIC EU-Series — 111,047
3. Nissan Leaf — 69,873
4. BYD Yuan / S2 EV — 67,839
5. SAIC Baojun E-Series — 60,050
6. BMW 530e/Le — 51,083
7. Mitsubishi Outlander PHEV — 49,649
8. Renault Zoe — 46,839
9. Hyundai Kona EV — 44,386
10. BMW i3 — 41,837

Source: *InsideEVs*

Sales figures have been showing a few trends, one of which is how important the US continues to be for Tesla's sales. Of the 145,846 Model 3s sold in 2018, 139,782 were sold in the US. About half of the Model S and Model X units delivered in 2018 were sold in the US with Europe being important for Tesla's growth. Now with its China plant starting up, that market is expected to be very important for future sales and model introductions.

The BAIC, BYD, and JAC models are sold almost exclusively in China, although BYD is continuing to sign more contracts for electric buses and other commercial vehicles around the world. The Nissan Leaf and Mitsubishi Outlander PHEV are seeing more success outside the US, with Europe being the main marketing focus.

Forecast reports usually cite upcoming vehicle emissions rules, governments moving toward banning gasoline- and diesel-powered vehicles, growth in Level 2 and fast-charging stations, and a wide variety of plug-in vehicle offerings — with many more coming to market over the next decade. Automakers expect the pricing to come down as battery costs decline and EV drivetrains, parts, electronic systems, and exterior and interior design, become more economical and efficient in the near future.

What automakers have in the pipelines: Another topic in the reports has been commitments made by manufacturers to roll out an extensive lineup of plug-in vehicles — and sometimes more hybrids and fuel cell vehicles.

The Volkswagen Group continues to lead the charge, expanding its list of new launches in March from 50 to 70 in the near future. The company expects to be building 22 million plug-in vehicles with its new electric drives, such as the MEB, over the next decade on the VW, Audi, Porsche, and SEAT brands — an increase from 15 million in the initial target. The German automaker has collaborated with the Petersen Automotive Museum in Los Angeles to demonstrate its vision of EVs and mobility of the future next month. “Building an Electric Future” will open November 20 and will celebrate Volkswagen’s history both globally and locally, as well as introduce VW’s new electric concept vehicles. A global concept unveiling of an all-new ID concept vehicle will take place at a private event on Tuesday, November 19.

BMW AG plans to increase sales of its battery electric and plug-in hybrids by 30 percent every year until 2025 to help meet incoming stringent emission regulation in the European Union. The company moved up its goal for rolling out a lineup of 25 all-electric and plug-in hybrid models by two years to 2023. This would mean BMW will have sold a total of about 700,000 plug-in vehicles by 2025.

Daimler plans to release 10 different all-electric vehicles by 2022. The company is taking a holistic approach to electrification under the new EQ technology and product brand and a charging infrastructure to support it. Daimler will also be electrifying the entire Mercedes-Benz portfolio. Customers will have the choice of at least one electric alternative in every Mercedes-Benz model series, taking the total to 50 overall.

Ford Motor Co. is increasing investments in electric vehicles to \$11 billion by 2022 and will have 40 hybrid and fully electric vehicles in its model lineup. In April, Ford said it planned to launch more than 30 new Ford and Lincoln vehicles in China over the next three years as it tries to reverse a decline in sales in the world’s biggest auto market; and about one third of them will be EVs. This summer, Ford revealed its first all-electric SUV for that market, the Territory EV, built on Chinese partner Jianling’s compact SUV. It follows a plug-in hybrid variant of the Ford Mondeo, and will be its second plug-in vehicle for the Chinese market.

Toyota has a company goal of selling 5.5 million electrified, Toyota-brand vehicles annually by 2030, up from about 1.6 million vehicles now. The company set up a \$10 billion r&d fund for catching up with competitors, and has created a new EV architecture that offers flexibility in size and battery power.

Honda announced a week ago that it will sell only plug-in electric and hybrid vehicles in Europe starting in 2022, three years earlier than previously planned. The Japanese automaker will be launching six new models in Europe over the next three years. The company said it shows its confidence in the technology and seeing regulatory changes that are changing the course of Europe's auto industry. "The pace of change in regulation, the market, and consumer behavior in Europe means that the shift towards electrification is happening faster here than anywhere else," said Tom Gardner, senior vice president at Honda.

Tesla has three models poised to come out in the next few years. The Tesla Roadster 2020 is the first-ever follow-up to the company's debut electric car, the Roadster 2008. CEO Elon Musk boasts that the upcoming supercar will be able to go from 0 to 60 in 1.9 seconds, and can reach a top speed of 250 miles-per-hour. It will cost at least \$200,000 when it rolls out next year. The compact SUV Model Y was revealed in March 2019, and will be the company's second mass market model after the Model 3. It will be able to go 300 miles on a single charge, and it will begin shipping in late 2020 with the standard range model following in Spring 2021. Starting prices for four different variations will go from \$39,000 to \$60,000. Musk brags that it will have SUV functionality, it will ride like a sports car, and will be the safest SUV in the world. The Tesla Semi heavy-duty truck will go into production next year, and will go nearly 400 miles on a 30-minute charge. The company also says it will go from 0-60 in 20 seconds while hauling 80,000 pounds. It's expected have a \$180,000 starting price.

BYD Company Ltd. sold a total of 520,687 vehicles in 2018, which was made up of petroleum-powered models, all electric, and plug-in hybrids. A Deloitte study forecasted that by 2030, the company will be selling about 18 million units, following Tesla's expected sales that year of about 22 million vehicles. However, I consider both of these forecast numbers to be extremely optimistic. Last year, BYD narrowly beat Tesla in deliveries to be No. 1 in the world — BYD sold about 250,000 EVs compared to Tesla's 245,240. In April, the company announced six new EV models will be coming up, a mix of all-electric and plug-in hybrid. In July, BYD announced an alliance with Toyota to develop EVs that will be coming out in China between 2020 and 2025. For now, the company is investing heavily in building its clientele for commercial vehicles such as electric buses and trucks in markets all over the world.

Market softening lately: Last year was tough for the Chinese makers, and the US followed a similar pattern; but strong sales in Europe last year helped stabilize the global EV sales market. Reductions in electric vehicle subsidies and a cooling economy

impacted the Chinese market. The US is seeing a similar sales slide with the overall new vehicle market down 1.3 percent from 2018, while EVs were down nearly 9% year-over-year. One reason for the drop is that the Tesla Model 3 had an unexpectedly high ramp up of production in the second half of 2018; but by the end of 2019, the Model 3 achieved a record setting mark with a little over 300,000 units sold worldwide.

What the forecast numbers look like: The most commonly cited forecast on 2030 comes from The International Energy Agency's New Policies Scenario. The study expects that by 2030, global plug-in vehicle sales will reach 23 million for that year and the stock of owned EVs will exceed 130 million vehicles (excluding two and three-wheelers). That's under one forecast analysis including the impact of announced policy ambitions by several governments; the IEA scenario includes another potential outcome where the number shoots up to 43 million with the stock coming to more than 250 million.

There've been other forecasts. In May, Mining and resources giant BHP forecasted that electric vehicles could achieve more than 50 percent share of global new vehicle sales by 2030, and 100 per cent of all vehicle sales by 2050.

Global new vehicle sales are expected to come in at about 80 million units this year. Germany's Center for Automotive Research (CAR) predicts that in 2022 sales will rise back to 84 million.

Let's say new vehicle sales reach 100 million by 2030. How much of it would likely be new plug-in vehicles?

Between 2011 and 2018, new EV sales in the US averaged a 56.8 percent annual increase, and global had an average of 67.34 percent. To refine the numbers to more recent market trends, between 2014 to 2018 the average annual growth for US plug-in sales came to 33.69 percent. For global sales, the average annual sales growth between 2014 to 2018 was 57.14 percent with China leading the boom.

Global car and light commercial vehicle sales in 2018 came to about 86 million new vehicle deliveries. Battery electric and plug-in hybrid vehicle sales came in at 2,018,247 units last year — 2.34 percent of the total. New vehicle sales came in at 17.27 million in the US last year; at 361,307 units, EVs made up 2.09 percent of that total.

So let's say market conditions look similar in the next few years, without big changes enacted such as a fossil fuel ban in a sizable country. What would that look like?

At the rate of 57 percent in global annual EV sales increases, plug-in vehicles would make up 100 percent of the global new vehicles sales market during 2027. As that scenario would be impossible to reach (aside from an unforeseen miracle), what about

viewing a much more conservative forecast — 10 percent annual growth in EV global sales under current market conditions? While a much lower percentage, 10 percent could be realistic given China will be soon cutting out its subsidies, blockades are coming from the Trump administration, downward auto sales in several countries will continue for a while, gasoline prices are staying fairly low, and challenges persist for convincing consumers and fleets to transfer over to EV purchases — charging infrastructure, battery capacity, range getting much better, and perceived long-term value and trustworthiness of transitioning over from ICEs to EVs.

Let's also assume that EVs making up at least 50 percent of global new vehicle sales would make for a realistic tipping point in emissions reductions, lessening dependence on oil, and hitting a few government targets. Going with the 10 percent annual sales growth scenario would only bring the number up to about 5,757,995 new EVs sold globally by 2030 — just shy of 6 percent of global new vehicle sales, given the forecast of 100 million units sold by 2030. A recent IHS Markit study, which takes a conservative approach, sees EVs making up 7.6 percent of total new vehicle sales by 2025.

If you take 25 percent annual EV sales growth in global sales, it's going to look a lot more like the low-end forecast of another study this year. The IEA's New Policies Scenario expects that by 2030, global EV sales will reach 23 million for that year and the stock of owned EVs will exceed 130 million vehicles.

Perhaps 2040 to 2050 is a more realistic scenario for EVs playing a major role in new vehicle sales, emissions reductions, and having a major impact on oil prices — in terms of hitting the 50 percent mark. If government mandates are enacted and enforced, it would be closer to 2040.

BloombergNEF's "Electric Vehicle Outlook 2019" report came to a similar conclusion. The report shows that EVs will take up 57 percent of global passenger vehicle sales by 2040. Electric buses will dominate their sector, holding 81 percent of municipal bus sales by the same date, according to the report.

Norway, Germany, France, China, Costa Rica, South Korea, the UK, Japan, Spain, Taiwan, Portugal, Netherlands, Israel, India, Denmark, and Ireland have proposed a ban on fossil-fuel powered vehicles. Previous Prime Minister Theresa May in June signed the "net-zero" mandate that would cut emissions 80 percent by 2050 compared to 1990 levels. Britain is the first G7 country to commit to a net zero greenhouse gas emissions target for 2050. The new Prime Minister, Boris Johnson, is continuing support for the net-zero emissions mandate.

BMW Group may present a more realistic view of how most global automakers are likely to perform in commitment to the new technology in the short term — a slower and gradual strategy rather than launching 20 or more new EV models with a commitment

to roll them out in vast numbers by 2025 to 2030 (that VW and other OEMs are championing). BMW predicts it will have sold about 700,000 plug-in vehicles sold by 2025.

The German automaker in late 2019 released a sales report on EV market share, or “Electromobility in Europe.” The study says that BMW has 13 percent of European sales and Tesla has 20 percent. As for the US, BMW had six plug-in models sold through September, coming in at 9,875 vehicles delivered — 4.18 percent of the country’s EV market.

So, what market conditions will be needed to reach the 50 percent mark? These factors are sure to be watched for:

- Continuing falls in the price of EV batteries. One study reports that since 2010, the average cost of lithium-ion batteries per kilowatt-hour has fallen by 85 percent.
- Extended range of battery power, 300 miles per charge.
- Fast charging networks in high-traffic zones, with free access or reasonable user pricing.
- China’s new energy vehicle mandate, and whether the national government decides to bring it back. Subsidies have also been generously spread by a few other countries (especially Norway); and states, provinces, and cities in North America, Europe, and Asia. Will these continue, and for how long?
- The future of California’s Advanced Clean Cars Program, and the battle between the state and the Trump administration over the future of those rules and the national standard.
- Fleet acquisitions, including the Electrification Coalition launched in 2018 and announced by LA Mayor Eric Garcetti — an online portal that provides cities with a single, equal price for EVs and charging infrastructure by aggregating the demand from Climate Mayors cities and other public agencies.
- Commercial applications for electric vans, light- and medium-duty trucks, and for municipal buses, will make a significant difference. That’s been the case in China, and is starting to take hold in the US and Europe.

EVs have the potential to become the leading powertrain system used in autonomous vehicles in the next couple of decades. The next feature exploring the 2030 trend will analyze when its likely to see regulatory hurdles cleared and self-driving vehicles going into high-volume production.

When will roads be filled with automated vehicles?



Five years ago, a speaker at AltCar Expo stirred up a lot of conversation among attendees and a few humorous references by panel speakers during the day. It was big enough for the speaker to be invited back the next year. Tony Seba, Silicon Valley entrepreneur and Stanford University lecturer, made dramatic forecasts about electric transportation, autonomous vehicles, and solar power. One of his revolutionary predictions is that all new vehicle sales in the US will be electrified and autonomous by 2030; and EVs will be powered by solar energy. The prediction came from his model analyzing the technologies' exponential growth rates in the market.

Earlier that year, in May 2014, Google revealed a new prototype of its self-driving car, which had no steering wheel, gas pedal, or brake pedal, and being 100 percent autonomous. It set off a tidal wave of ambitious goals announced by automakers, media coverage and analysis, and a series of studies and speaker panels on what autonomous vehicles would mean — and how it will soon be the norm with US vehicles and possibly at a global scale.

During this year, KPMG and other analysts were not putting out likely timelines and significant benchmark years for autonomous vehicles (AVs) clearing regulatory hurdles and seeing mass production from major and specialty automakers, and an obvious presence on public roads. Seba's "disruptive technology" theory is intriguing, but taking the latest look suggests that the new industry and technology hasn't been building the needed momentum to see historic change over the next decade; not that it's going to disappear, though.

Safety remains the key barrier to overcome for the new technology to clear regulatory hurdles and find public support. National Transportation Safety Board reports on Uber and Tesla tell some of the story.

Uber Technologies Inc.'s autonomous test vehicles were involved in 37 crashes in the 18 months before a fatal March 2018 self-driving car incident in Tempe, Ariz., the NTSB said on Tuesday. Between September 2016 and March 2018, there were 37 crashes of Uber vehicles in autonomous mode at the time, including 33 that involved another vehicle striking test vehicles. Uber's self-driving test car that struck and killed a pedestrian in March 2018 wasn't programmed to recognize and react to jaywalkers, according to the board. The NTSB on Nov. 19 will hold a probable cause hearing on the Arizona crash.

Tesla still has to resolve warnings sent out by fatal crashes that have been attributed to its Autopilot semi-autonomous feature. The National Transportation Safety Board (NTSB) in September cited both driver error and Tesla's Autopilot design as the probable causes of a January 2018 crash, in which a Model S slammed into a parked fire truck at about 31 mph. The driver was distracted and did not see the fire truck, according to the federal agency. NTSB says that Tesla's Autopilot was also at fault, as its design "permitted the driver to disengage from the driving task."

KPMG published its second annual Autonomous Vehicle Readiness Index (AVRI) with a metric that takes into account four pillars to determine which country will lead the new transportation mode: policy and legislation; technology and innovation; infrastructure; and consumer acceptance. European countries dominated the rankings this year, with Netherlands at No.1, followed by Singapore, Norway, the US, and Sweden. Norway was a new entry to the list, and passed up the US — which has fallen one place to fourth.

Taking a look at the four categories used by KPMG in the study to develop the measures and methodologies reveals more. For policy and legislation, AV regulations, government-funded AV pilots, and AV-focused agency were key factors; Singapore leads this pillar. For technology and innovation, partnerships, patents, and investments are key factors, with Israel taking the lead this year. For Infrastructure, the Netherlands

leads through having the most EV charging stations scaled by the size of its road network, as well as consistently high scores on the other measures. (More on those interesting categories below.) For consumer acceptance, Singapore scored highest overall in the KPMG study, partly due to all of the city-state's population living in an AV test area.

For countries with a high acceptance rate in AVs, India and Mexico also took leading positions. Those living in Great Britain and the US are the least accepting. A new study by Society of Automotive Engineers International (SAE) with US respondents found that 73 percent of them preferred to share control with their vehicle. An overwhelming 92 percent said it is a requirement to be able to activate an emergency stop function in a self-driving car.

Here are a few other interesting details from the KPMG study and recent news:

- When looking at the AV infrastructure, some of the factors being reviewed have been density of EV charging stations; quality of mobile internet; 4G coverage (the bridge to much faster 5G networks that are slowly coming out now); and quality of roads.
- Americans tend to be skeptical about trusting AVs in surveys. But one area of mobility experience that may help adoption in the US and a few other markets is ride hailing. China leads in market penetration of ride-hailing, followed by the US and the UK. Some of the most interesting test projects have involved partners working toward bringing robotaxis and shared rides in AVs — GM working toward its Maven car-sharing unit offering autonomous vehicles including the all-electric Chevrolet Bolt. Uber and Lyft have been investing in it, with Waymo leading the way.
- Baidu is leading the way in China. China's search-engine giant is getting the most test miles under its belt, which is critical in building public support for the new technology.
- Volkswagen is stepping up its efforts to become a leader in autonomous vehicles and ride services by spinning off its own startup that it claims will be among the "best-funded" in the world. Volkswagen Autonomy, or VWAT, plans to bring robot taxis and cargo vans to three continents by 2025.

Autonomous a decade away? What about connected smart apps until then?



January 2020 saw the big CES show in Las Vegas, where autonomous vehicles took over five years earlier; the star then was the Audi A7 self-driving prototype. Many attendees this year were very disappointed that automakers and tech partners have changed their story from the AV Revolution over to cool, connected features being added to new cars.

Consulting companies Gartner and PwC now estimate that autonomous vehicles reaching mass production and sales — along with the much-hyped robotaxis — will take another decade or so to get here. Auto sales will probably continue declining for a while and then should go back up in the US to over 17 million or more as car buyers aren't going to be ready to change their lifestyles with AVs — and electric vehicles and mobility services — for quite a while.

At last year's CES show, several companies revealed advanced driver-assist technologies. It was a letdown for many attendees, and began signaling that the AV Revolution is going to take a while.

"I remember the projections from CES four or five years ago that by 2021, we'd have autonomous fleets and, obviously, that's not happening as quickly," said Gary Shapiro, CEO of the Consumer Technology Association, which runs CES. "There's a lot of barriers."

A Deloitte study launched right before CES affirms it. Nearly half of US consumers (48 percent) of the respondents believe that fully autonomous vehicles will be unsafe; and 58 percent aren't willing to pay more than \$500 for AV technology.

The Deloitte 2020 Global Automotive Consumer Study surveyed more than 35,000 driving-aged consumers, from 20 countries, across the world. While increased connectivity in new vehicles is thought to be the bridge between the current models and AVs of the future, surveyed consumers have mixed feelings. People in India (80 percent) and China (76 percent) are embracing the idea at over twice the rate compared to Germany (36 percent), followed by the US (46 percent). Some issues do carry over to India and other countries — concerns over privacy and data security being a top issue.

Consulting company PwC says autonomous vehicles used in robotaxi operations will not reach roads in any significant presence until after 2030.

Nissan's Intelligent Mobility sets a clear example of where the technology is now, and where it's headed. Intelligent Mobility offers a suite of integrated technology designed to increase safety, comfort, and control while driving, "connecting you with your vehicle and the world around you." Intelligent Driving starts now with driver assistant technology like Safety Shield 360 that helps you see more and sense more, giving you a helping hand when you need it. Then there's the e-Pedal that makes electric car driving even more fun. And going to the next step: smart vehicles that connect with each other in an ecosystem that improves safety and traffic flow.

Automakers and tech giants like Apple and Alphabet are following the lead set by Amazon in recent years with the launch of its Alexa and Echo systems. They integrate control systems and devices into a personalized, customized system for giving voice commands to driving directions, EV charging, playing the music you love to hear, and much more. You might say, "Alexa, tell me the best place nearby to pickup a low-carb dinner, and the best way to get there fast while playing great music from the 1980s."

Test projects may be the tipping point for mobility



Most Americans are skeptical about completely turning over their car rides to an automated, electric vehicle. It would eventually mean giving up an old, classic tradition — getting behind the wheel and taking off for whatever destination they choose, exercising personal freedom of choice. And there are those who adore classic and vintage cars, and won't ever want to give it up.

The latest J.D. Power study on autonomous vehicles and electric vehicles, and an interview with a top automaker CEO, indicate that peoples' expectations for new technology development will remain in place; but opinions are leaning toward the transformation and adoption taking much longer than 2030 (more on Honda and the Power study later). Earning the public's buy-in is going to take a while.

Autonomous, electrified shared rides and robotaxis appear to be the most likely way that cultural transformation will be taking place — in the US and other markets where ownership of personal vehicles became the expected norm years ago.

There are other pathways expected to play a vital role in these historic shifts. Automated shuttles are becoming the first application for autonomous vehicles to be deployed as people movers under restricted conditions. Fleet deployment of electric light-to-heavy duty vehicles equipped with the latest connected, automated technologies will also play a vital role.

For now, test projects are being carried out integrating autonomous, sometimes electric, vehicles with increasingly popular transportation modes — ride hailing, car sharing, bus and shuttle rides, and a variation on age-old taxi rides. So let's take a look.

Waymo is the closest example of what it might look like next, certainly in the US and likely around the world. The Waymo One app used to hail rides in Phoenix's suburb of Chandler provides an alternative to taking a bus ride, taxi, or ride hailing. Started in December 2018, Waymo One has given members of its early rider program (that will go out to the general public eventually) access to an autonomous ride-hailing service. Just hit the button on the app, and very soon an empty Chrysler Pacifica minivan will approach and come to a stop right in front of you.

In 2017, Waymo CEO John Krafcik declared during a conference that “fully self-driving cars are here.” But it would take longer for them to show up for riders. Most all of the Pacifica minivans in the Phoenix area still have human riders trained to take over the van in the event of an emergency; a few self-driving vehicles are operating in limited test areas. There are hundreds of customers in the early-rider program, with some limitations.

Riders will get access to Waymo One if there's an available vehicle nearby. It's taking place in a controlled, geo-fenced environment. Riders are selected based on what zip code they live in and have to sign NDAs. The rides are free for now.

Waymo just expanded its working relationship with leading dealer network AutoNation. The autonomous Chrysler Pacifica can now be used to move auto parts between AutoNation's Tempe, Ariz., locations and other repair shops in the area, including those operated by independent third parties. It's bound to make the consumer's vehicle maintenance and repair experience more time efficient and reliable. Previously, the relationship led to Waymo's Pacificas being serviced at AutoNation garages, and as a mobility source for AutoNation customers to get rides to their dealerships.

Lyft Level 5: On March 28, Lyft began testing on public roads. Lyft has hired over 300 engineers, applied researchers, product managers, operations managers, and more.

The focus has been on creating the world's best computer vision, robotics, and machine learning experts. Cited accomplishments include 3D segmentation frameworks, new methods of evaluating energy efficiency in vehicles, and tracking vehicle movement using crowd-sourced maps.

The investment from General Motors has merely provided Lyft with needed capital. The company's autonomous ride group, called Lyft Level 5, about a year ago launched a public self-driving program in Las Vegas with partner Aptiv. In August 2018, the project surpassed 5,000 self-driving rides. That recently surpassed over 50,000 autonomous rides to Lyft passengers. The company said it makes it the largest self-driving program in the US.

Waymo is another partner, where some its self-driving minivans are available for Lyft ride sharing. It's restricted to Waymo's authorized zone outside of Phoenix. Waymo CEO Krafcik believes the relationship gives both companies "the opportunity to collect valuable feedback."

Last spring, Lyft said in its mandatory IPO filing that it wants to begin providing self-driving ride-hail trips on the app within five years. Within a decade, Lyft wants to be ready to provide a network of autonomous vehicles providing a majority of its trips. Five years later, the company wants to see its "purpose-built" self-driving vehicles on the road — able to take passengers on long-haul journeys.

Advanced Technologies Group (Uber ATG): Before being forced out, Uber founder and former chief executive, Travis Kalanick, said in 2016 that self-driving technology was "basically existential" for the company.

The company believes the future of mobility is increasingly shared, sustainable, and automated. The payoff will be big — supporting sustainability, helping make roads safer, and making transportation more affordable for everyone. But the capital drain continues.

Questions have come and gone about whether Uber will be able to stay in the autonomous vehicle race, with things ending badly in its Pittsburgh test market years ago. Last year's pedestrian fatality also raises the challenges of clearing the investigation and restoring trust in its ability to safety test its AVs.

Uber is still testing adapted Volvo vehicles in its partnership with Volvo Cars through its, a company that does emphasize safety. A test project with Toyota also continues. Another alliance exists with PTIO, the Partnership for Transportation Innovation and Opportunity, to find solutions that ensure everyone benefits from the adoption of self-driving technology.

AV testing through Advanced Technologies Group (Uber ATG) continues in Dallas, Pittsburgh, San Francisco, and Toronto, with about 32 AVs being monitored and tracked. Dallas has been the center of testing, with ancillary test runs and Uber services being tried out, including shared rides, Uber Eats, JUMP scooters, Transit, Uber Freight, and more. The city's modern infrastructure, unique traffic patterns, road characteristics, and climate offer new information that inform the company's ongoing engineering efforts.

Tesla continues to cooperate with officials during investigations over fatalities tied to its Autopilot semi-autonomous feature. But the race is far from over. The company does have a sizable early lead in this space both in terms of autonomous miles driven as well as monetization of its self-driving technology.

The electric automaker has already delivered over 780,000 vehicles since its launch, and most of them come with pre-installed self-driving capabilities that users can unlock by paying for software. The company's autonomous driving hardware is based on mature technology such as Radar, Ultrasonic, and Passive video, which is cheaper than some rivals who use LIDAR – a laser-based system.

Going this route has enabled the company to equip the hardware as standard in all its vehicles, irrespective of whether or not a user enables it by paying money. As the company's vehicles are estimated to have driven over 1.88 billion Autopilot miles in total thus far, this could be further enhancing Tesla's log of driving data.

CEO Elon Musk has suggested that its AV system will be available in various applications, including as a revenue source for owners. Those opting in can rent their Model 3, or other Tesla vehicle, out to Uber and Lyft drivers (or another ride-hailing firm) needing an autonomous EV to do their work.

Maven and GM: In May, GM began shuttering its Maven car-sharing business in eight major U.S. cities, including Boston, Chicago and New York. GM won't ending Maven anytime soon, but it is taking much longer than hoped to expand. It started up in early 2016 when a team of engineers and project managers were brought over from Google and Zipcar, along with staff it acquired from Sidecar, a failed competitor to Uber and Lyft.

Business has been smaller and slower than anticipated, and with competition coming from established car-sharing brands Zipcar and Car2Go. Two other segments were added — Maven Gig, a rental service for carless Uber and Lyft drivers. Maven Reserve added longer-term rentals; and the latest sub-segment is a peer-to-peer rental service. Maven had also been a good channel for testing out EVs and AVs. In 2017, Maven added over 100 Chevy Bolts to its fleet and participated in GM self-driving car testing.

CEO Mary Barra in recent years had emphasized that her company will become the global leader in advanced, autonomous, and electric vehicles as automakers shift over from vehicle manufacturers to full-service mobility service providers. Maven has been a slow-development projects and AVs are going that route. In July, Its self driving car unit, GM Cruise, said in July it was backing off plans to make available autonomous taxis by the end of this year. More testing of the vehicles will need to happen first.

GM's \$500 million investment in ride-hailing firm Lyft in 2016 has moved far away from any type of joint project, with Lyft continuing to test its own small fleet of self-driving cars without GM's involvement.

Apple-backed DiDi Chuxing has received a license to operate a fleet of up to 50 self-driving cars on a pilot basis in part of the Jiading district in Shanghai, China. Automakers SAIC and BMW also received permits at the World Autonomous Vehicle Ecosystem Conference on September 16.

Apple had invested about \$1 billion in DiDi in 2016. The tech giant has expected that its investment and involvement would boost both companies' efforts in product research and development — especially in China's massive auto market. In January, the company cut more than 200 employees from its self-driving car initiative, Project Titan, in what it described as a restructuring. Five months later, Apple confirmed that it had acquired Drive.ai, a self-driving startup backed by more than \$77 million in funding.

Didi, a giant ride-hailing company in China, was scheduled to begin picking up ride-hailing passengers with self-driving cars in Shanghai soon. The project will be expanded the program from that city — going toward the deployment of self-driving vehicles outside of China by 2021.

Test rides include another rider providing safety intervention in the event of an emergency. Didi is waiting for a few remaining licenses before it can start transporting customers in AVs. Self-driving rides will be free for customers, and more than 30 different vehicles will be offered for self-driving trips as part of the pilot, the company said.

Amazon: Amazon continues its move as the central player in goods delivery, warehousing, and integrating technology advancements like delivery drones into the equation. One of the decisions was for Amazon to set up acquisition of 100,000 all-electric delivery vans to Amazon over the next decade. Michigan-based startup Rivian Automotive will be building and delivering them. Amazon chief Jeff Bezos said 100,000-unit fleet will eliminate 4 million metric tons of carbon emissions when fully operational.

Over the last decade, the tech giant has spent billions of dollars working on finding solutions to the “last-mile” problem in urban delivery. The company has built its own fleet of cargo jets, and explored delivery by drone in the form of “Prime Air.” More recently, an increasing percentage of that investment has been directed toward autonomous vehicle technology.

In January, the company introduced the Amazon Scout, a six-wheeled electric-powered delivery robot. Six of these robots are currently making deliveries in a Washington neighborhood during daylight hours, Monday through Friday. The next month, Amazon invested in Aurora Innovation, an autonomous tech startup run by former executives from Google and Tesla.

Penske is getting into car sharing through its Penske Dash subsidiary, with an initial launch in Washington, DC, and Arlington, Va. The trucking logistics, rental, and leasing giant, is offering Volkswagen Jetta SE models for rent by the minute, hour, or day through its proprietary app. Rates are inclusive of fuel, parking, and insurance.

The truck leasing and rental company has joined the race with three other rental companies — Hertz, Avis, and Enterprise — which have been testing out car-sharing projects in recent years. Avis has made the biggest splash with its acquisition of Zipcar.

Penske partnered with Ridecell, which is powering the mobile app, payment processing, parking info, and predictive analytics for the fleet. Members using the service have 24/7 access to a call center and a local fleet operations team.

Operational efficiency will be a big part of the unit’s success, the company said. “We can take advantage of infrastructure through our joint venture partners at Penske Corporation and Penske Truck Leasing, particularly on the service and roadside assistance portion of the car-sharing business,” said Michael Montri, chief operating officer.

Hyundai recently announced it will launch a free ride-hailing service with a fleet of autonomous electric cars in Irvine, Calif., starting this month. The news comes after the South Korean automaker announced that it would invest \$35 billion in autonomous and electric vehicle development over the next five years.

Hyundai is partnering with AV startup Pony.ai and ride-hailing service Via for the free taxi service. Interested riders can hail a self-driving car via a smartphone app. Korea’s largest automaker said it won’t be fully autonomous. Hyundai says a safety driver will be behind the wheel, and there will also be an additional engineer in the passenger seat.

It's one piece in the Korean maker's new global campaign. The company promotes itself as a world-leading smart mobility solutions provider that will be able to offer solutions through its cutting-edge technologies and solutions. That will offer customers "quality time and empower them to pursue their passions at full throttle," the company said — and has been depicting it in a new global brand campaign called #BecauseofYou.

The first of these TV commercials was filmed in downtown Amsterdam during the morning rush hour. The commercial shows a female office worker being overwhelmed by the traffic — a crisis becomes instantly transformed when she steps out of her Hyundai Nexo fuel-cell SUV and hops onto a Hyundai electric scooter — solving the "last mile" dilemma becoming common in cities around the world with booming populations, and getting to her office on time.

Some automakers backing off: While 2030 has been named the magic year in a few market reports and conference keynote speeches, the timeline for automated EVs to become the industry norm in global vehicle manufacturing and sales likely will be taking much longer. One auto executive recently spoke to the question.

"The hurdles to battery electric vehicles and complete autonomous driving are still quite high," Honda CEO Takahiro Hachigo recently said in an interview at Honda Motor Co.'s global headquarters.

Honda will focus on gasoline-electric hybrids, not full EVs, through 2030. As for fully autonomous vehicles, Honda will roll out incremental advances that offer real-world safety at affordable prices. The automaker already has a number of new technologies ready to include in its new vehicle lineup, including a hands-off autonomous system for highways. But the company will be taking a "wait-and-see" approach with autonomous and electric vehicles.

Hachigo's perspectives are shared by other leaders in auto manufacturing, including Japanese rival Toyota's Executive Vice President Shigeki Tomoyama. The executive last month said in a speech that even with its \$10 billion r&d budget, Toyota has always seen the path to commercialization as long and challenging.

Last year, Apple co-founder Steve Wozniak said he's "given up" on ever seeing Level 5 fully autonomous vehicles being allowed on public roads during his lifetime. Apple is still working on a self-driving car project, but Wozniak said it's become much harder to achieve than had originally been thought.

A new survey by J.D. Power last month supports the conclusion that reaching mass adoption will be taking well over a decade. The study found that consumer sentiment

about self-driving vehicles and electrification has stayed flat recently, even through the technology growth has been impressive.

J.D. Power's 2019 Q3 Mobility Confidence Index Study found that opinions haven't changed since the last survey three month prior. The index now stands at 36 (on a 100-point scale) for self-driving vehicles and 55 for battery-electric vehicles — identical to the previous one.

"It was a little surprising to find consumer sentiment about self-driving vehicles and electrification has stayed flat," said Kristin Kolodge, J.D. Power's executive director-driver interaction and human-machine interface research. "But it shows that consumers are really steadfast in their opinions about new mobility technologies right now, regardless of how close they are to being available for purchase."

The studies polled more than 5,000 consumers and industry experts on self-driving vehicles, and another 5,000 on battery-electric vehicles. One industry expert in the study agrees with colleagues on how tough the challenge has become. "Tech and automotive companies continue to learn how difficult the problem really is," the expert said.

In February 2018, a global ride-hailing industry association was formed and found membership from several leading companies.

BlaBlaCar, Citymapper, Didi, Keolis, LimeBike, Lyft, Mobike, Motivate, Ofo, Ola, Scoot Networks, Transit, Uber, Via, and Zipcar joined the association. They signed the Shared Mobility Principles for Livable Cities today, pledging to prioritize people over vehicles, lower emissions, promote equity and encourage data sharing, among other goals.

The companies estimated they provide about 77 million passenger trips per day in cities around the world. The Shared Mobility Principles offer a vision for the future of cities, and creates alignment between the city governments, private companies, and NGOs working to make them more livable.

These companies and a few others — Waymo, Apple, Tesla, other automakers and automotive suppliers — are expected to be at the center of all of it. Their roles and corporate identities will be transforming, but that will take shape well after 2030.

About the report's author

Since 2013, Jon LeSage has been Editor & Publisher of *Green Auto Market*, which tracks clean transportation, electric vehicles, alternative fuels, mobility services, autonomous and connected vehicles, and the future of transportation. Readers include stakeholders in automotive, fleet management, regulatory agencies, research centers, and individuals with fascination and engagement in the subject matter.



LeSage served as an editor at *Automotive Fleet*, *Auto Rental News*, *LCT Magazine*, and *Automotive Digest*. His articles have appeared in *Autoblog Green*, *HybridCars.com*, and *Oilprice.com*. Professional experience also includes working as a market analyst in travel, ground transportation, and automotive; and market research in consumer opinions and purchase trends.

He's chaired and served on editorial advisory groups in car rental, clean transportation, and electric vehicles. He's also chaired and participated on panels at AltCar Expo in Santa Monica, Calif.

His published market reports have covered autonomous vehicles, Uber and the impact of ride-sharing, and how fleets can prepare for the upcoming mobility revolution.