Sustainable Automotive Trend Analysis for U.S. Market

At a glance

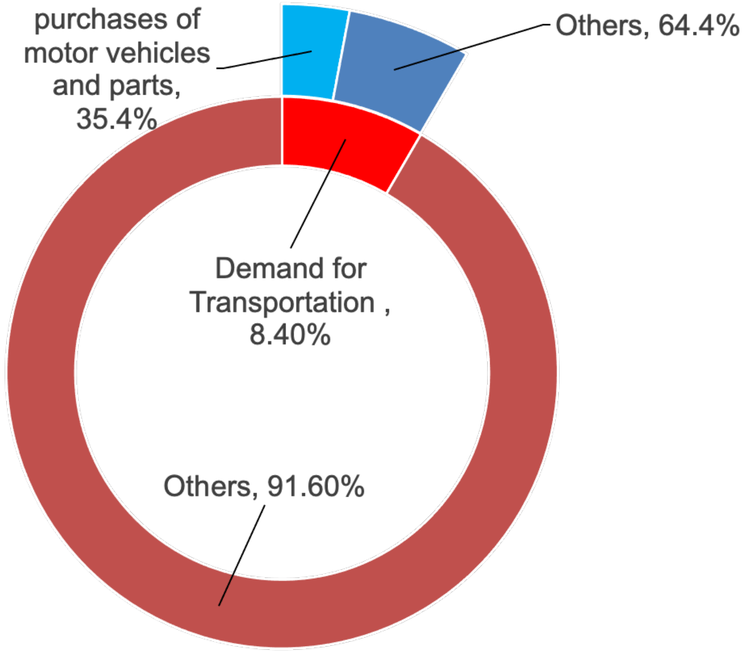
- Fuel cell vehicles is not competitive in the U.S. market
- Electric car tend to dominate the auto industry in the future

Importance of U.S. Auto Industry

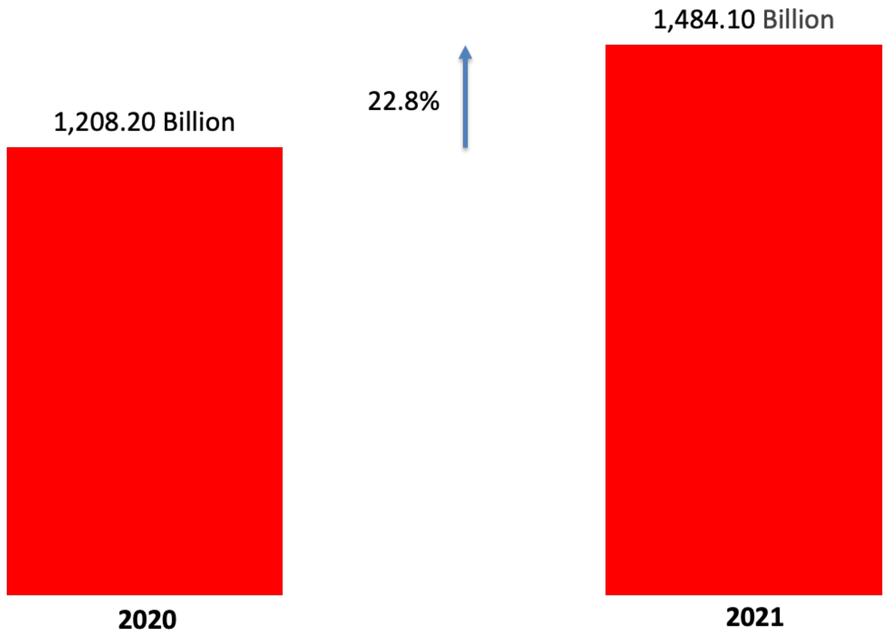
U.S has one of the largest automotive industry in the world. Thanks to assembly line invented by Henry Ford, America begun auto mass production to significantly reduce the price of car by 60% at the year of 1913. Middle-class population was able to afford it.

Auto industry also plays an essential role in the U.S. economy. The demand for transportation owned 8.4% of total GDP in 2021. The growth rate of motor vehicle and parts increased by 22.8% during the time of pandemic.

Automative manufactures in Total GDP in 2021



Purchase of Motor vehicles and parts sales in 2020 and 2021

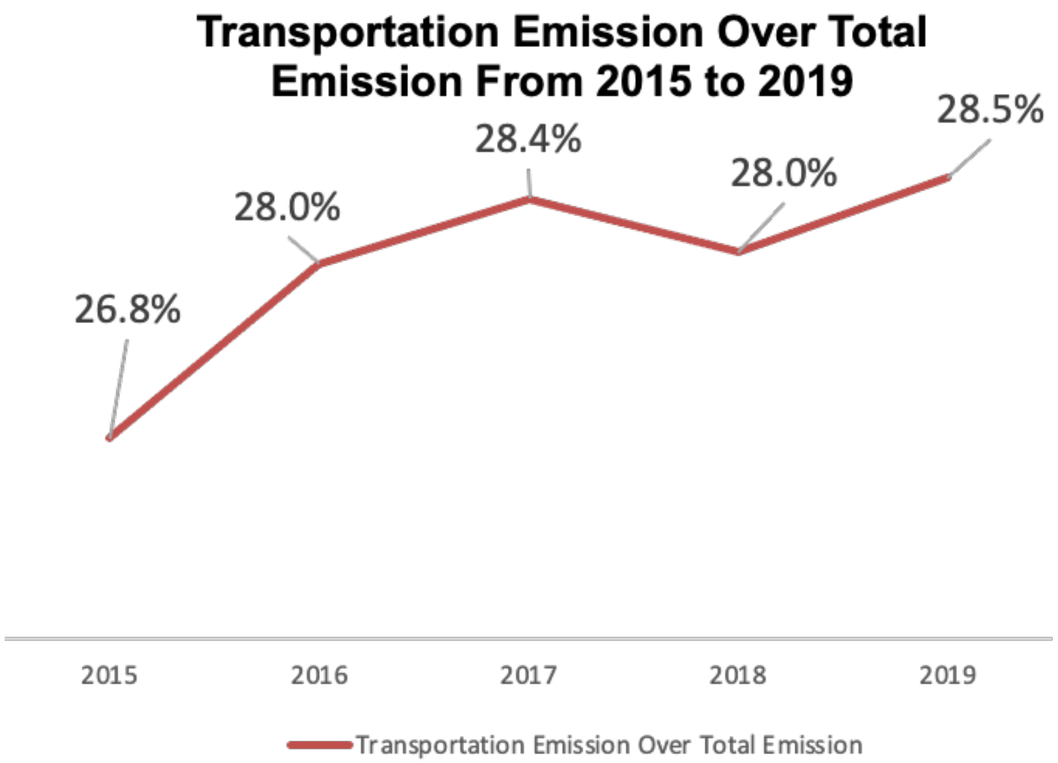


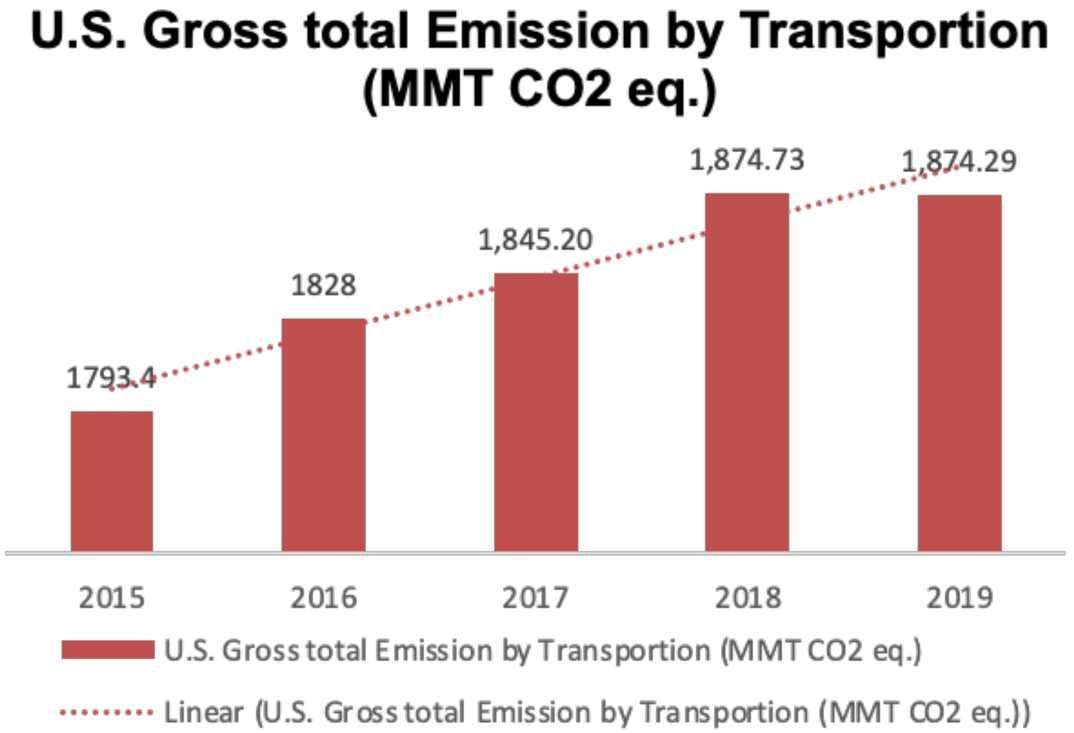
Source: https://data.bts.gov/stories/s/Transportation-Economic-Trends-Contribution-of-Tra/pgc3-e7j9/ https://www.census.gov/newsroom/press-releases/2022/retail-sales.html, Self analysis

U.S. Greenhouse Emission Trend

As more and more gasoline vehicles sold in the U.S., air pollution becomes a serious consequence. The share of transportation emission in total emission had grown from 27% to 28.5% by 2019. Among all economic sectors, transportation has always been one of the largest pollution sources.

Therefore, in order to reduce the total emission, the topic of transportation reduction will be an inevitable topic for the U.S. government.





Source: https://cfpub.epa.gov/ghgdata/inventoryexplorer/#allsectors/allsectors/allgas/econsect/current, Self analysis

U.S. Policies To Tackle Greenhouse Emission

U.S. has strong confidence to tackle climate challenge. After President Biden took the office in January 2021, his administration declared following government announcement:

Nation Climate Task Force published by The White House on 2021 requires:

- U.S. greenhouse down 50% comparing to the level of 2005 by 2030
- Electricity utilization reaches 100% by 2035
- Net Zero-Emission by 2050
- 40% of federal investment gain will go to deprived communities

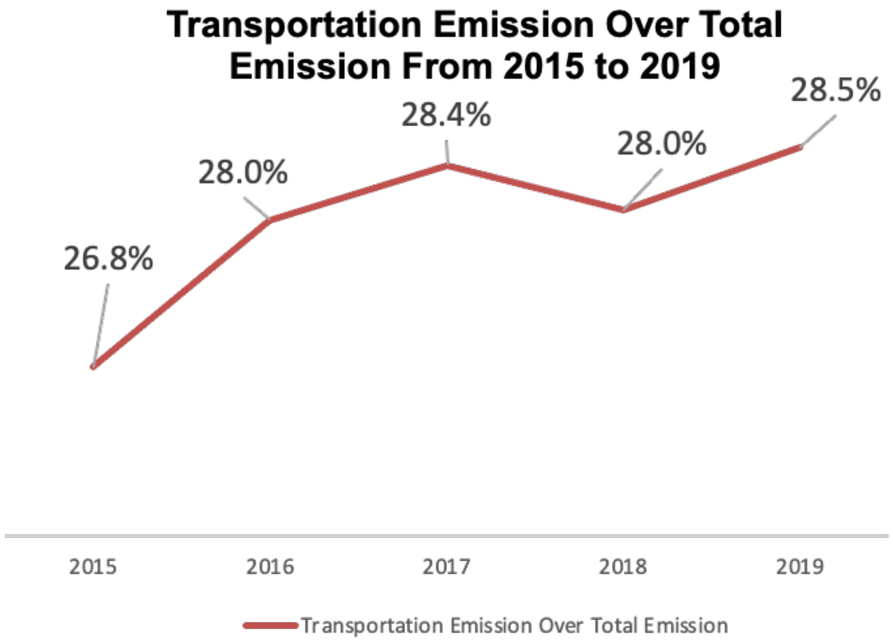
Bipartisan Infrastructure Law announced by Biden-Harris Administration enhance:

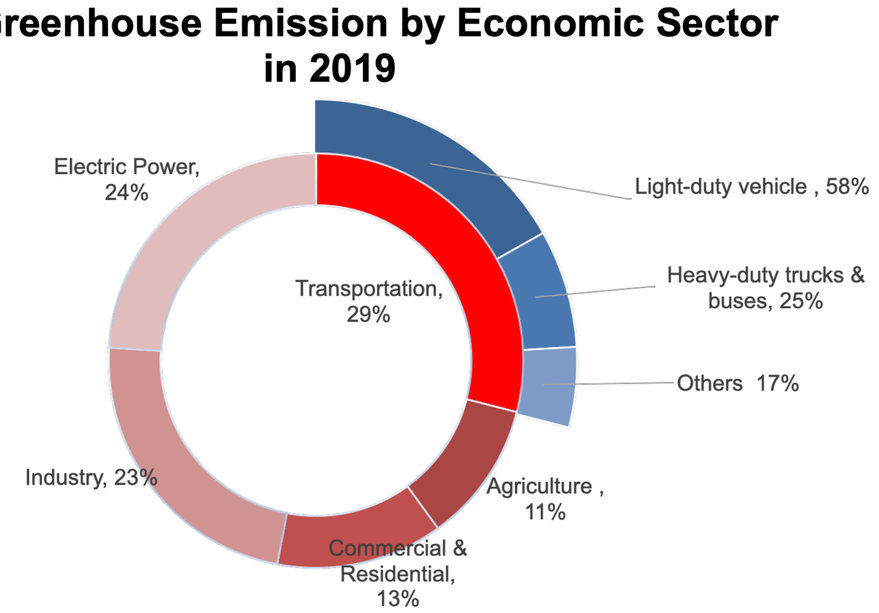
- emission-free public transit and school buses
- Charging station for EV nationwide
- Power network station

Importance of Transportation on Greenhouse Gas Reduction

By U.S. Environmental Protection Agency(EPA), among all greenhouse emission sectors, transportation has the largest source of emission. Within transportation, light-duty vehicle contribute over a half. Additionally, 90% of transportation fuel came from both gasoline and diesel. Thus, Controlling emission from vehicles can significantly reduce pollution

To be concluded, goal of the U.S. government is to keep expanding auto industry because of important role of GDP and to reduce the greenhouse gas emission simultaneously. One of the top choices will be transitioning to sustainable automative industry





Source: https://cfpub.epa.gov, https://www.epa.gov, Self analysis

U.S. Policies Rewarding Sustainable Vehicle's Buyer

The Inflation Reduction Act of 2022(Public Law 117-169) gives Clean Vehicle Credit(CVC) tax credit[1] to customers who purchase sustainable vehicles after December 31, 2022

- CVC tax credit has based amount of $2500 if your vehicle has minimum battery capacity of 7 kilowatt-hours(kWh)
- Additional $417 can be added to the based amount with additional 5kWh
- CVC tax credit can be up to $7500

In order to receive full amount CVC tax credit, you must meet both critical mineral guidance and battery component guidance published by *Treasury Department*. However, you can earn $3750 for each guidance satisfaction

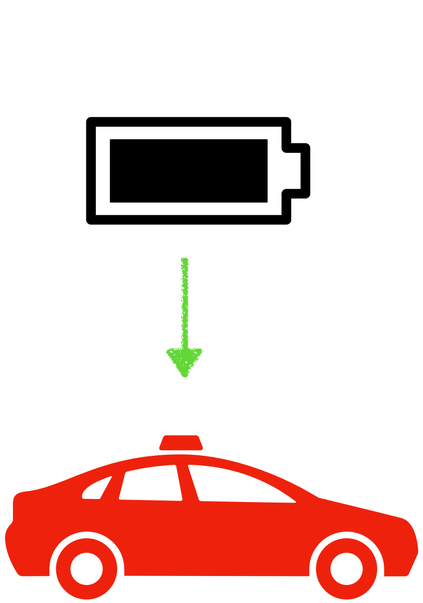
- *Critical mineral guidance* requires, in 2023, 40% of value of battery's critical mineral must be mined or processed in the U.S. or America free-trade agreement partner or recycled in North America. The value percentage increases 10% each year and stops at 80% in 2027
- *Battery component guidance* requires, in 2023, 50% of value of battery components must be mass-produced in North America. The value percentage increase 10% each year(except 2025) and stops at 100% at 2029

[1] Eligible CVC tax credit can reduce the tax amount you owe or raise your tax refund

Source: https://www.irs.gov/credits-deductions-for-individuals, https://afdc.energy.gov/laws/409, Self analysis

Mankind of Sustainable Vehicles

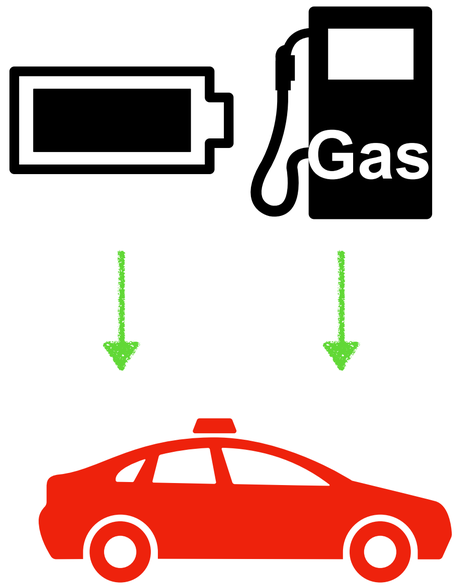
By Environmental Protection Agency(EPA) green vehicle guide, followings belong to sustainable vehicles:



BEV

(Battery Electric Vehicles)

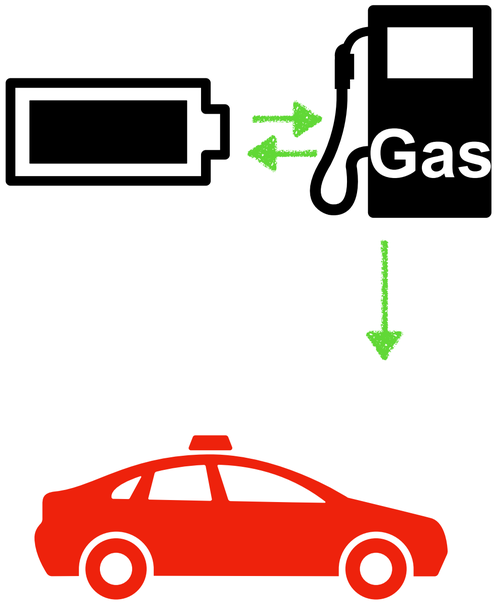
- Powered Solely by battery pack
- Charge battery by plugging into Electric Source



PHEV

(Plug-in Hybrids Electric Vehicles)

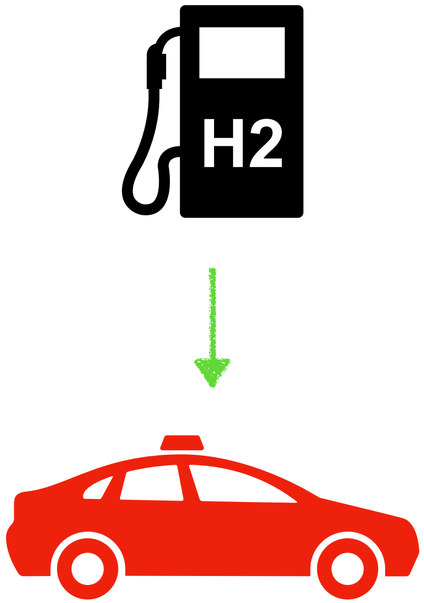
- Powered by either gas or battery
- Charge battery by plugging into Electric Source



HEV

(Hybrids Electric Vehicles)

- Powered Solely by gas engine
- Electric motor assist gas engine
- Gas engine charges electric motor



FCV

(Fuel Cell Vehicles)

- Powered solely by Fuel cell, which is powered by pressurized Hydrogen
- Charge Hydrogen at H2 station

Source: https://www.epa.gov/greenvehicles/learn-about-green-vehicles, Self analysis

Charging Time Between Electric and Hydrogen

From the perspectives of charging times, FCV has huge advantage then other type of sustainable vehicles. Time consuming is very similar to gasoline cars.

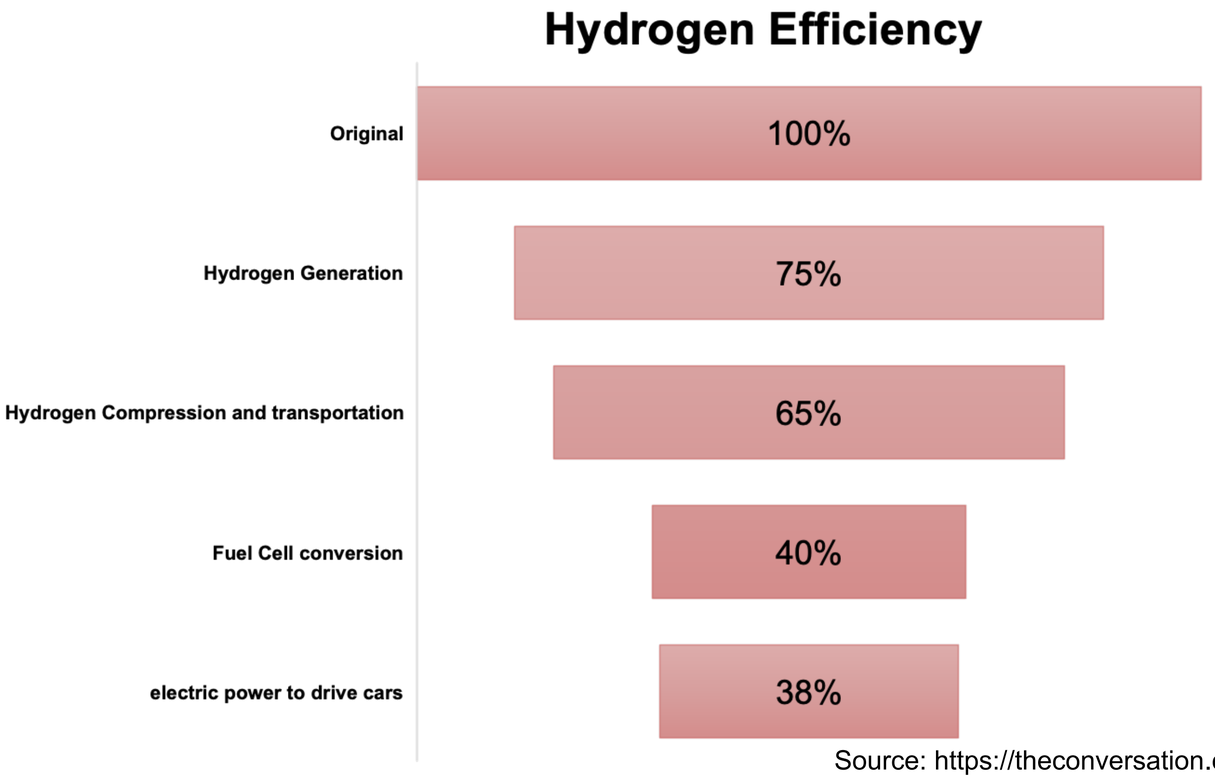
	BEV	PHEV	HEV	FCV
(7-19kW) Charging time from empty	4 - 10 (Hours)	1 - 2 (Hours)	X	X
(7-19kW) Range per Hour	10 - 20 miles	10 - 20 miles	X	X
(50-350kW) Charging time from empty	1/3 - 1 (Hours)	X	X	X
(50-350kW) Range per Hour	180 - 240 miles	X	X	X
Charging times using Hydrogen	X	X	X	3-5 minutes

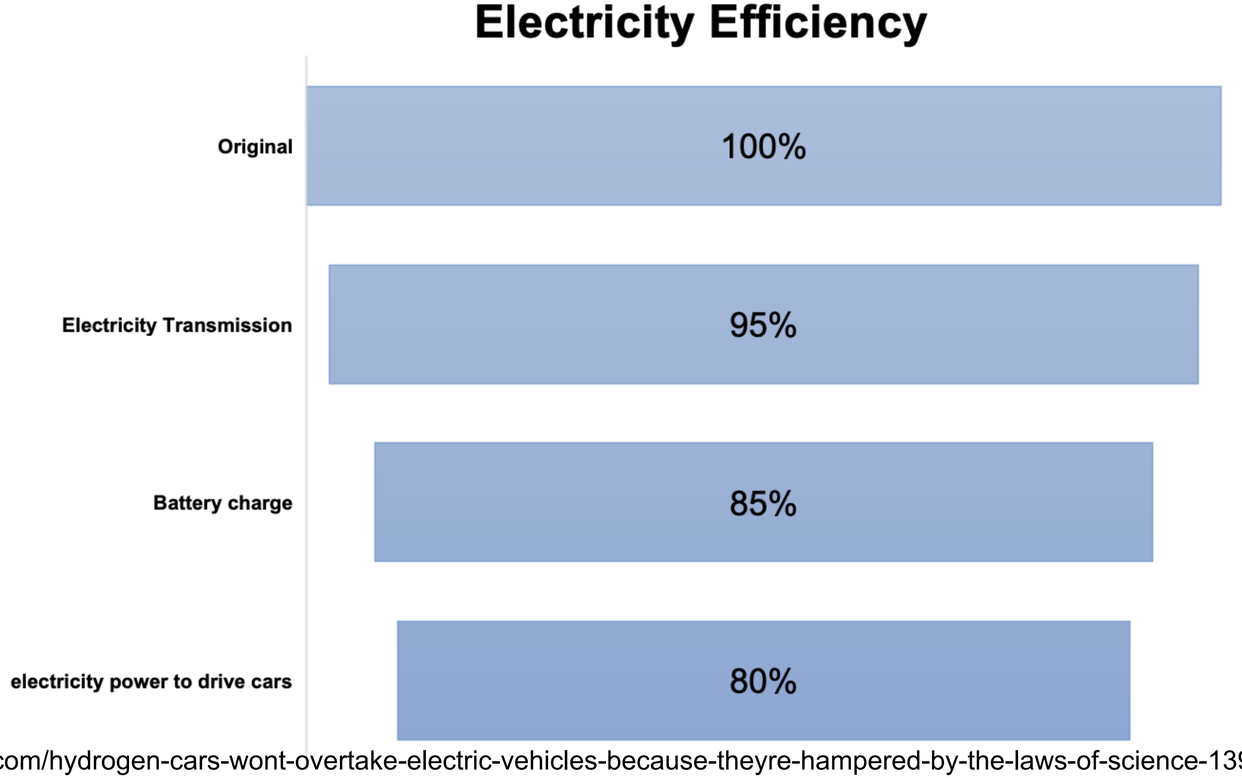
Source: https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds, Self analysis

Energy Efficiency Between Fuel Cell Vehicle and Electric Vehicle

By U.S. Department of Energy, the conversion rate of electric energy is 77% from grid to wheel. Additionally, according to Tom, a chemical researcher at University of Aberdeen, Hydrogen can only use 38% of the original source energy to power the car. However, electricity is able to use 80% of its original source energy.

The reason behind is that, by theory, FCV needs to convert pressurized hydrogen to electric, then use generated electric to power the car. The energy consumption lost significantly by this step.



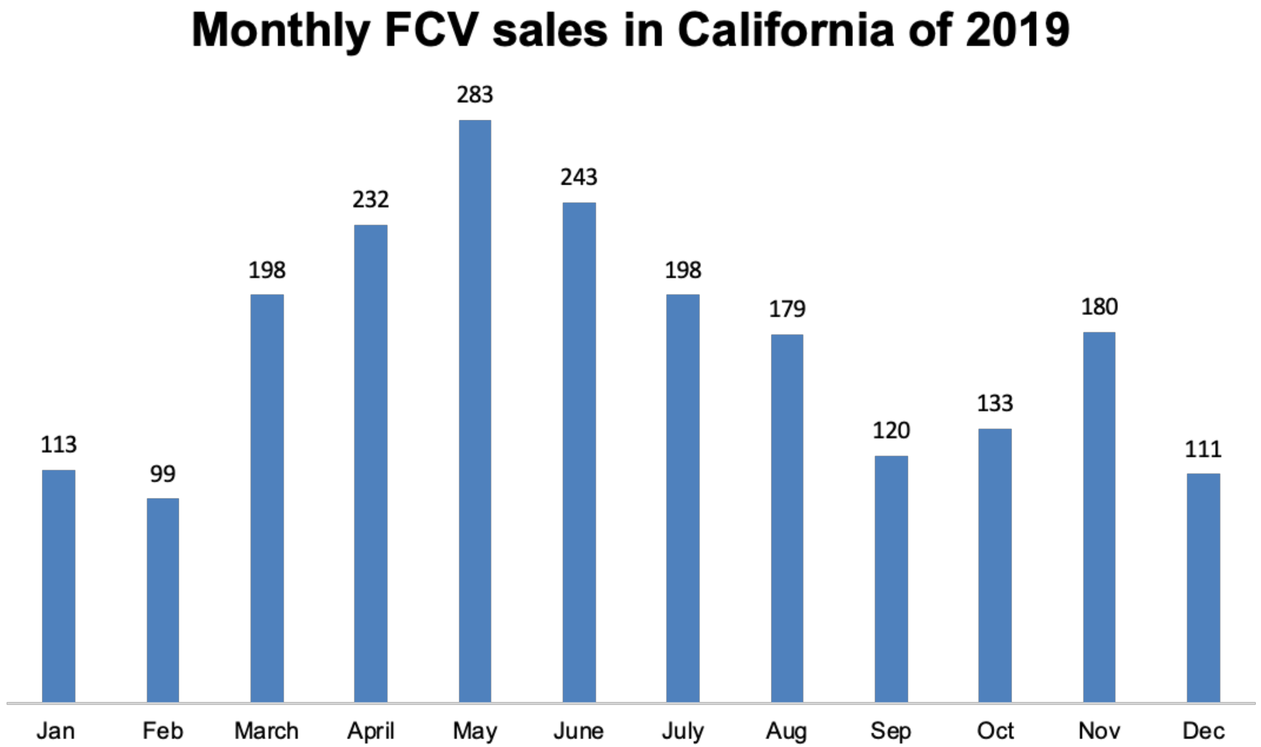


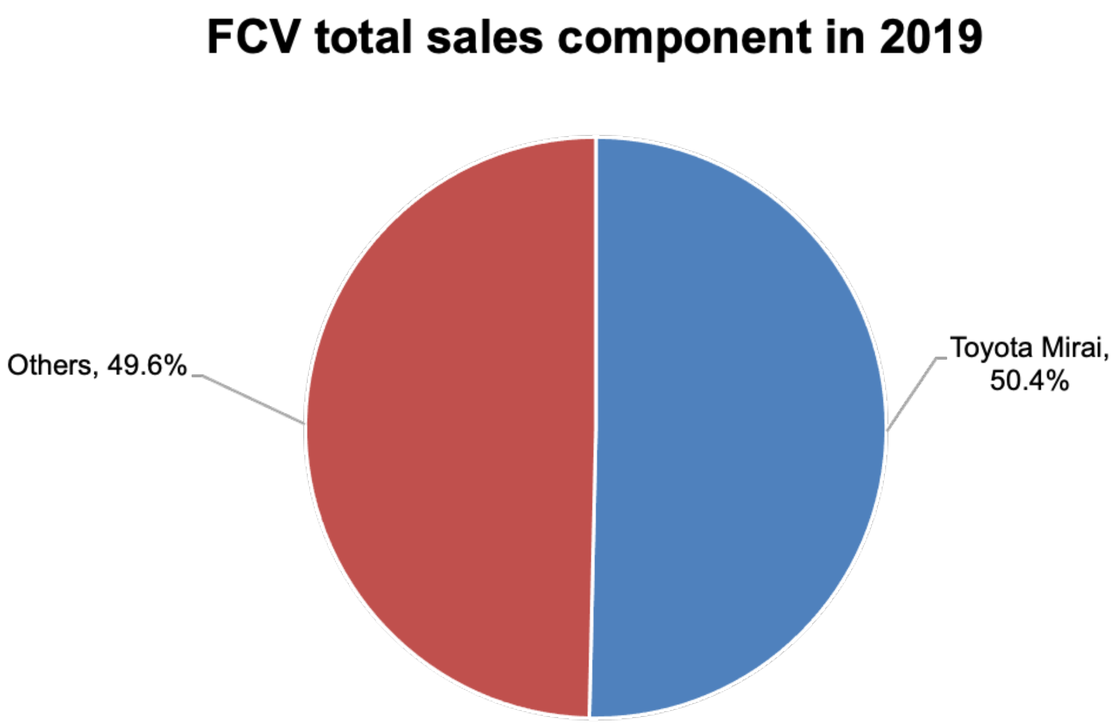
Source: https://theconversation.com/hydrogen-cars-wont-overtake-electric-vehicles-because-theyre-hampered-by-the-laws-of-science-139899, https://www.fueleconomy.gov/feg/evtech.shtml Self analysis

Fuel Cell Vehicle Sales number In California

By statistics from Department of Energy, in 2019, total FCV sales in California was 2089. It was a 12% decline comparing with 2018 sales number.

The majority of these FCV came from one model, Toyota Mirai. Mirai alone sold 1052 FCV in California, As we can observe, Japanese brand has most competitive FCV models in the market since Japan owns most of the Hydrogen, fuel cell patents. Second largest FCV model comes from Hyundai.





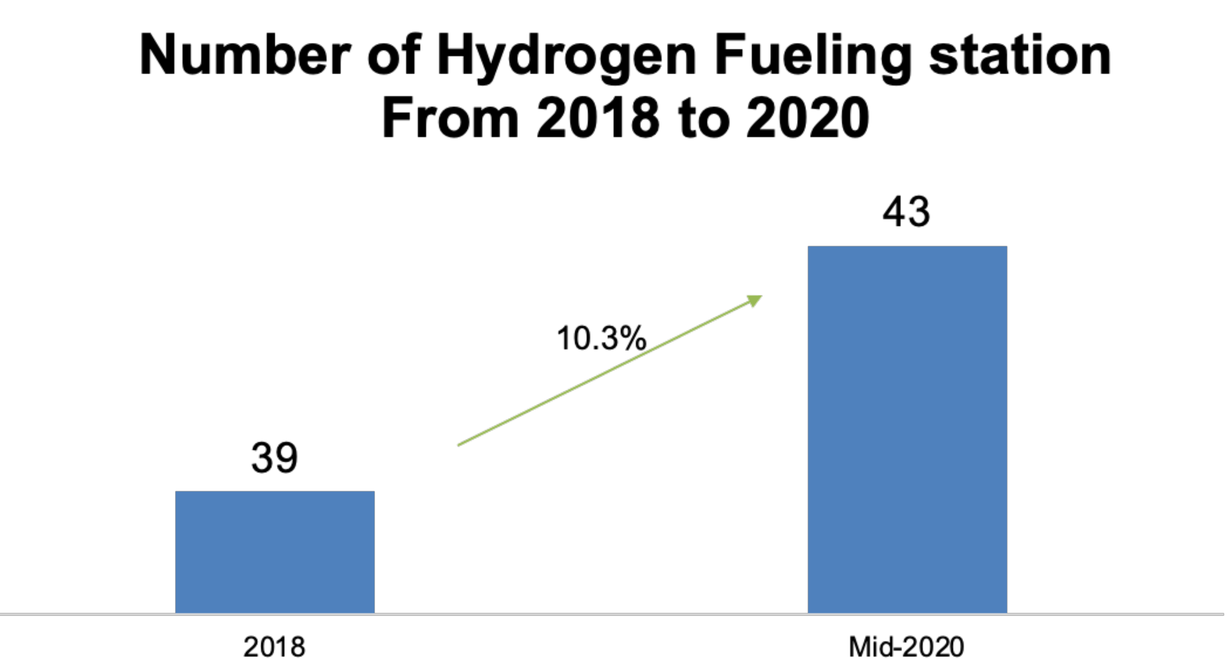
Source: https://afdc.energy.gov/data/search?q=2019, Self analysis

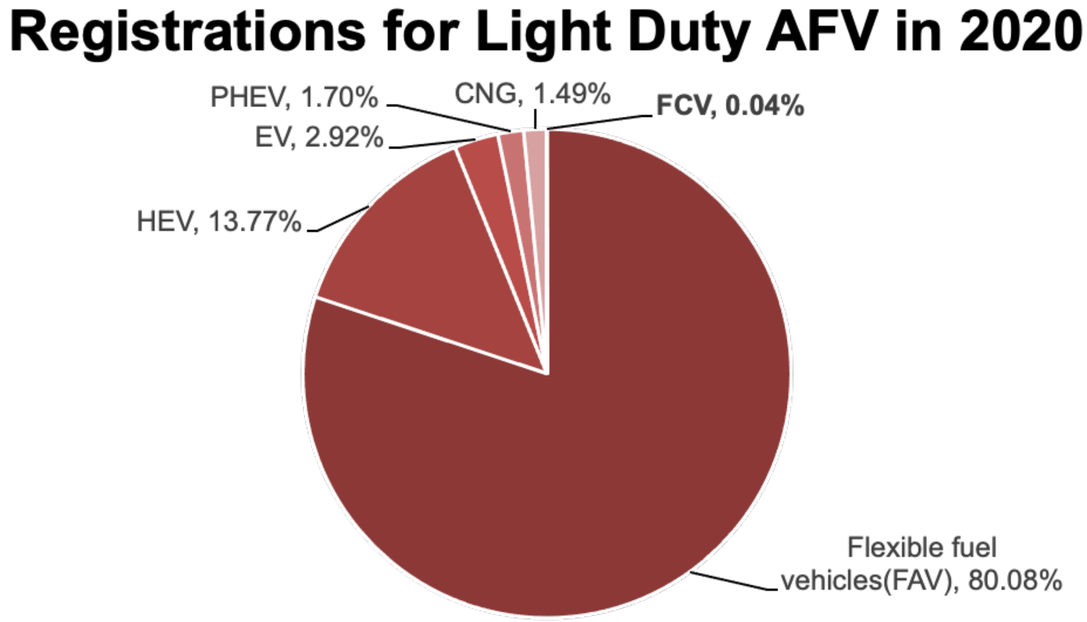
Fuel Cell Vehicle Conclusion

Even the charging time of FCV is very similar to gasoline cars, FCV is still a very tiny market in the U.S.

By Energy Department, in 2020, the market share of FCV only had 0.04%. From another perspective, the infrastructure still at very beginning stage. Hydrogen Fueling station only increase 10.3% from 39 stations to 43 stations in two years. Less fueling station causes less people willing to buy hydrogen car, less hydrogen car sold, less fueling station will be built.

Finally, current market environment of Fuel Cell Vehicle in the U.S. is not competitive comparing to electric-powered vehicle.



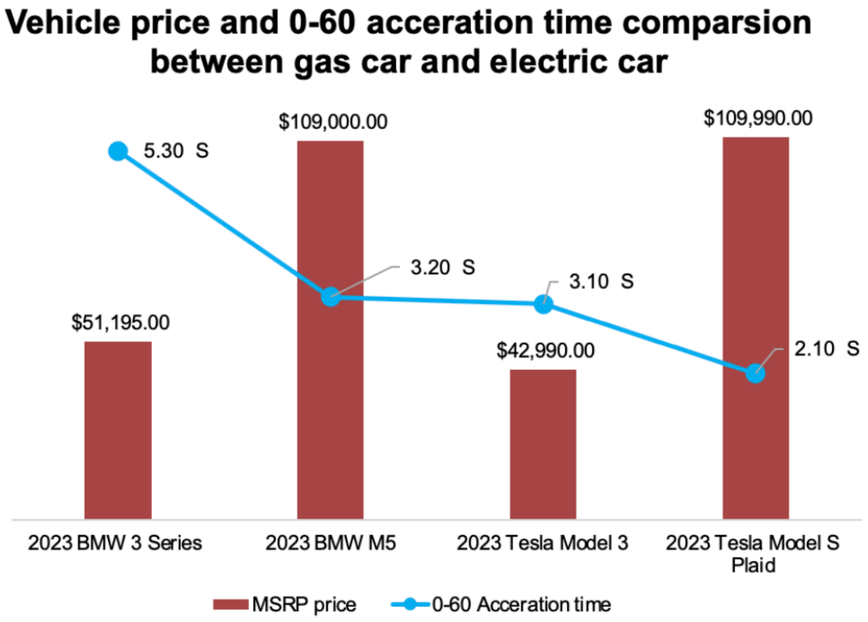


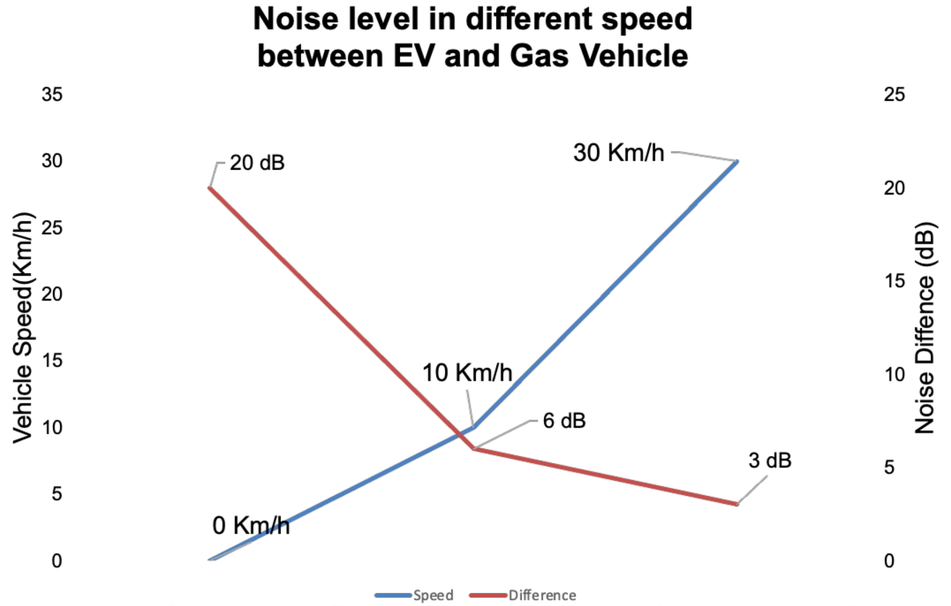
Source: https://afdc.energy.gov/fuelshydrogen_stations.html, https://afdc.energy.gov/data/10861, https://www.energy.gov/eere/fuelcells/fact-month-18-01-january-29-there-are-39-publicly-available-hydrogen-fueling
Self analysis

Electric Vehicle Acceleration Time

In the gasoline car era, you need to spend hundreds of thousand of dollars to buy a 3-second performance vehicle. However, you can get a vehicle with the same performance but at less than half of the price. Additionally, if you spend price amount of performance gas car on electric car, the performance will be much better, Tesla Model S Plaid for example.

EV doesn't have gas engine. Therefore, its internal noise will be much better than gas car. By study, the maximum noise difference occurs at idle situation. Even thought the noise difference will decrease as the vehicle speed increases, we will feel much comfortable driving electric cars.



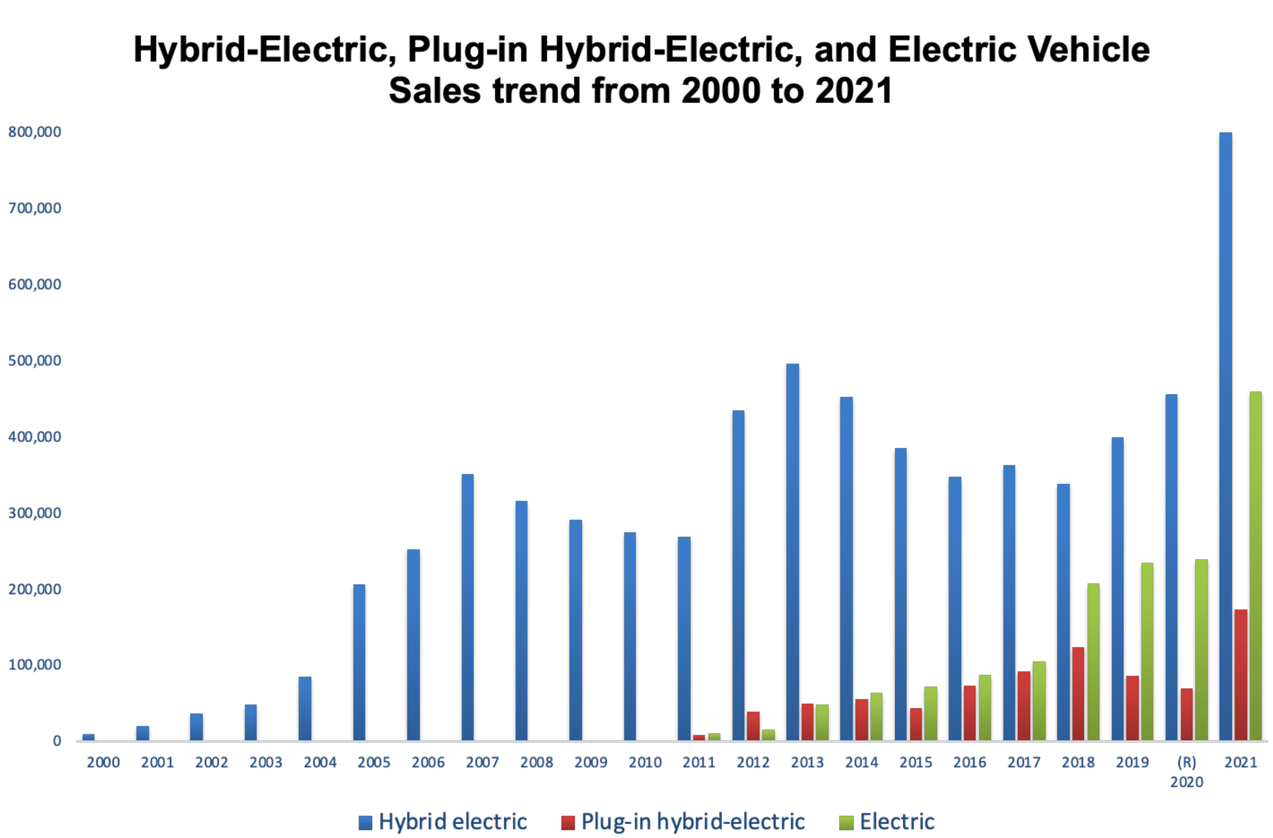


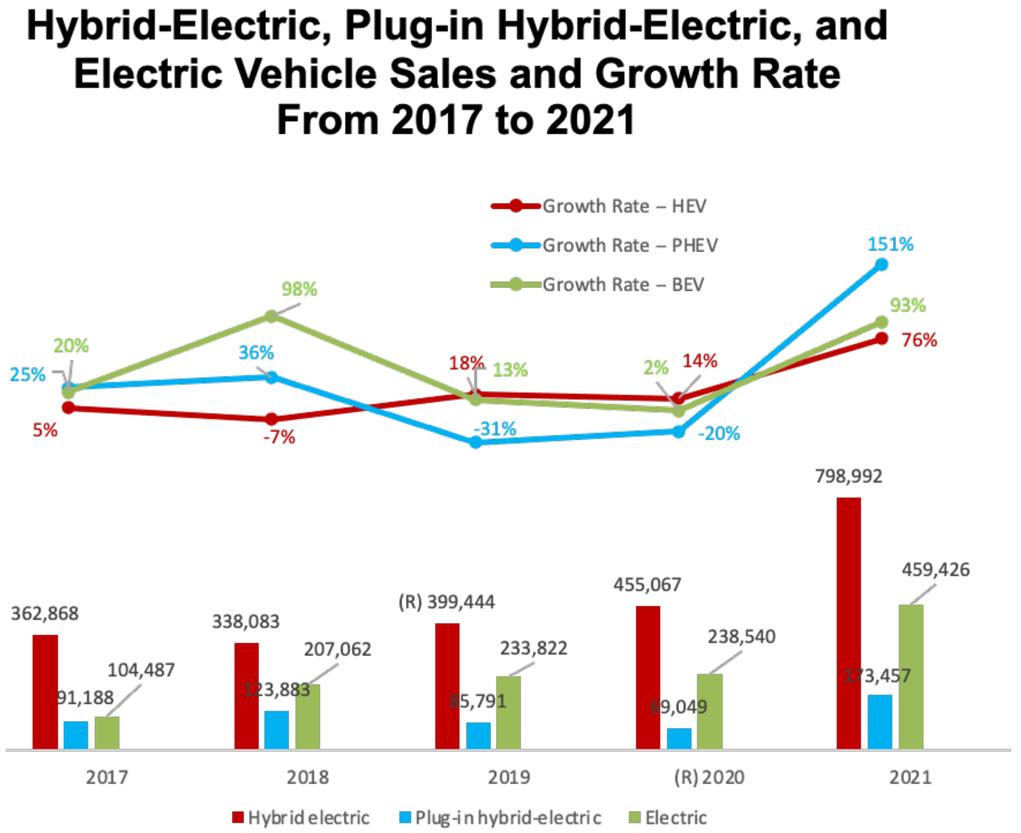
Source: https://www.bmwusa.com/, https://www.tesla.com/model3, Self analysis
https://www.researchgate.net/publication/288270778_Evaluation_of_Annoyance_and_Suitability_of_a_Back-Up_Warning_Sound_for_Electric_Vehicles

Electric Vehicle Trend

On the left hand side, we can observe that electric car started growing in 2011 when hybrid electric car sales far more than electric cars. However, in 2021, electric car reaches about half of the sales of hybrid cars.

On the right hand side, from 2017 to 2021, the growth rate of BEV was the only rate that had four consecutive positive growth rates.



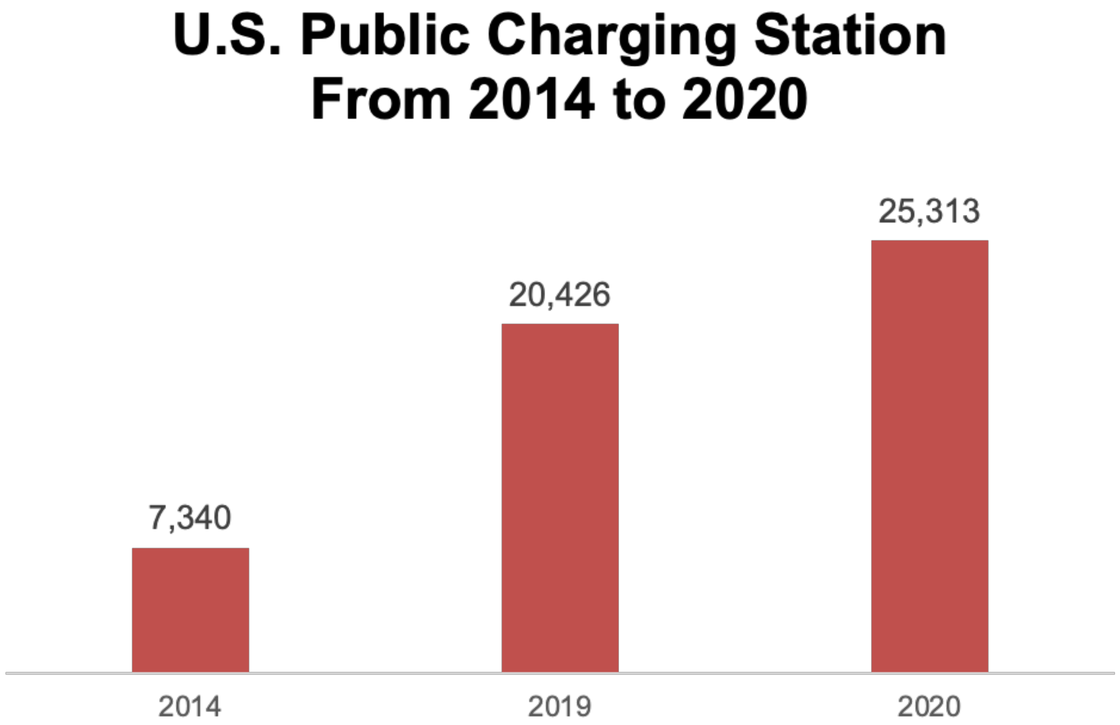


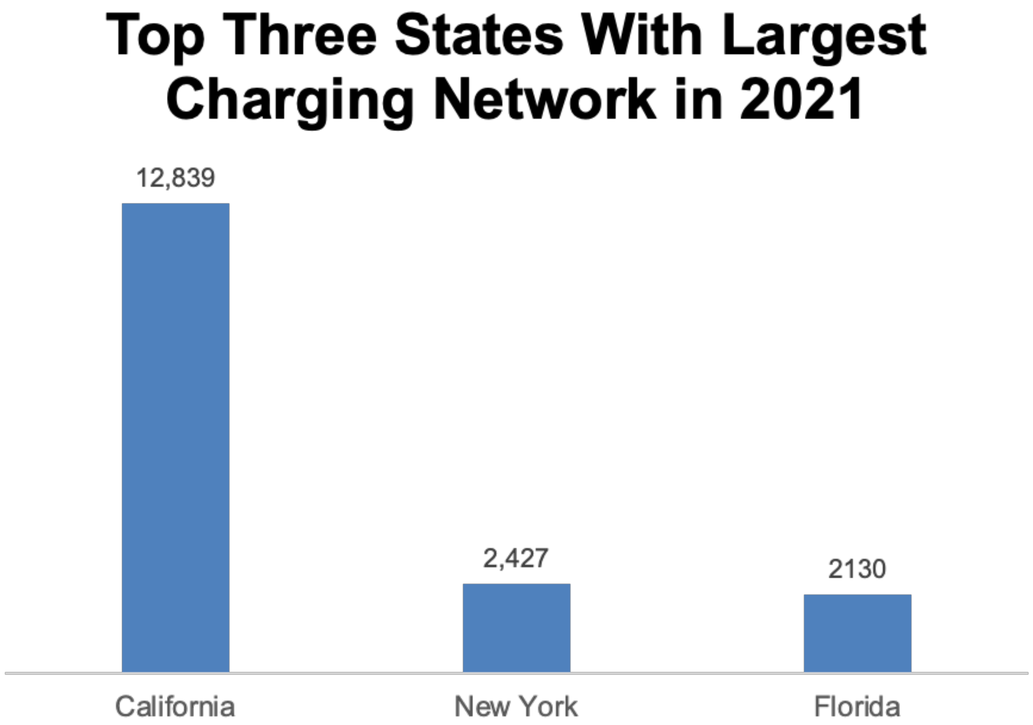
Sources: U.S. Department of Energy, Energy Vehicle Technologies Office, Oak Ridge National Laboratory, Self analysis

Charging station

Charging station number in 2020 has been increased more than three times. Among all states, California has six times as many charging stations as New York in 2021. We also notice that top three charging station states are all costal states.

As more and more infrastructure, charging stations for example, has been built, electric vehicles will be accept by most of population.



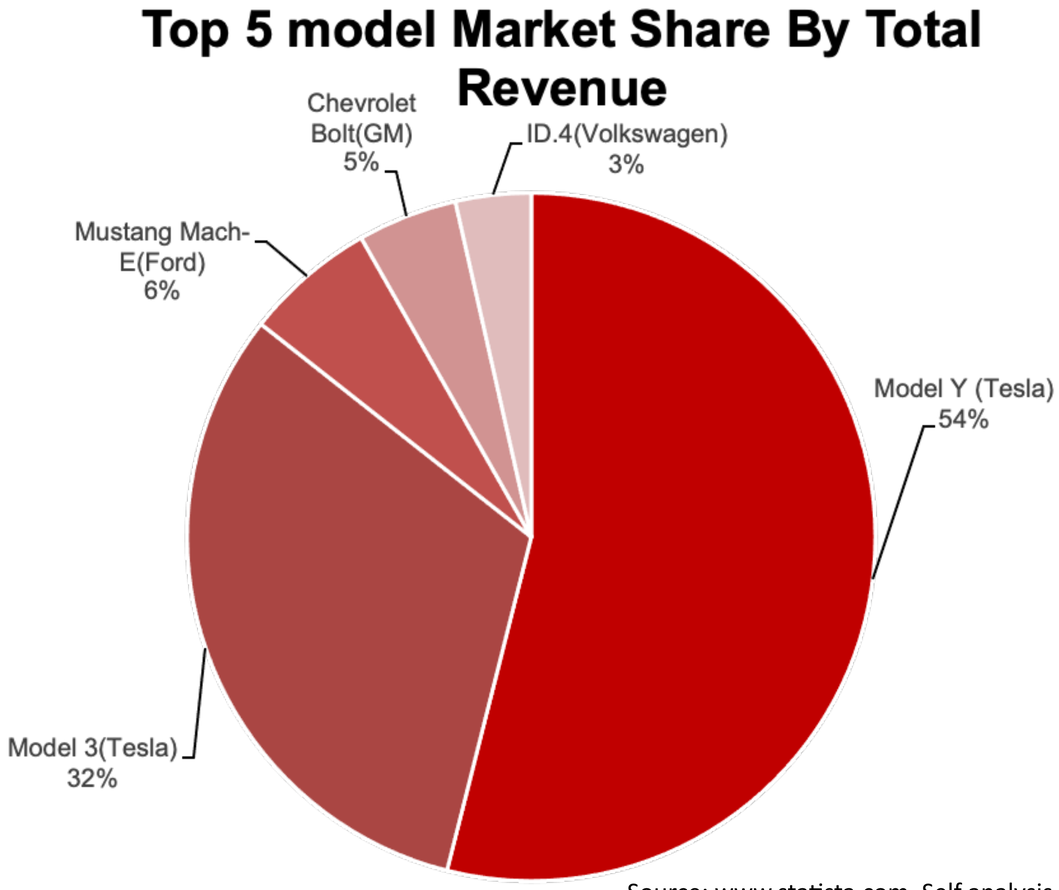


Source: https://www.bts.gov/data-spotlight/electric-vehicle-use-grows, Self analysis

Electrical Vehicle Top Players

In 2021, Tesla obtained 86% of total sales revenue from top 5 best selling electrical vehicles. Additionally, the average selling price of Tesla's two models both were also higher than remaining three models from conventional auto manufactures.

In 2022, Tesla sold 1.7 Billion dollars on regulatory credit to other manufactures.It was 49% increase from year 2021.

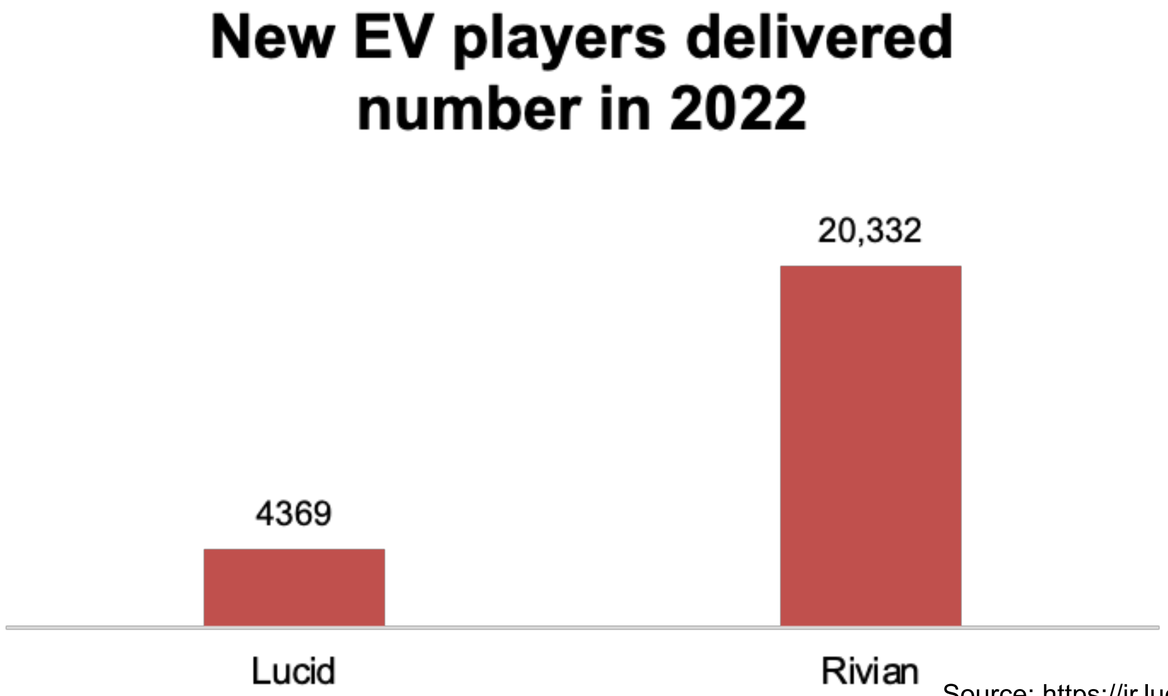


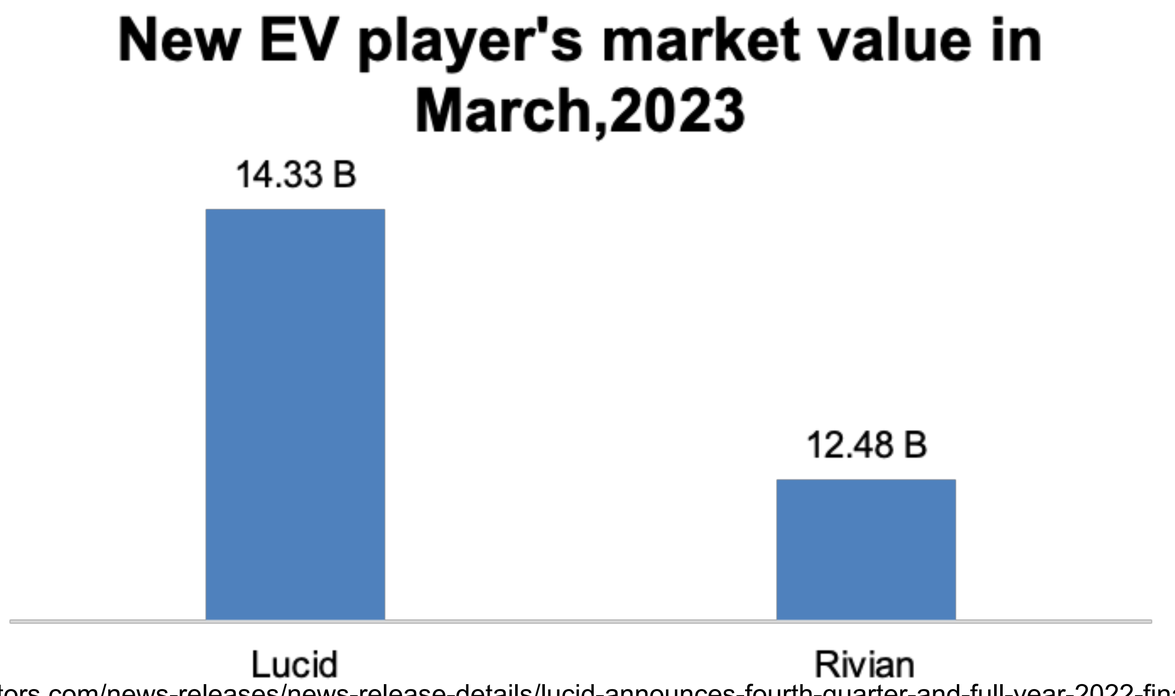
Source: www.statista.com, Self analysis

Other Electric Players

Lucid was founded in 2007 and is headquartered in Neward, CA. Currently, Lucid only has one product - “Lucid Air”. Lucid air starts at 77,400 dollars. In 2022, Lucid delivered 4369 Lucid air to the customer. Current market value is 14.33 billion dollars.

Rivian was founded in 2009 in Irvine, CA. The biggest share holder is Amazon. Rivian delivered 1000 vans to Amazon in 2022. Rivian has two electric pickup truck products called R1T and R1S. R1T starts at 73,000 dollars and R1S starts at 78,00 dollars. Current market value is 12.48 billion dollars.





Source: https://ir.lucidmotors.com/news-releases/news-release-details/lucid-announces-fourth-quarter-and-full-year-2022-financial
https://rivian.com/r1t, Self analysis

Conclusion

In 2022, only 5.8% of vehicle sold in the U.S. were electrical-powered. By the theory of basis of innovativeness, electric vehicle market is still at early adopters stage. The majority market is still remain unexplored.

By the force of both government's net-emission goal and trend of electric car sale, this market will become much bigger when it reaches Early Majority and Late Majority.

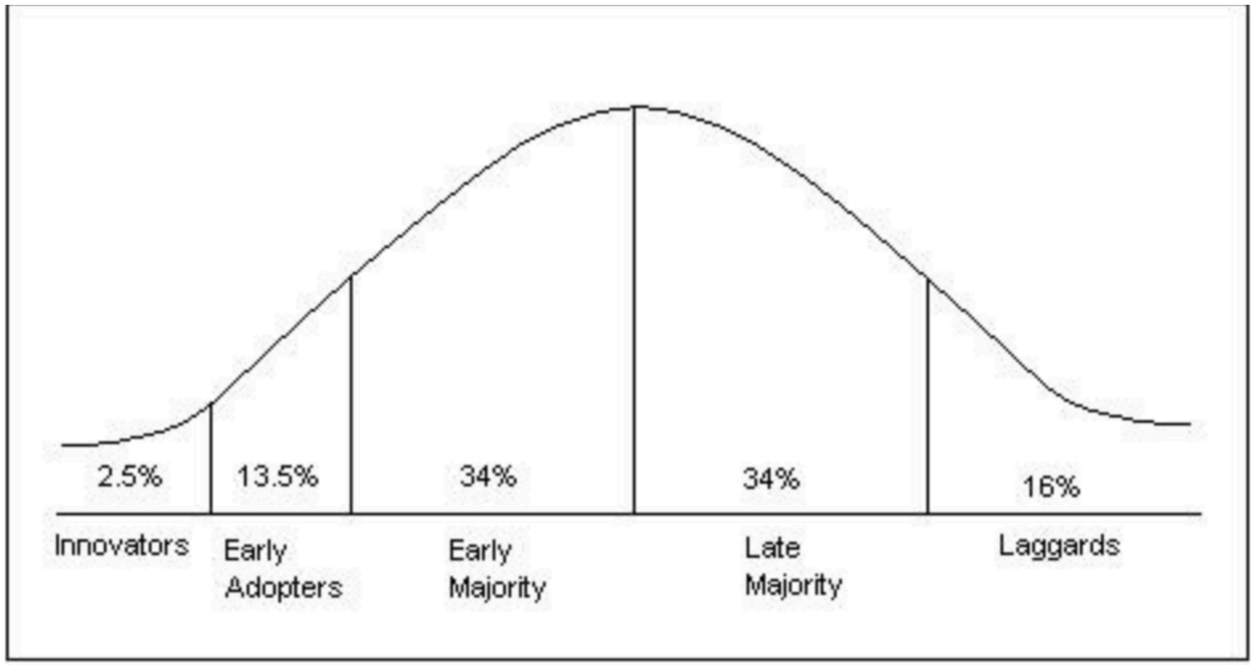


Fig. 1 - Adopter categorization on the basis of innovativeness

Source: https://www.ou.edu/deptcomm/dodjcc/groups/99A2/theories.htm