

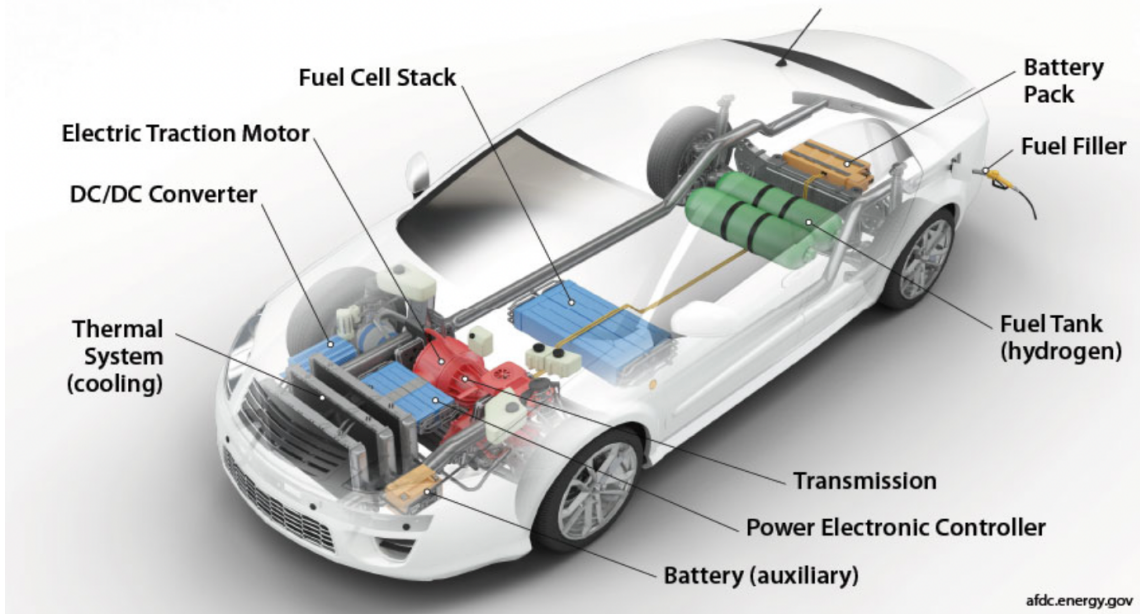


Market Intel

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

**Taking a deep
dive on hydrogen
fuel cell vehicles
as zero emission
regs approach**

Hydrogen Fuel Cell Electric Vehicle



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A new version of EVs vs. FCVs

The debate over which technology is better to hit the zero-emission vehicle target — plug-in electric or hydrogen fuel cell — still comes up occasionally. A decade ago, it was common to hear the arguments, when Elon Musk might have attacked fuel cell vehicles just a few years after the movie *Who Killed the Electric Car?* accused the California Air Resources Board for backing hydrogen over electric. During that time, the Bush administration would lean toward hydrogen and fuel cell vehicles — soon to be followed by the Obama administration, who were champions of EVs.



Toyota and Kenworth have sent over 10 fuel-cell trucks to the Port of Los Angeles as part of a grant from the California Air Resources Board.

The federal government, California, and a few other states, tend to take an all-inclusive, technology-neutral approach; and have done so for a couple of decades. Electric vehicles and their charging networks tend to take the top spot for funding, incentives, and other support, but fuel cell vehicles won't be going away anytime soon. Toyota's Mirai has gained most of the visibility for passenger fuel-cell cars but hydrogen-powered commercial trucks have been getting more of the focus lately.

This report will take a good look at where it all stands in passenger and commercial/fleet vehicles; and a second report will later look at where hydrogen is going as it gains

serious support for powering industrial plants, forklifts, electricity generation, stationary energy storage, heating, petroleum refining, fertilizer production, and other duties.

There's been quite a lot of activity on the hydrogen and fuel cell front lately, including:

- On Sept. 22, **The U.S. Department of Energy made available a \$7 billion fund** to create regional clean hydrogen hubs (H2Hubs) across the country. It's part of a larger \$8 billion hydrogen hub program funded through President Biden's Bipartisan Infrastructure Law. It's been put together to help communities across the country benefit from clean energy investments, good-paying jobs, and improved energy security – while also supporting President Biden's goal of achieving a net-zero carbon economy by 2050.
- In August, California **Gov. Gavin Newsom and the California Air Resources Board** announced a new policy: one-fifth of automakers' sales after 2035 could be plug-in hybrids, but the rest must be powered solely by electricity or hydrogen. Californians can keep driving gas-powered cars they'd owned before the deadline, but no new models of this type will be sold in the state.
- **New companies are becoming active in the hydrogen space** — Amazon, Bosch, and Cummins Inc., with one veteran hydrogen supplier — Shell — continuing to play a leading role outside of the oil market. Amazon recently made a deal with Plug Power to supply 10,950 tons per year of green hydrogen for its transportation and building operations starting in 2025. Green hydrogen is expected to replace grey hydrogen, diesel, and other fossil fuels as it continues to make moves to decarbonize its operations. (Grey hydrogen comes from natural gas, or methane, using steam methane reformation but without capturing the greenhouse gases made in the process, according to National Grid. Green hydrogen is produced by splitting water into hydrogen and oxygen using renewable electricity.)
- **Toyota Motor North America and Kenworth Truck Co.** said they have been more than pleased with their jointly designed Class 8 fuel cell electric vehicles (FCEVs) as a replacement of diesel-powered trucks with the completion of their operations in the Zero- and Near-Zero Emissions Freight Facilities (ZANZEFF) “Shore to Store” project at the Port of Los Angeles, the Los Angeles basin, and the Inland Empire. Ten of these hydrogen trucks have been delivered. The vehicle makers have been joined by the Port of Los Angeles as the project lead, Shell for the hydrogen fuel infrastructure, and a grant from the California Air Resource Board (CARB). The goal was to match and then surpass the performance of 2017 diesel engine trucks operating about 200 miles a day. The T680 FCEV has a range of about 300+ miles when fully loaded to 82,000 lbs. (GCWR), and with no downtime between shifts for charging but merely 15- to 20-minute fill time for the hydrogen. The FCEVs could run multiple shifts a day and cover up to 400 to 500 miles, while also helping the port support the state's zero emission vehicle targets.¹

¹Green Car Congress, Sept. 23, 2022.

<https://www.greencarcongress.com/2022/09/20220923-tmczanzeff.html>

- **BMW will be mass-producing fuel-cell cars.** BMW is advancing the series production of hydrogen-powered cars. The first small series of BMW hydrogen cars is expected to roll out before the end of 2022. The BMW X sport utility model will also be coming out in a hydrogen-powered version. “The upper end of our X family, which enjoys great popularity with our customers, is particularly suitable here,” says Oliver Zipse, Chairman of the Board of Management (CEO). “I can well imagine that we will also see the fuel cell in series production in the new class in the future.”²

But the hurdles are still in place. Can you get enough decision makers to trust the technology enough to transition over? The competition is steep out there with better, more fuel-efficient gasoline-engine cars, SUVs, and light trucks, hybrids, and a long list of available electric vehicles. Then there’s the short list of fuel cell cars with only two of them having gone into a larger volume of production. The commercial/fleet truck side is looking hopeful with plenty of impressive medium- and heavy-duty fuel cell trucks rolling into the harbors. But then there’s competition from diesel, electric, and in California, an abundant supply of renewable natural gas and renewable diesel.

Green car journalist John Voelcker does an excellent job of running down the list of questions that must be answered by a car shopper (or for those enraptured with vehicle technology and powertrain systems) before they would consider buying a fuel cell car.³ The refueling is much better than EV charging, but where are you going to find the well-supplied fueling stations — even in California?

Another tough one for fuel-cell vehicle advocates is the *Bloomberg* feature from Sept. 13, 2022, on the legal battles that plague fuel cell and battery electric truckmaker Nikola for its very survival. CEO “Trevor Milton looked like the next Elon Musk—and may end up the next Elizabeth Holmes. As the first of his several trials gets under way, the people who exposed him reveal how it all went down,” according to the article’s subhead.⁴

Let’s look at the sales numbers — domestic and international

Last year was very good for U.S. fuel cell vehicles. Sales came in at over three times the volume than in 2020. That’s compared to doubling the numbers in EV sales and reaching only 3.4% gain in all new vehicles sold last year. However, that only came out to 3,341 of these fuel-cell vehicles sold last year. Compare that to 660,000 plug-in electric vehicles sold in the U.S. last year; however, when it comes to alternative fuel

²BMW Group Produces Fuel Cell Systems. BMW. Aug. 31, 2022.

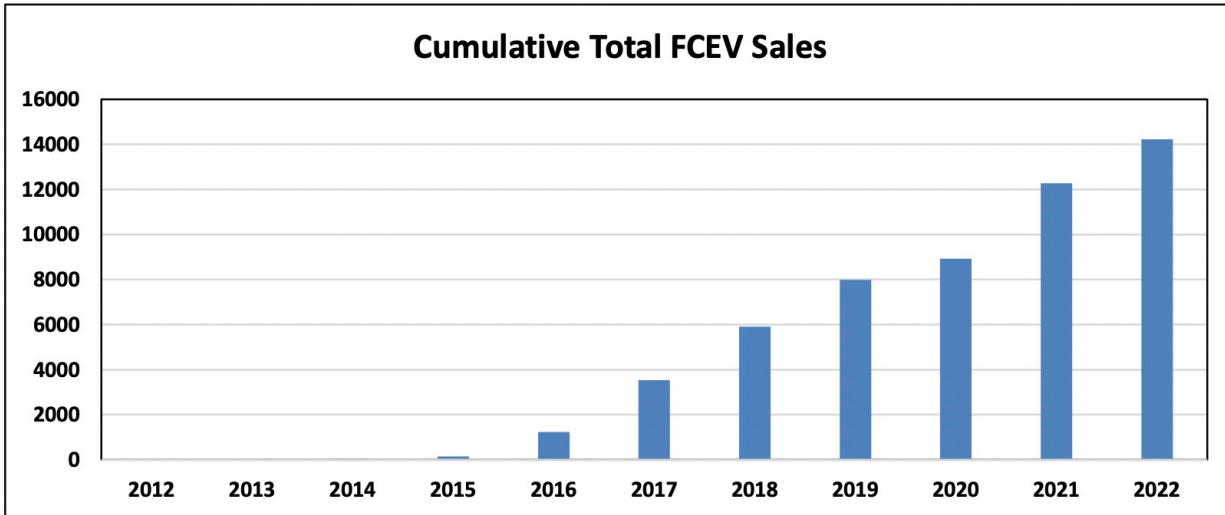
<https://www.bmwgroup.com/en/news/general/2022/FuelCell.html>

³ *Car and Driver*, Sept. 26, 2022.

<https://www.caranddriver.com/features/a41103863/hydrogen-cars-fcev/>

⁴ *Bloomberg*, Sept. 13, 2022

<https://www.bloomberg.com/news/features/2022-09-13/nikola-truck-scandal-has-trevor-milton-facing-whistleblowers#xj4y7vzkg>



	CY2012	CY2013	CY2014	CY2015	CY2016	CY2017	CY2018	CY2019	CY2020	CY2021	CY2022
Total	4	10	31	112	1082	2298	2368	2089	937	3341	1953
Cumulative	4	14	45	157	1239	3537	5905	7994	8931	12272	14225

vehicles, hydrogen fuel cell electric vehicle sales have some significance – especially given the rate of increase seen in these sale units over the past five years.

Source: Hydrogen Fuel Cell Partnership

These charts, from Hydrogen Fuel Cell Partnership (formerly known as California Fuel Cell Partnership), are based on fuel cell cars sold and leased in the U.S. The 2022 numbers go through the end of August. It also shows the limited reach that fuel cell vehicles have had in the U.S., with this total being based almost entirely in California.

JATO Dynamics reported that global sales of hydrogen fuel-cell cars totaled 15,500 units around the world in 2021. This signified an increase in demand of 84% compared to 2020. Since 2011 when fuel cell cars started limited production, approximately 41,700 hydrogen vehicles have been sold. Prices for these vehicles are high, and the limited number of hydrogen refueling stations also hurts. The choices are also very limited for consumers, with commercial/fleet vehicle buyers seeing more options come to market (at least in limited test runs).

America’s top selling fuel cell car, the Toyota Mirai, starts at \$49,500, prior to federal and state/local incentives bringing down the purchase price. *Kelley Blue Book* says that the Mirai XLE has a slightly higher range than the Limited, estimated at 402 miles; and that its MSRP starts at \$50,525.⁵ The second-generation Mirai helped its sales go way up in 2021.

⁵ Kelley Blue Book, 2022 Toyota Mirai
<https://www.kbb.com/toyota/mirai/2022/xle/>

The Toyota Mirai and Huyundai Nexo make up the vast majority of hydrogen fuel vehicles being sold on the global market, according to Motorsport Network's *Motor1*. The Honda Clarity is being phased out, and manufacturers are still testing out a small number of test fuel cell cars have been rolled out by Renault, Maxus, BMW, and Peugeot. BMW says it will be increasing its number with 100 hydrogen test units of the X5 this year. Kia announced plans for a hydrogen fuel-cell lineup in 2028. Volkswagen is turning everything over to an Audi development team.

South Korea has by far been the largest hydrogen fuel-cell car market. The figures for 2021 put this nation ahead of all others by a significant margin, according to Motor1.⁶ The U.S. has been the second largest fuel cell vehicle market, followed by Japan and then Europe. The Toyota Mirai made up a lot of the sales in the three markets following behind South Korea.

The Chinese government has made it sound like the country would be taking a leading role in fuel cell vehicles – similar to what it's said about autonomous vehicles rolling out in test mode and then in fully autonomous model. But the numbers are nothing like what China has been doing in its role as dominant world leader in plug-in electric vehicle sales.⁷

China is known to be a major producer of hydrogen, perhaps the largest in the world with an estimated annual production at 33 million tons. Essence Securities reported that there were 1,586 hydrogen fuel cell vehicles sold in China in 2021. Most of this has been in fleet usage, with only about 10% going to retail sales last year.

⁶ Motorsport Network, published in Motor1 Numbers.

⁷ Essence Securities, designed by Daxue Consulting, Production and sales of hydrogen vehicles in China from 2015 to 5/2021

Market Intel: Doing the Numbers

Top Selling Electric Vehicle Models in the First Half of the Year: What does that tell us?

Top 20 in US Market – 1st Half of 2022

• Electric vehicle	• Number of vehicles sold
1. Tesla Model Y	102,834
2. Tesla Model 3	93,800
3. Tesla Model X	18,000
4. Ford Mustang Mach-E	17,765
5. Tesla Model S	14,424
6. Hyundai Ionic 5	13,692
7. Kia EV6	12,568
8. Nissan Leaf	7,622
9. Chevy Bolt EV/EUV	7,303
10. Rivian R1T	5,694
11. Audi e-tron	4,738
12. Porsche Taycan	4,449
13. Volkswagen ID.4	4,415
14. Mercedes EQS	4,050
15. Ford F-150 Lightning	2,296
16. Audi e-tron Sportback	1,880
17. BMW iX	1,428
18. Audi e-tron GT	1,411
19. Lucid Air	1,139
20. Hummer EV	379

Sources: Automakers, EV Volumes, *CleanTechnica*, and Urban Science.

Top 20 in Global Market — 1st Half of 2022

• Electric vehicle	• Number of vehicles sold
1. Tesla Model Y	314,921
2. Tesla Model 3	219,095
3. Wuling Hong Guang MINI EV	207,829
4. BYD Song (BEV + PHEV)	159,091
5. BYD Qin Plus (BEV + PHEV)	132,495
6. BYD Han (BEV + PHEV)	97,225
7. Volkswagen ID.4	63,597
8. Li Xiang One EREV	60,404
9. BYD Dolphin	58,613
10. BYD Tang (BEV + PHEV)	57,000
11. Chery QQ Ice Cream	54,097
12. BYD Yuan Plus	54,970
13. Hyundai Ioniq 5	52,108
14. Changan Benni EV	51,512
15. Chery eQ1	46,914
16. GAC Aion Y	44,251
17. Hozon Neta V	41,404
18. Kia EV6	41,437
19. GAC Aion S	39,929
20. Ford Mustang Mach-E	36,050

Source: *Inside EVs*

The latest research from Canalys, an independent analyst company, reports that 4.2 million electric vehicles (EVs) were sold worldwide in the first half of 2022, up 63% compared to the first half of 2021. EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Ward’s Intelligence reported that overall global new vehicles sales hit 39.03 million vehicles sold in the first half of this year, versus 44.02 million in the first half of last year. North America and Europe had the largest declines. The U.S. wasn’t up as high as the global market (led by China), but it was up 41% over the first six months of 2021, according to auto consultancy Urban Science.

Alternative Fuel Stations in the U.S.

Fuel	Stations
Biodiesel (B20 and above)	827
Compressed Natural Gas (CNG)	821
Electric	45,874*
Ethanol (E85)	4,233
Hydrogen	54
Liquefied Natural Gas (LNG)	1,313
Propane (LPG)	1,260

Source: U.S. Dept. of Energy, Alternative Fuels Data Center

*Locations with Level 2 and DC fast charger stations; and there are 116,816 EVSE ports.