ECE 398GG – ELECTRIC VEHICLES

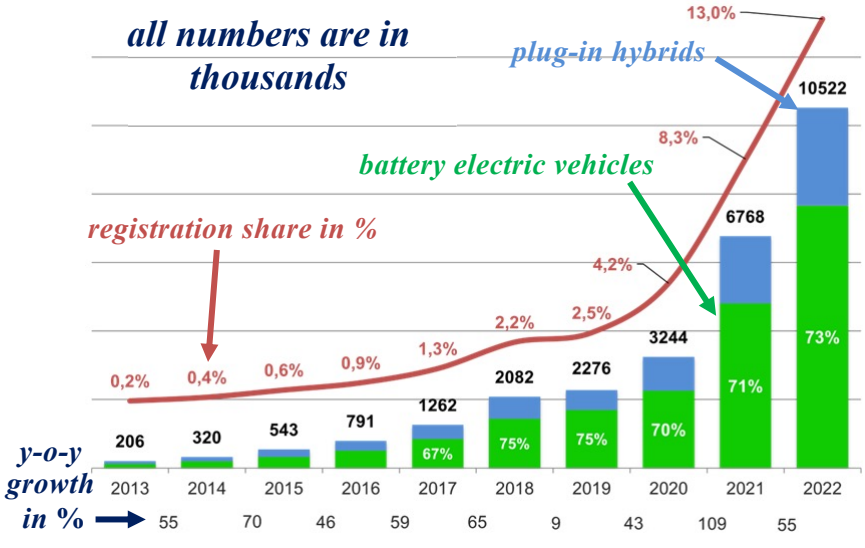
17. *EV* DEPLOYMENT AND *EVCI* STATUS

George Gross

Department of Electrical and Computer Engineering

University of Illinois at Urbana–Champaign

GLOBAL *BEV* AND *PHEV* SALES: 2013 – 2022



Source: EV volumes; available at https://www.ev-volumes.com/

GLOBAL *EV* SALES 2022

- 2022 global *BEV* and *PHEV* sales saw the delivery of 10.5 *million* cars – a 55 % increase over those in 2021 – and *outnumbered* the 8.4 *million non-pluggable HEV*s sold in 2022
- The resilience of global *EV* sales in the weak 2022 auto markets is notable as the global *ICEV* sales declined by 7 % from their 2021 level, with the *light-duty vehicle* (*LDV*) *ICEV* sales slipping from their 82.2 % share in 2021 to 76.8 % share in 2022

GLOBAL *EV* SALES 2022

- *EV* sales constituted 13 % of the 2022 global *LDV* sales, of which 9.5 (3.5) % were *BEV*s (*PHEV*s) – a marked increase from their 8.3 % share in 2021
- *US* and *Canada EV* sales grew 48 % from 2021 despite a reduction of 8 % in overall *LDV* sales
- *China*'s *BEV* and *PHEV* sales increased 82 % over 2021 sales to constitute 27 % of *China*'s *LDV* sales

GLOBAL *EV* SALES 2022

- *BYD* more than tripled its sales to 1.85 *million* cars, including 944,500 *PHEV*s, to catapult *BYD* to the first position in global *EV* sales
- *TESLA* sold 1.31 *million BEV*s in 2022 – by far the global leader in *BEV* sales
- *Norway*'s leading global status in *EV* sales with a 79 *%* share of all *LDV*s sold in 2022 – 71 (8) *%* in *BEV* (*PHEV*) sales

GLOBAL *EV* SALES 2022

- *Europe*'s *BEV* and *PHEV* sales made up a 20.8 *% share* of its total *LDV* sales
- The *fastest growing EV* sales markets in 2022 were in *Indonesia* – a jump from 1,000 in 2021 to 10,000 *EV*s in 2022 – and *India* – a growth of 223 *%* over 2021 sales to 50,000 *EV*s, virtually all *BEV*s

GLOBAL *EV* SALES 2022

- Global *PHEV* sales were 27 % of *EV* sales – a decline from 29 % in 2021, even though the *volume* of sold units increased; the *PHEV* share is in *global decline* with an annual increase of 46 % *vis-à-vis* the 59 % growth in *BEV* sales
- The global sales of fuel cell *EV*s in 2022 were 15,400 units – less than 0.02 % of the global annual *LDV*s sold

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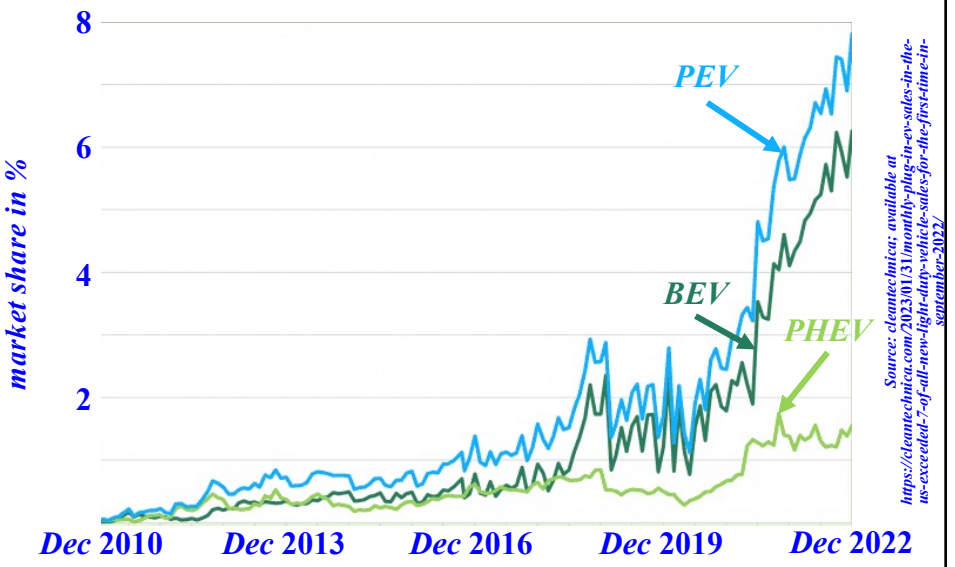
LIGHT–DUTY *PEV* MONTHLY MARKET SHARE DEC 2010 – DEC 2022



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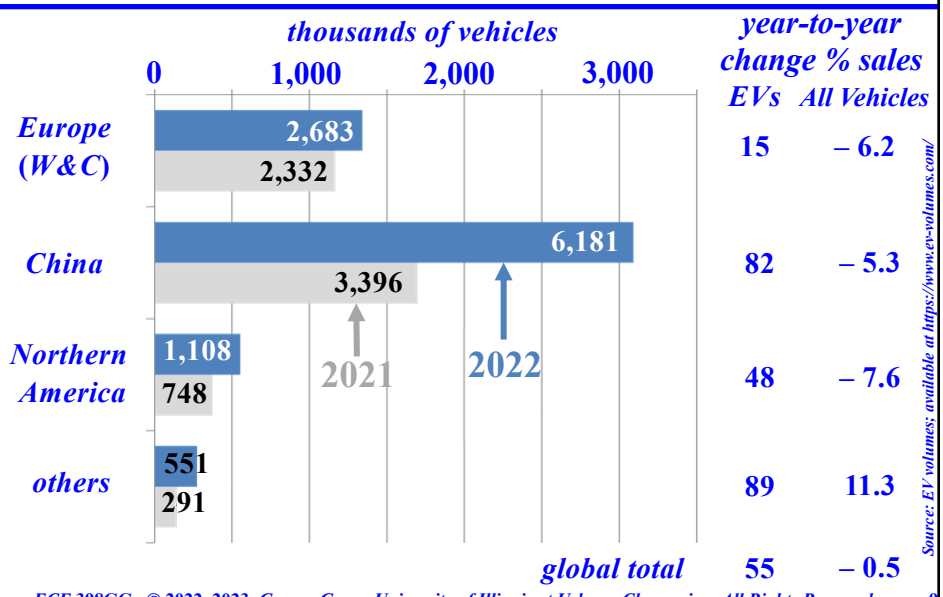
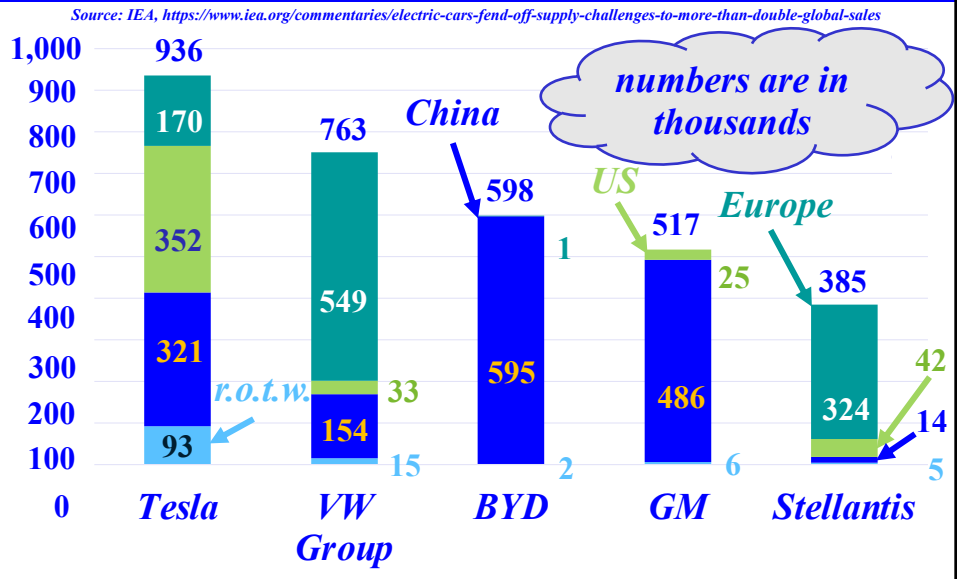
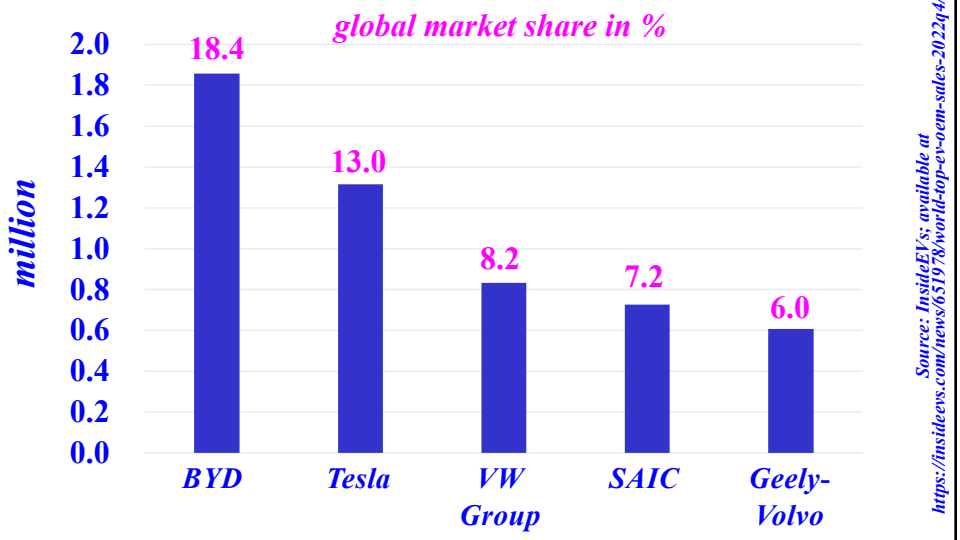
2022 GLOBAL *BEV & PHEV* SALES BY REGION



TOP 5 AUTOMAKER GLOBAL *EV* SALES BY REGION: 2021

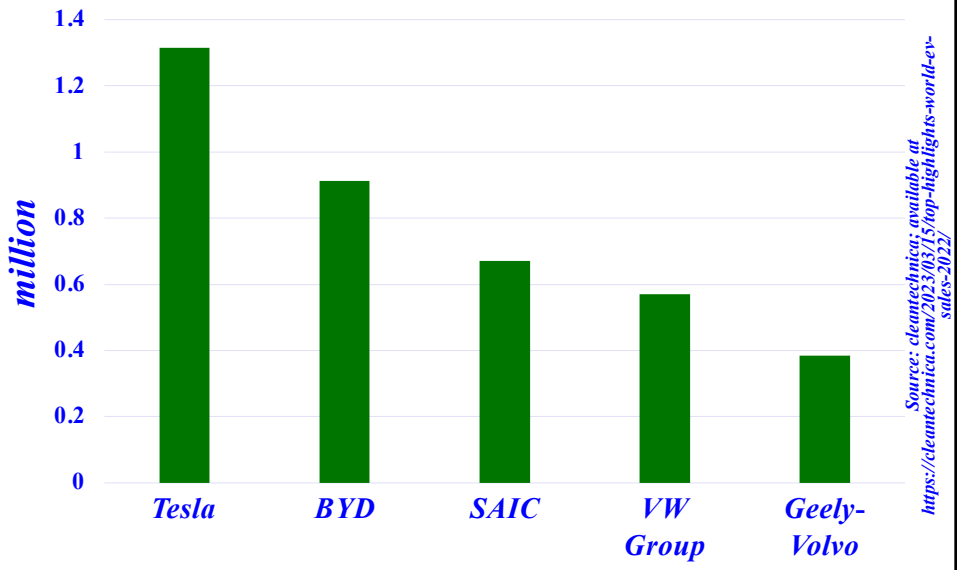


TOP 5 AUTOMAKER GLOBAL *EV* SALES: 2022



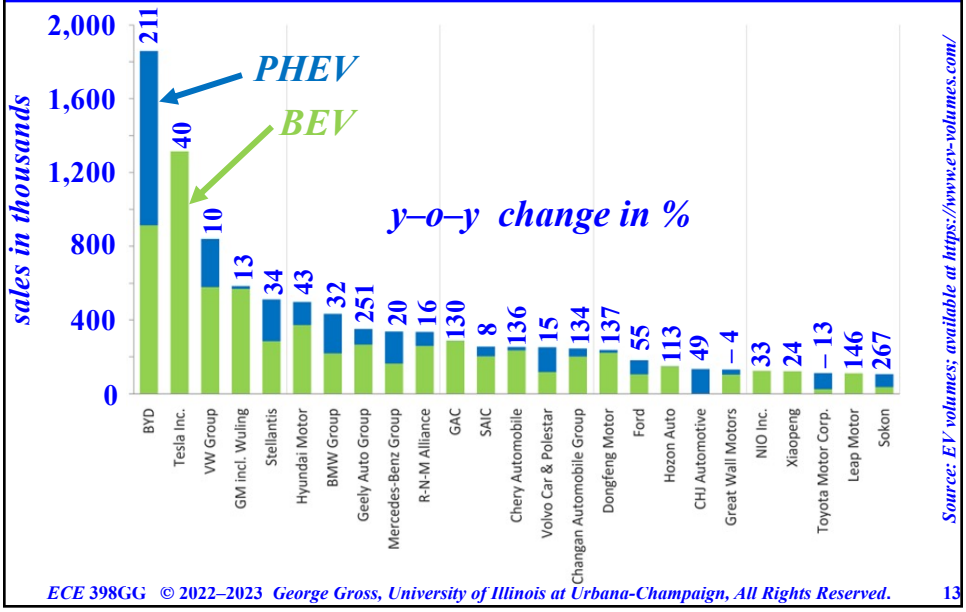
Source: InsideEVs; available at https://insideevs.com/news/651978/world-top-ev-oem-sales-2022q4/

2022 *TOP–SELLING* GLOBAL PLUG-IN VEHICLE BRANDS



Source: cleantechnica; available at https://cleantechnica.com/2023/03/15/top-highlights-world-ev-sales-2022/

2022 GLOBAL *EV* SALES BY MANUFACTURER



Source: EV volumes; available at https://www.ev-volumes.com/

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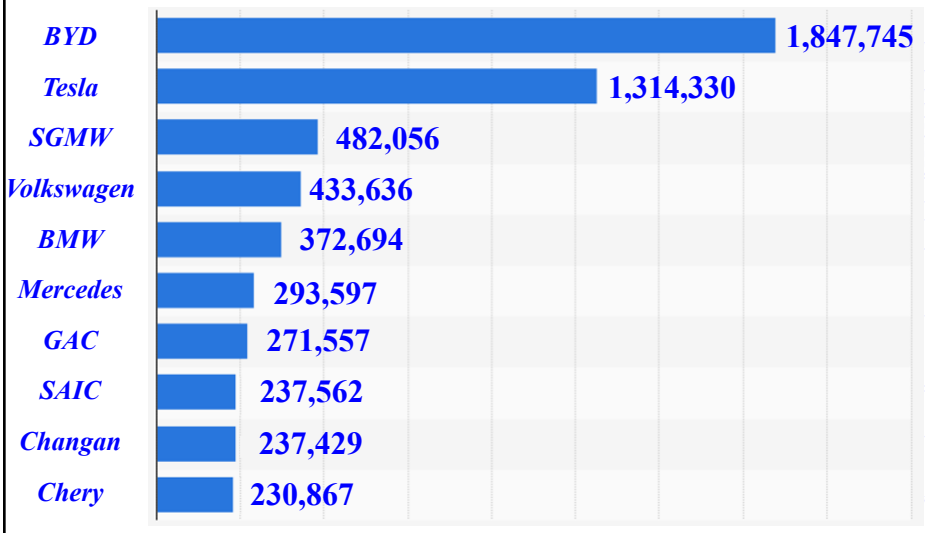
THE LEADING PLUG-IN VEHICLE SALES IN 2022



Source: https://www.statista.com/statistics/977407/global-sales-of-plugin-electric-vehicles-by-brand/

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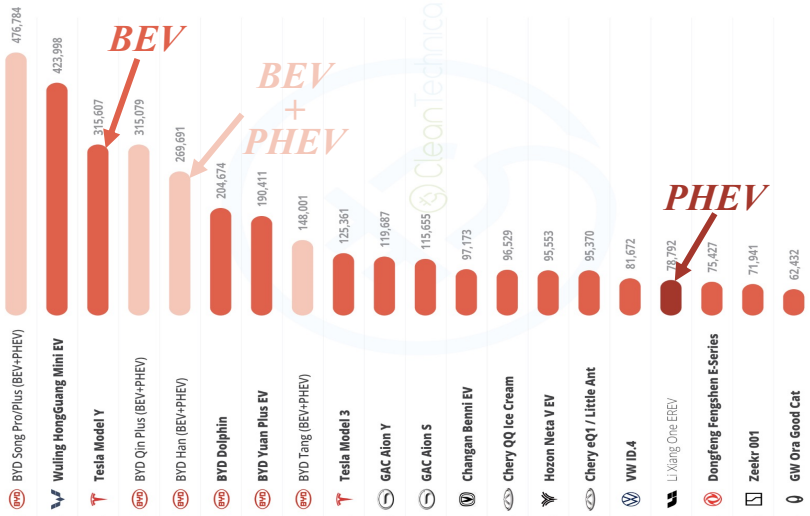
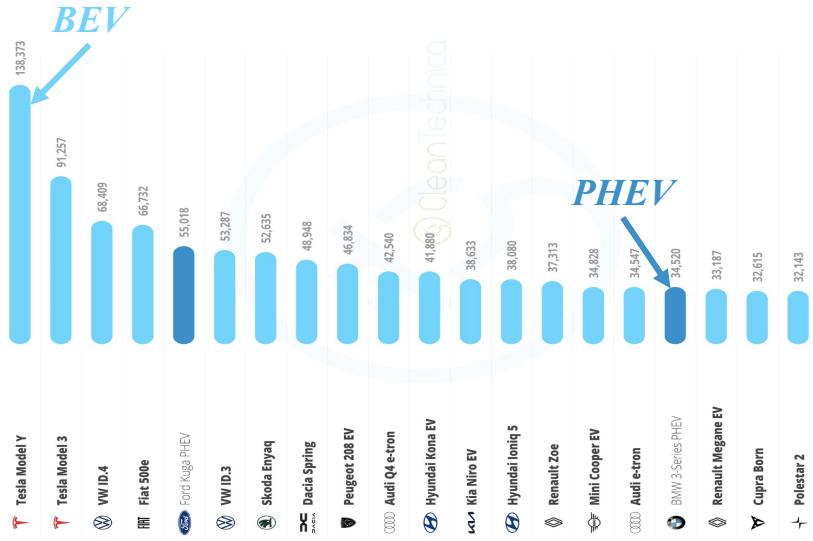
TOP–SELLING *EV* MODELS IN CHINA: 2022



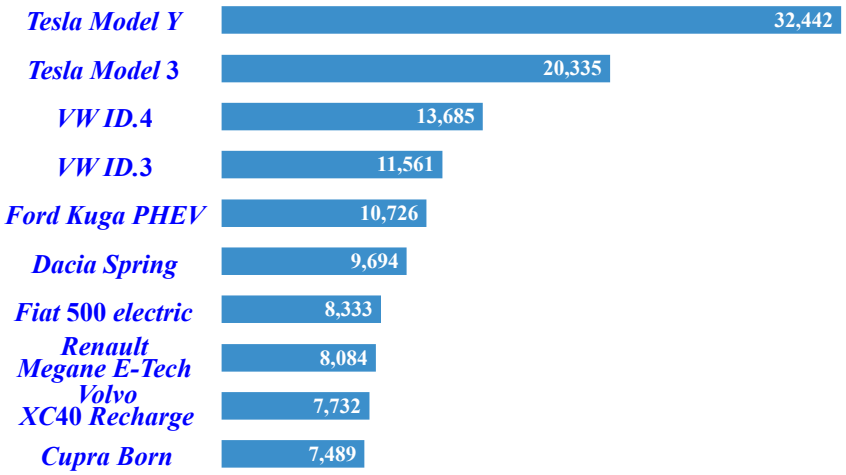
Source: cleantechnica; available at https://cleantechnica.com/2023/03/15/top-highlights-world-ev-sales-2022/

TOP–SELLING *EV* MODELS IN EUROPE: 2022



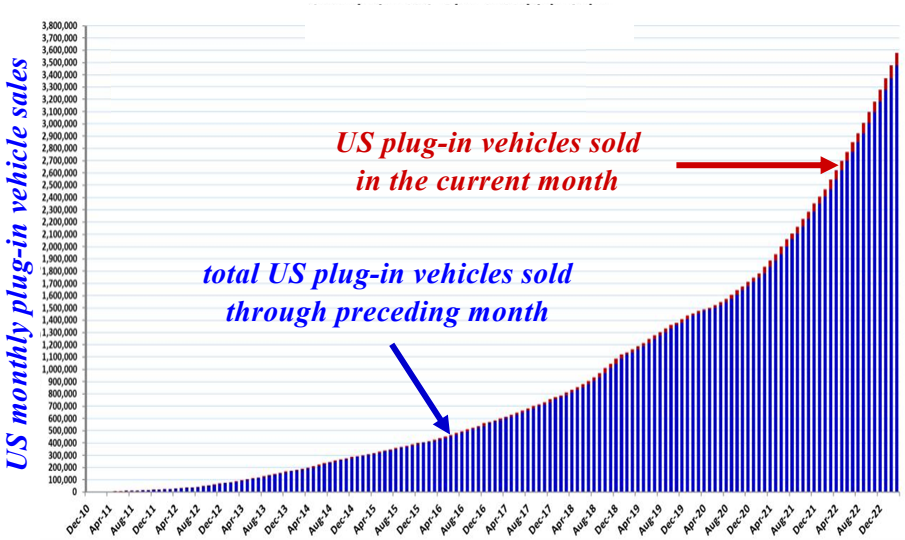
Source: cleantechnica; available at https://cleantechnica.com/2023/03/15/top-highlights-world-ev-sales-2022/

TOP 10 *PHEV* MODELS IN EUROPE DECEMBER 2022



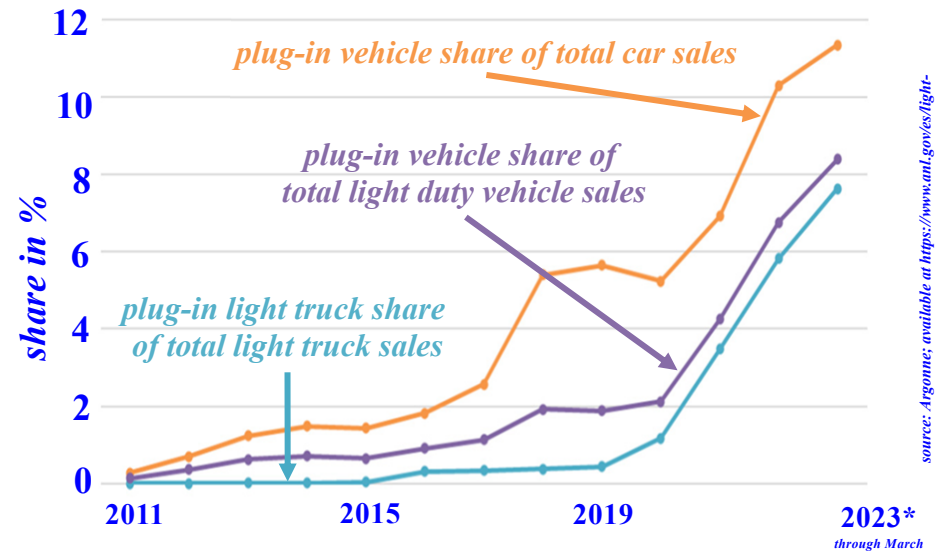
Source: InsideEVs; available at https://insideevs.com/news/651295/europe-plugin-car-sales-december2022/

TOTAL *US PLUG-IN* VEHICLES SOLD: DECEMBER 2010 – DECEMBER 2022

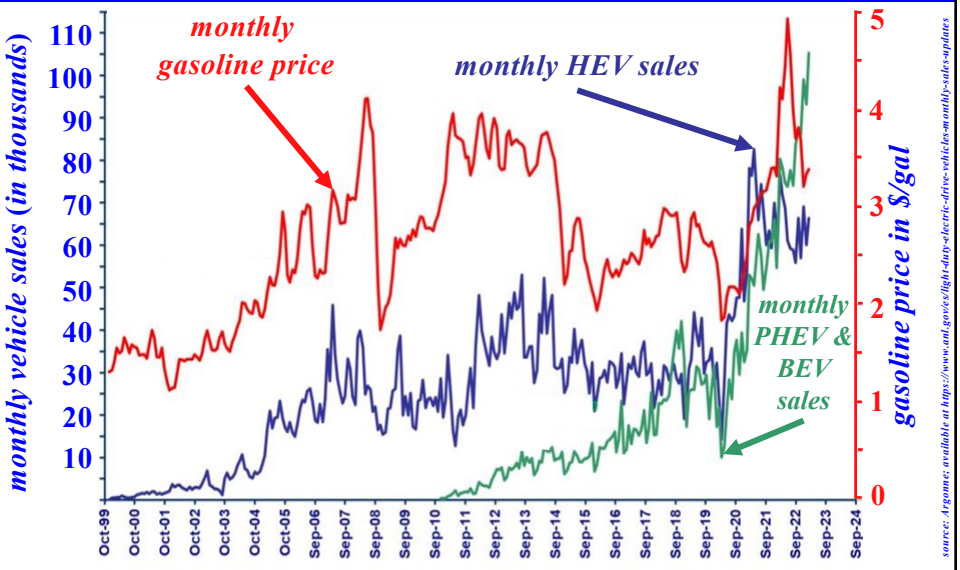


source: ANL; available at https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

THE ANNUAL SHARE OF *US PLUG-IN* CARS OF ALL VEHICLES SOLD: 2011 – 2023



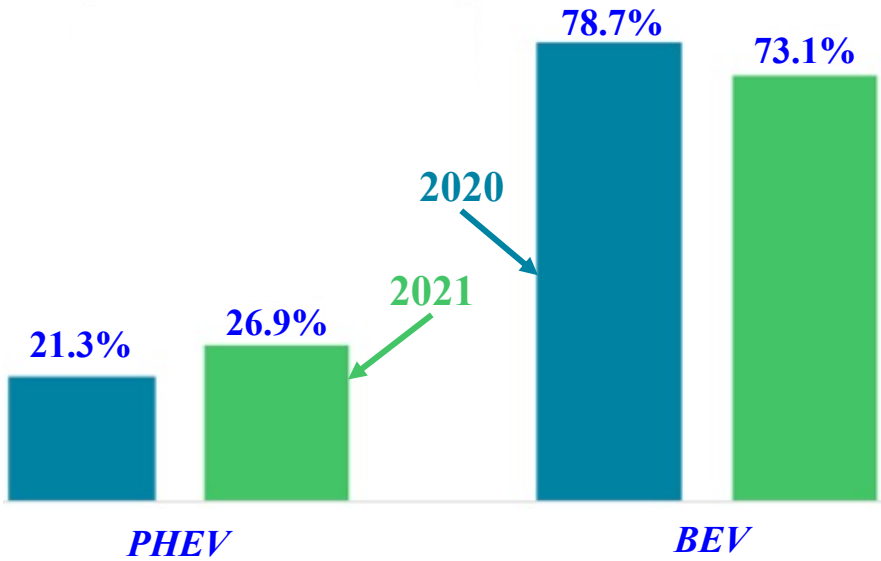
THE MONTHLY *US* ELECTRIC DRIVE VEHICLE SHARES AND GASOLINE PRICES



*Q*1 2022 *CA* GASOLINE PRICES

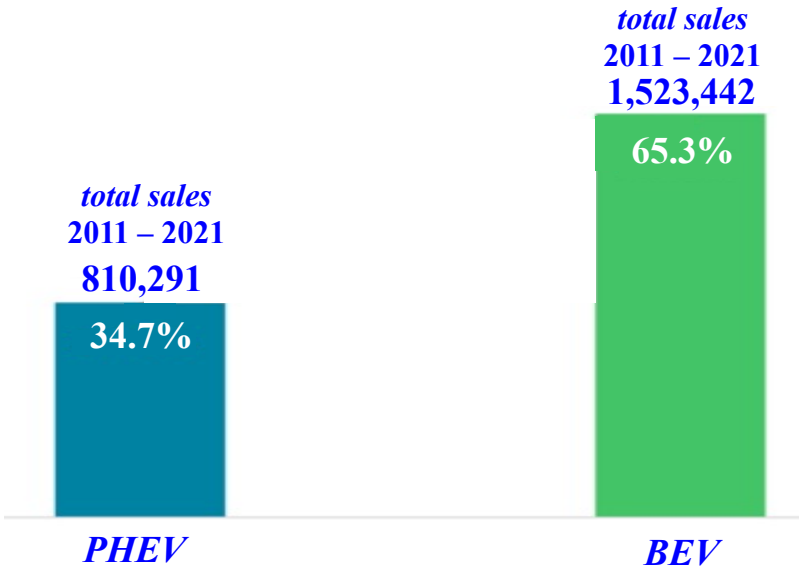
Source: Jae C. Hong, AP, via Chicago Tribune, March 12, 2022,
https://digitaledition.chicagotribune.com/html5/desktop/production/default.aspx?&edid=314fe922-5548-4698-8ea4-c1360b3335fe

BEV AND *PHEV* SHARE OF TOTAL *US EV* SALES: 2020 – 2021



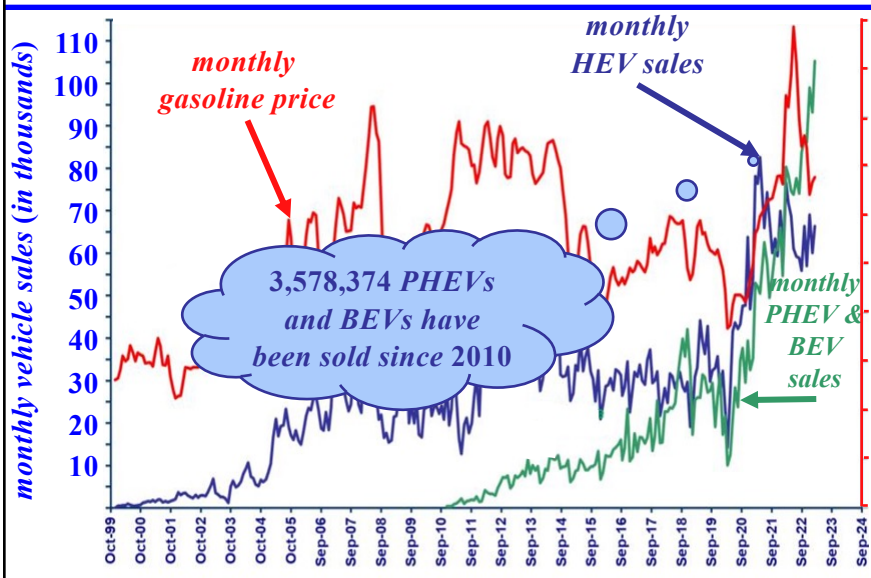
Source: IHS Markit / Auto Manufactures Alliance, Advanced Technology Sales; chart by Loren McDonald / EVAdoption, LLC; available at https://evadoption.com/us-hybrid-and-phev-sales-growth-rate-outpaced-bevs-in-2021/

TOTAL *US BEV & PHEV* SALES FROM 2011 TO 2021



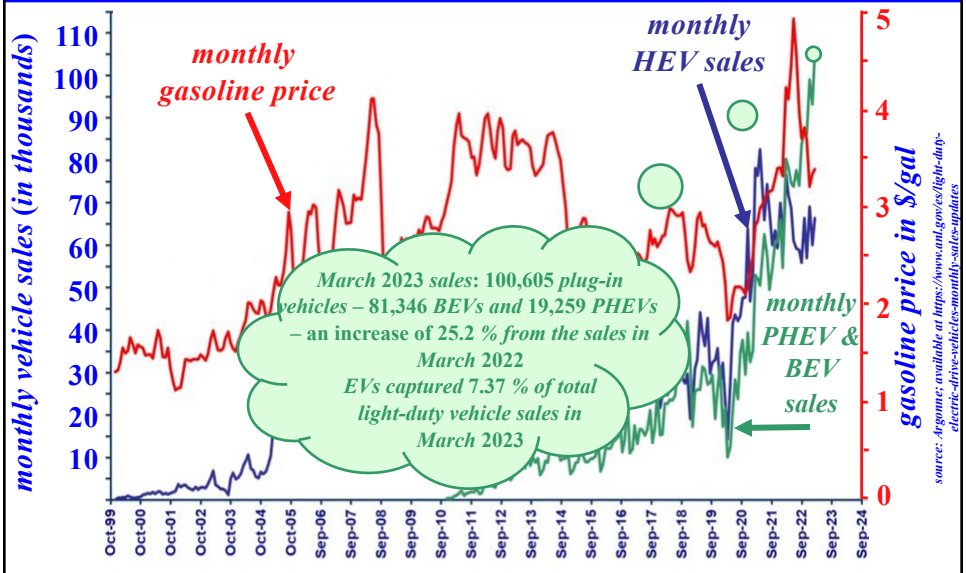
Source: IHS Markit / Auto Manufactures Alliances, Advanced Technology Sales; chart by Loren McDonald / EVAdoption, LLC; available at https://evadoption.com/us-hybrid-and-phev-sales-growth-rate-outpaced-bevs-in-2021/

THE MONTHLY *US* ELECTRIC DRIVE VEHICLE SHARES AND GASOLINE PRICES

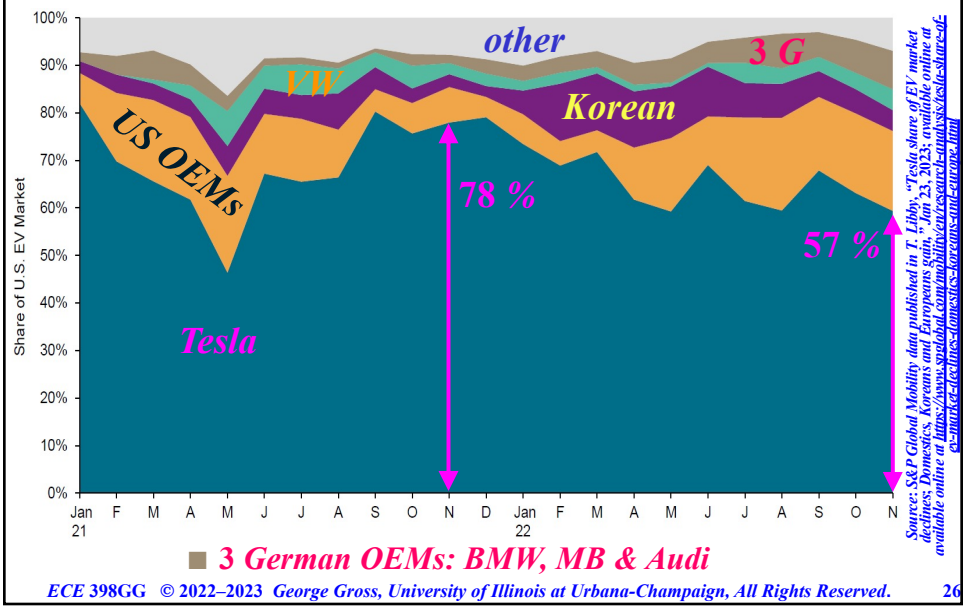


source: Argonne; available at https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

THE MONTHLY *US* ELECTRIC DRIVE VEHICLE SHARES AND GASOLINE PRICES



TESLA'S SHARE OF NEW 2022 *US EV* REGISTRATIONS DECLINES



NOVEMBER 2022 *US* SALES OF NEW *EV* MODELS

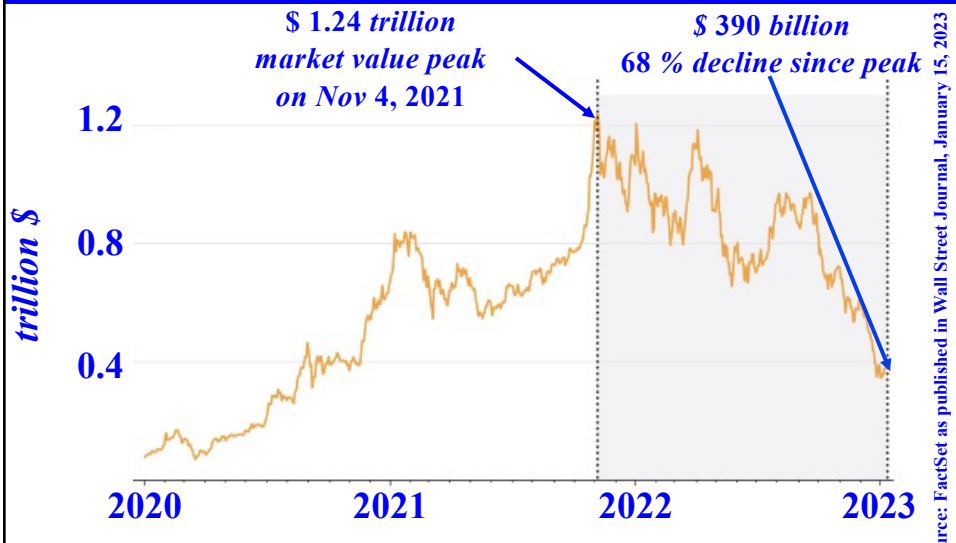
model	sales		share of the Nov 22 EV market in %
	Nov-21	Nov-22	
Ford F series	0	2,217	3.2
BMW I4 Edrive 49	0	1,424	2.1
Hyundai Ioniq 5	0	1,190	1.7
Rivian EDV	0	1,187	1.7
BMW IX Xdrive 50	0	841	1.2
Ford Transit van	0	784	1.1
KIA EV6	0	688	1.0
BMW I4 M50	0	539	0.8
Volvo C40	0	477	0.7
Toyota BZ4X	0	257	0.4
Rivian R1S	0	217	0.3

model	sales		share of the Nov 22 EV market in %
	Nov-21	Nov-22	
Mercedes-Benz EQB	0	164	0.2
Genesis GV60	0	142	0.2
Audi E-tron sportback	0	70	0.1
Mercedes-Benz EQE	0	61	0.1
Cadillac Lyriq	0	43	0.1
Cruise AV	0	32	0.0
BMW I7	0	31	0.0
Genesis G80	0	26	0.0

total sales Nov-22:
10,390

Source: S&P Global Mobility data published in T. Libby, "Tesla share of EV market declines; Domestics, Koreans and Europeans gain," Jun 23, 2023, available online at available online at https://www.spglobal.com/mobility/en/research-analysis/tesla-share-of-ev-market-declines-domestics-koreans-and-europeans.html

TESLA STOCK PRICES: 2020 – 2023



Source: FactSet as published in Wall Street Journal, January 15, 2023

TESLA's MANY CHALLENGES

- *Tesla*, for the longest time, could do no wrong has capped off a rough 2022 with an awful December, with losses of about *$* 219 billion of market value from December 1 – 23, 2022 – roughly, the market value of *Toyota*
- Key contributors to this situation include:
  - drastic production and price cuts in *China*
  - heavy discounting in the *US*, where *Tesla*'s growth seemed unabated for a decade

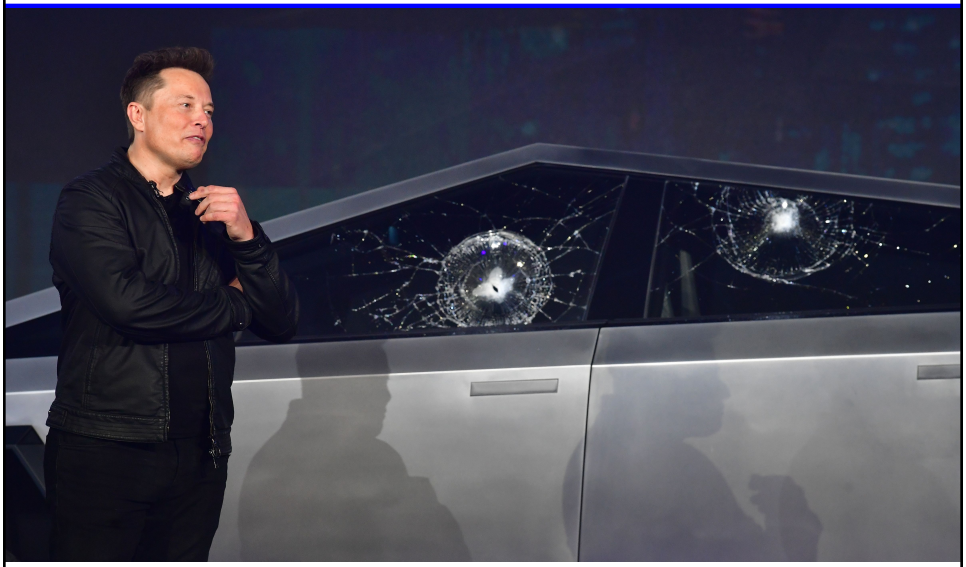
TESLA's MANY CHALLENGES

- lack of attention/focus due to Elon Musk's purchase of *Twitter*
- Musk's repeated sales of *Tesla* shares
- challenges posed by a tough economy with high inflation and rising interest rates
- inability to keep at bay the many legacy automakers pushing into the *EV* market

TESLA's MANY CHALLENGES

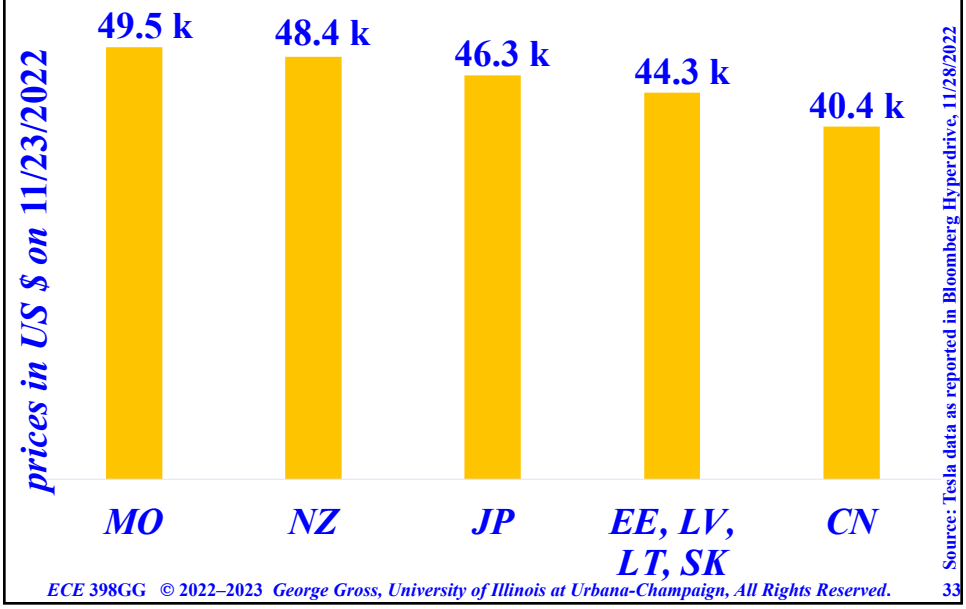
- *Tesla* must deliver reinforcements for its product line in 2023 and reveal plans for
  - the systematic, scaled-up production of the multi-year delayed delivery of its Semi truck that ended on December 1, 2022
  - specifics on the start of the production of its first pickup – the *Cybertruck*

THE 2019 *CYBERTRUCK* PROTOTYPE



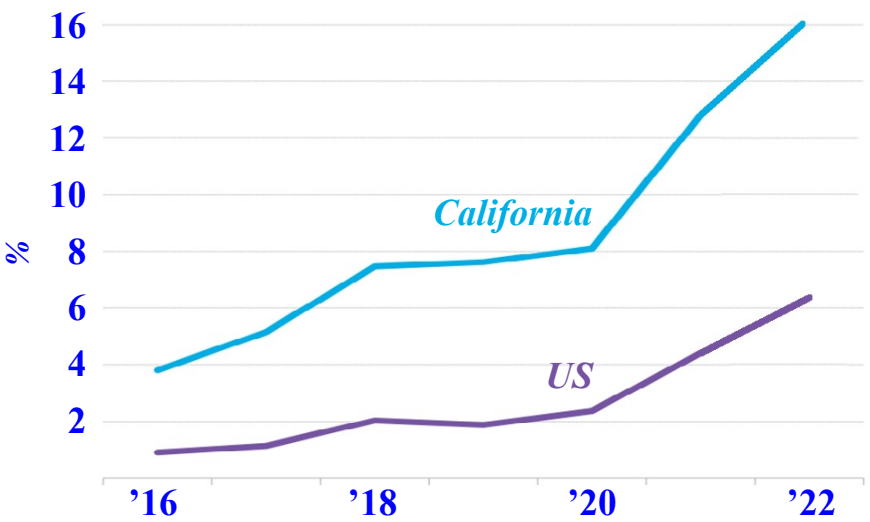
Source: Photograph by Frederic J. Brown, AFP, in Bloomberg Hyperdrive, December 24, 2022

TESLA MODEL Y PRICES VARY BY POINT OF PURCHASE



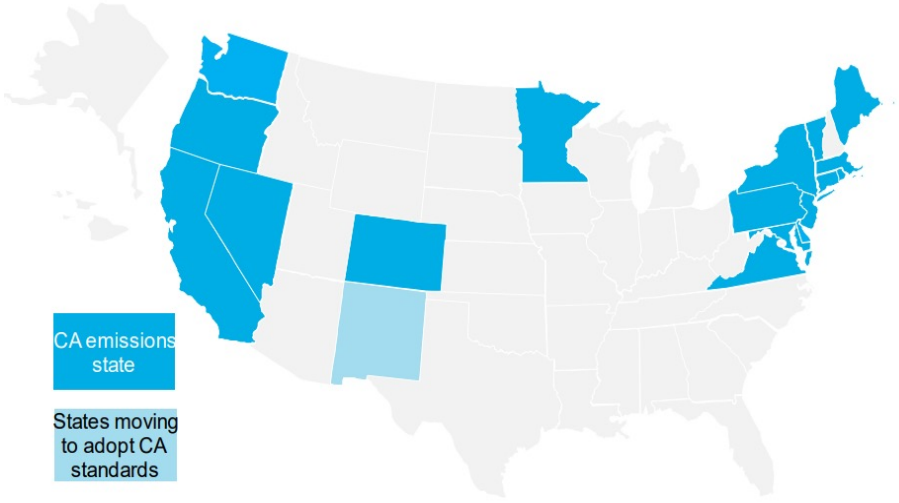
Source: Tesla data as reported in Bloomberg Hyperdrive, 11/28/2022

ANNUAL *EV* SHARE OF LIGHT DUTY VEHICLE SALES



Source: The Business Council for Sustainable Energy; https://bcse.org/factbook/; p.33

JURISDICTIONS THAT ADOPTED *CA* VEHICLE EMISSIONS STANDARDS



Source: The Business Council for Sustainable Energy; https://bcse.org/factbook/; p.33

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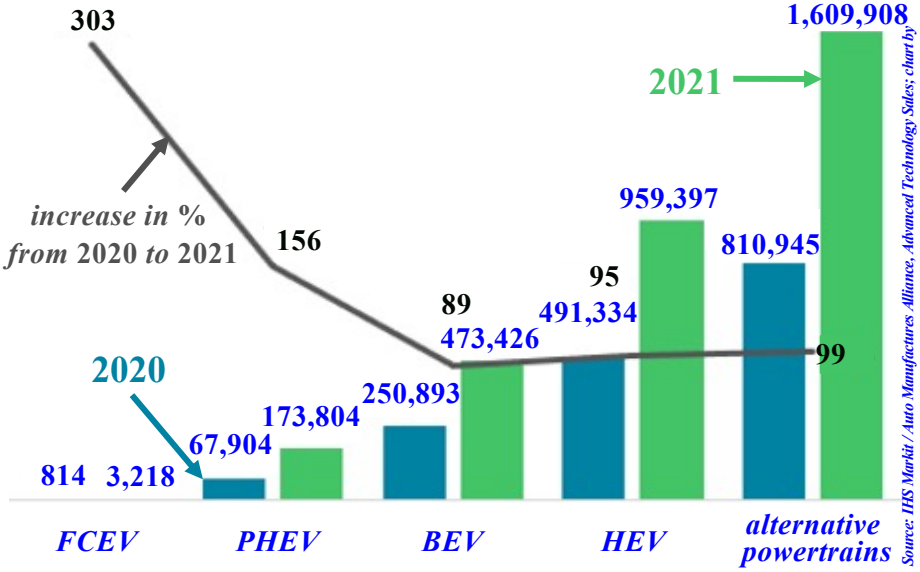
ALTERNATIVE POWERTRAIN *US* SALES AND *Y-O-Y* INCREASES: 2020 – 2021



Source: IHS Markit / Auto Manufactures Alliance, Advanced Technology Sales; chart by Loren McDonald / EVAdoption, LLC; available at https://evadoption.com/us-hybrid-and-phev-sales-growth-rate-outpaced-hevs-in-2021/

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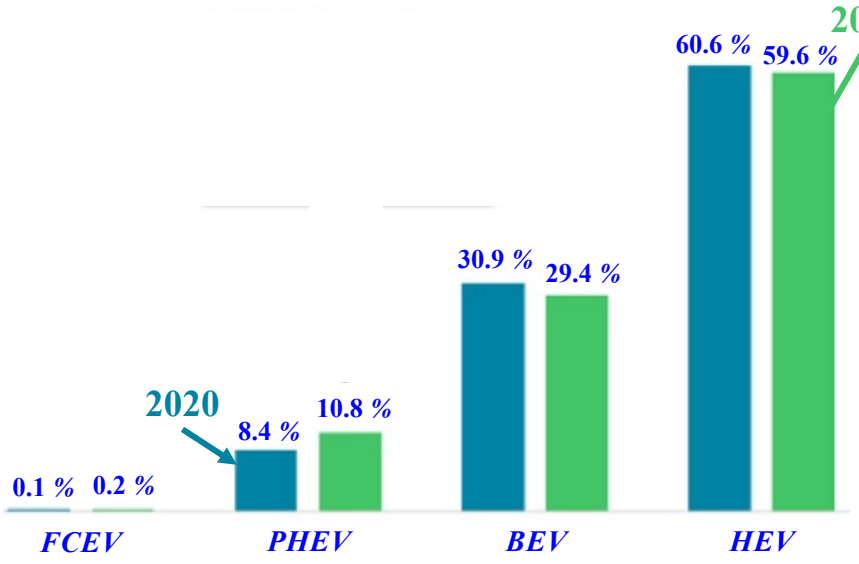
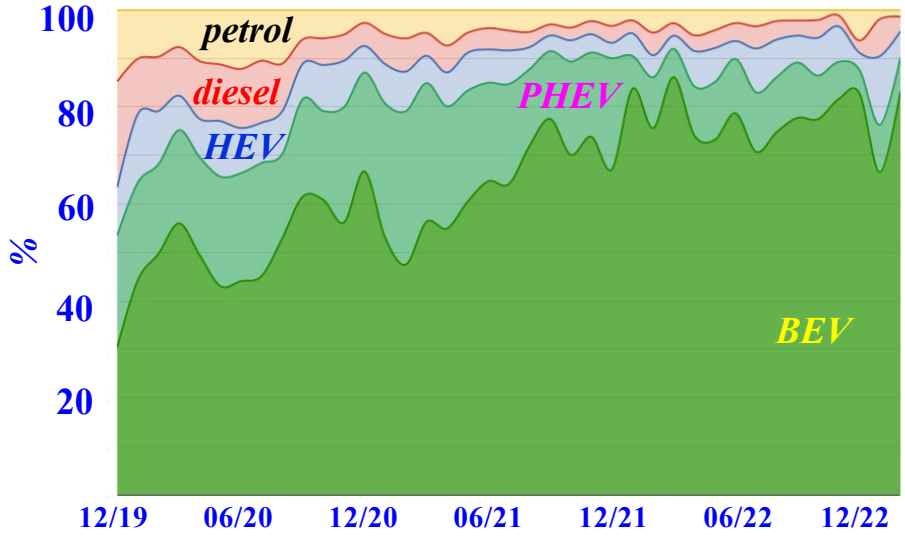
SHARE OF TOTAL *US* ALTERNATIVE POWERTRAIN SALES: 2020 – 2021



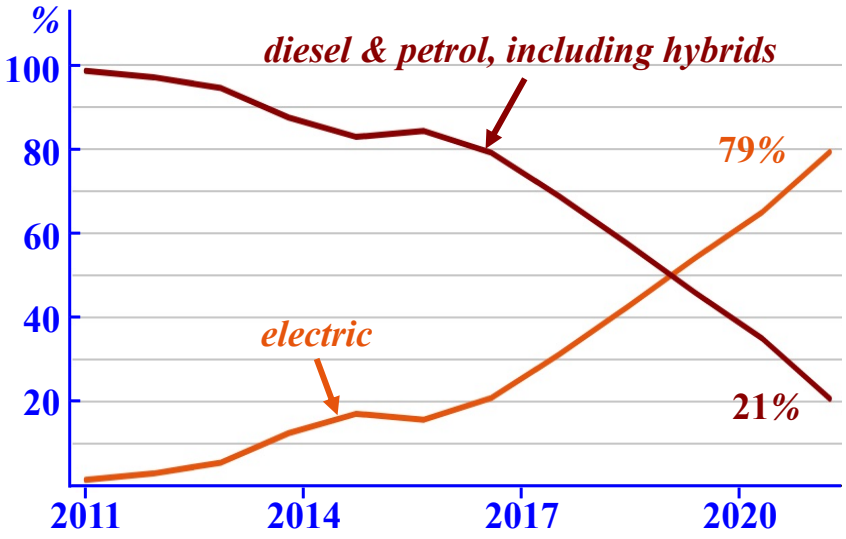
Source: IHS Markit / Auto Manufactures Alliances, Advanced Technology Sales; chart by Loren McDonald / EVAdoption, LLC; available at https://evadoption.com/us-hybrid-and-phev-sales-growth-rate-outpaced-bevs-in-2021/

NORWAY MONTHLY POWERTRAIN MARKET SHARE: DEC 2019 – FEB 2023



Source: cleantechnica; available at https://cleantechnica.com/2023/03/15/top-highlights-world-ev-sales-2022/

NORWAY NEW CAR SALES *EV* SHARE GROWTH: 2011 – 2022



Source: OFV, the Norwegian Road Federation, and Victoria Klesty, Reuters Graphics; published by Reuters, January 2, 2023; available on-line at https://www.reuters.com/business/autos-transportation/hitting-record-electric-cars-sales-norway-near-80-2022-2023-01-02/

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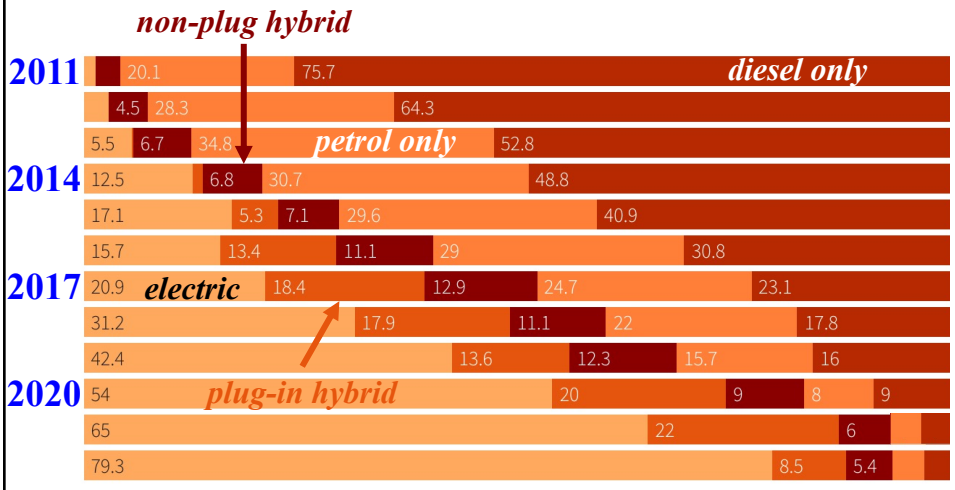
NORWAY ANNUAL CAR SALES: 2011 – 2022

Source: OFV, the Norwegian Road Federation, and Victoria Klesty, Reuters Graphics; published by Reuters, January 2, 2023; available on-line at https://www.reuters.com/business/autos-transportation/hitting-record-electric-cars-sales-norway-near-80-2022-2023-01-02/



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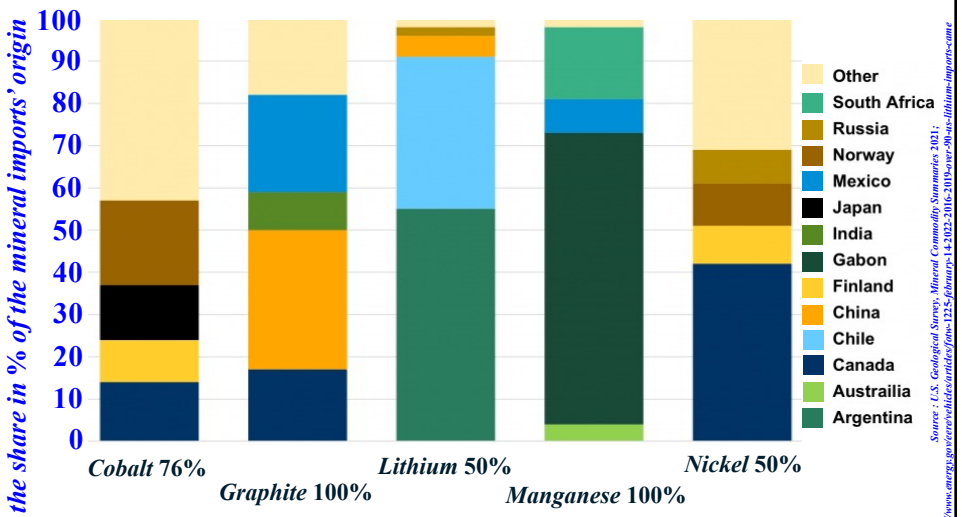
US IMPORTS OF THE MINERALS USED IN *EV* BATTERIES



the imports' share of the 2020 *US mineral consumption*

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BIDEN INVOKES *DPA* ON MINERAL IMPORTS

- President Biden on March 31, 2022, invoked the Defense Production Act – *DPA* – to spur domestic mining and processing of minerals used to make batteries for *EV*s and energy storage resources
  - this effort aims to strengthen *US* energy independence and to develop more domestic production of storage technology

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BIDEN INVOKES *DPA* ON MINERAL IMPORTS

- the directive supports *lithium, graphite, cobalt, manganese* and *nickel* production/processing
- Department of Defense is tasked to perform feasibility studies that adhere to "strong" environmental, labor, community and tribal consultation standards

BIDEN INVOKES *DPA* ON MINERAL IMPORTS

- The directive, via the deployment of a Cold War relic, is timely since the minerals supply chain reliability is absolutely essential to the effective domestic manufacturing of batteries for *EV*s
- Notwithstanding the limited scope of the Biden administration's *DPA* invokement, the action is significant since it sends a markets signal of its aim to bolster domestic battery production

THE STATUS OF GLOBAL PUBLIC CHARGING

- As *EV* sales increase at a pace much faster than the number of public charging ports, the criticality of the *EVCI* development is becoming a more pressing issue globally
- The *BNEF* 2022 public charging report indicates that the global number of *EV*s on the road per public charging port rose to 9.2 at the end of 2021 from 7.4 at the end of 2020

THE STATUS OF GLOBAL PUBLIC CHARGING

- The public charging facility developments in 2021 failed to keep pace with the 2021 global *EV* sales of 6.6 *million* cars, with the singular exception of *China*, whose ratio of the number of *EV*s to that of charging ports remained basically unchanged since 2018
- China's push to expand its *EVCI* has resulted in the fact that more than half the world's public

THE STATUS OF GLOBAL PUBLIC CHARGING

charging ports are in China

- The rapid increase in the deployment of *EV*s in the *US* was not accompanied by a larger number of public chargers and, therefore, there are fewer chargers per *EV* or there are more *EV*s per charging port than in earlier years
- The situation is even more acute in *Europe*, where,

THE STATUS OF GLOBAL PUBLIC CHARGING

EV sales surged since 2019, *e.g., Germany*'s ratio of the number of *EV*s per public charging point grew from 8 in 2019 to 20 in 2021 and in *Norway* – the most mature *EV* market in the world – the ratio is in the range of 30 to 40 *EV*s on the road per public charging port

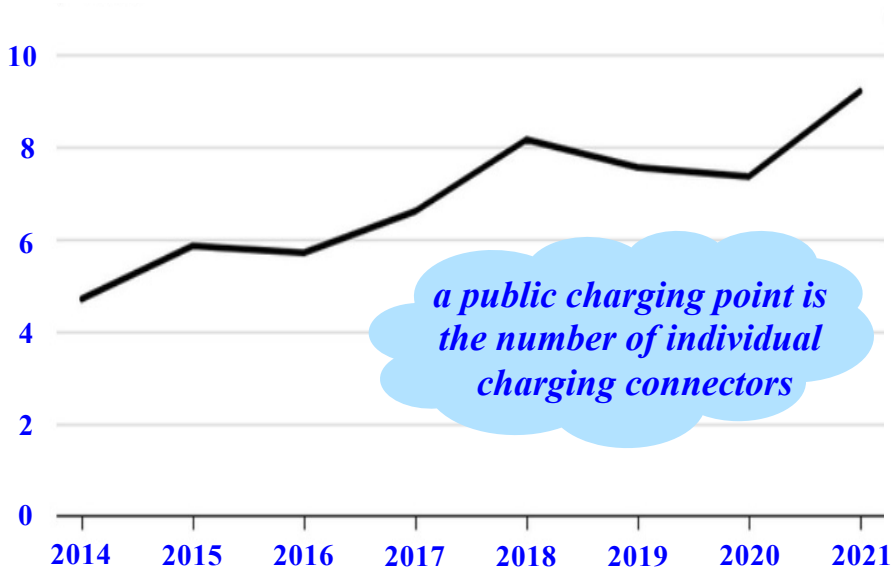
THE STATUS OF GLOBAL PUBLIC CHARGING

- A very similar situation exists for *DCFC*s in the respective regions – *China* has 16 *EV*s for every ultra-fast charger and the *US* ratio is about 100
- The number of 350-*kW* stations that are capable to add 100 *km* of range to an *EV* in just a few minutes is growing globally – a timely development as the trend to electrify trucks and pickups gets into a higher gear

EV CHARGING AT ONE OF THE 4 *MILLION CHINA* CHARGING UNITS

Source: Getty images in the New York Times, September 26, 2022

ANNUAL GLOBAL RATIO OF *EV*s PER PUBLIC CHARGING POINT: 2014 – 2021



Source: *BNEF data in Bloomberg Hyperdrive issue of April, 12, 2022*

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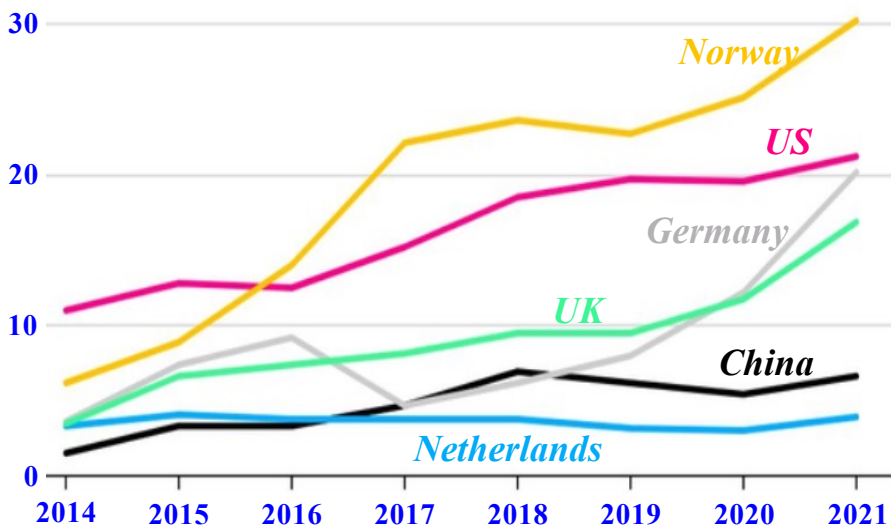
RATIO OF *EV*s PER PUBLIC CHARGING POINT BY COUNTRIES: 2014 – 2021



Source: *BNEF data in Bloomberg Hyperdrive issue of April, 12, 2022*

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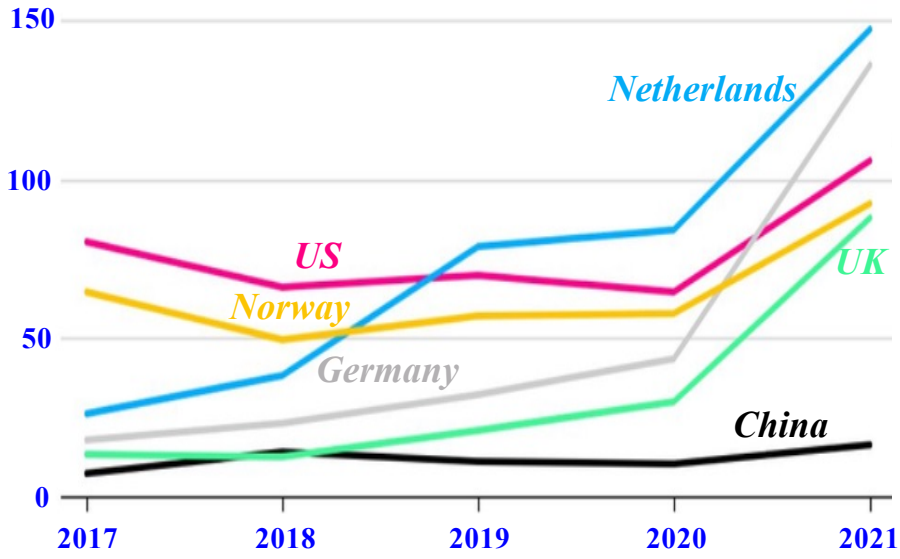
RATIO OF *EV*s PER FAST/ULTRA-FAST PUBLIC CHARGING POINT: 2017 – 2021



Source: *BNEF data in Bloomberg Hypendrive issue of April, 12, 2022*

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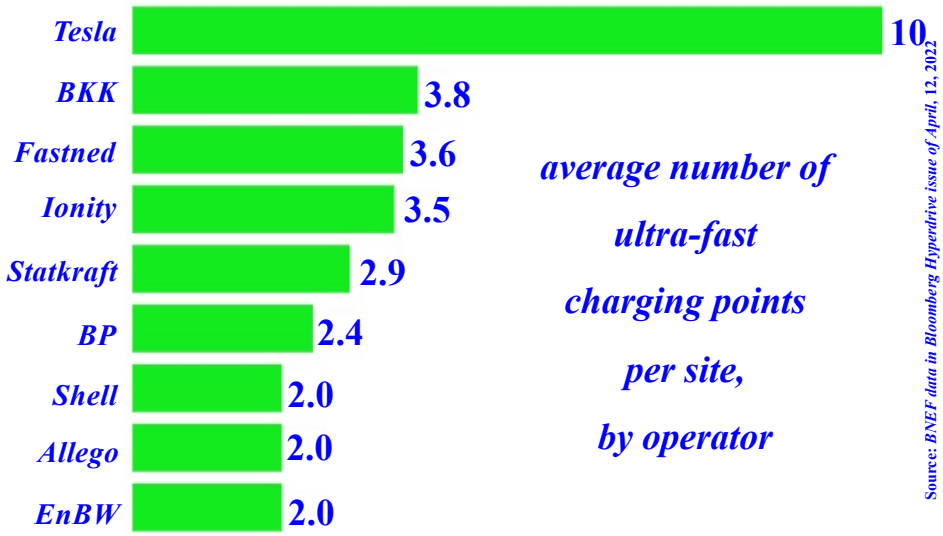
MEAN NUMBER OF CHARGING CONNECTORS PER CHARGING STATION BY OPERATORS



Source: *BNEF data in Bloomberg Hypendrive issue of April, 12, 2022*

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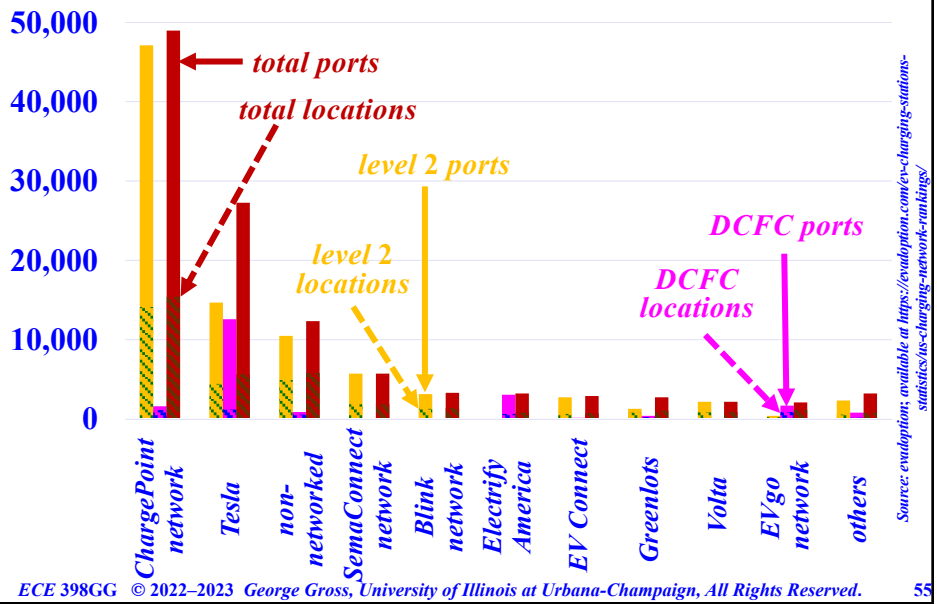
THE 10 LARGEST *US* CHARGING NETWORKS: 2021



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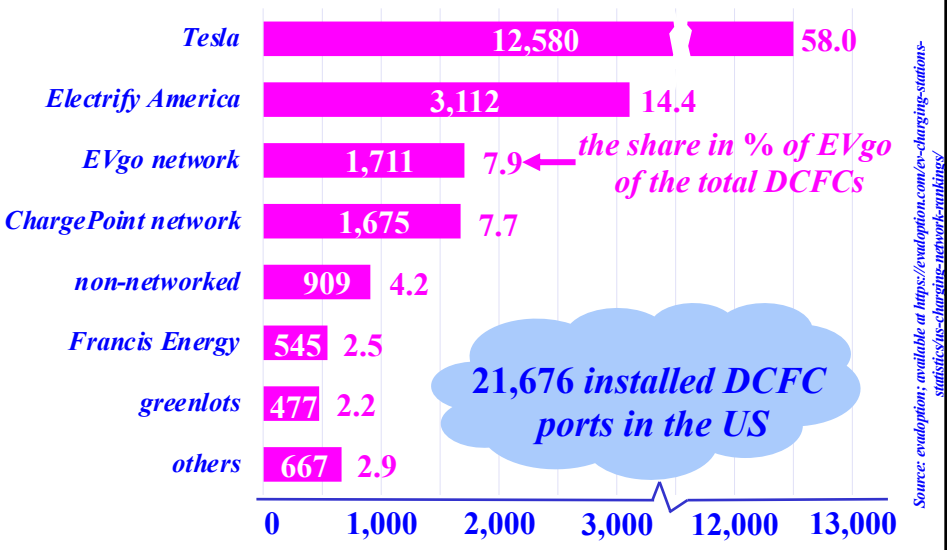
LARGEST *US DCFC* NETWORKS: 2021



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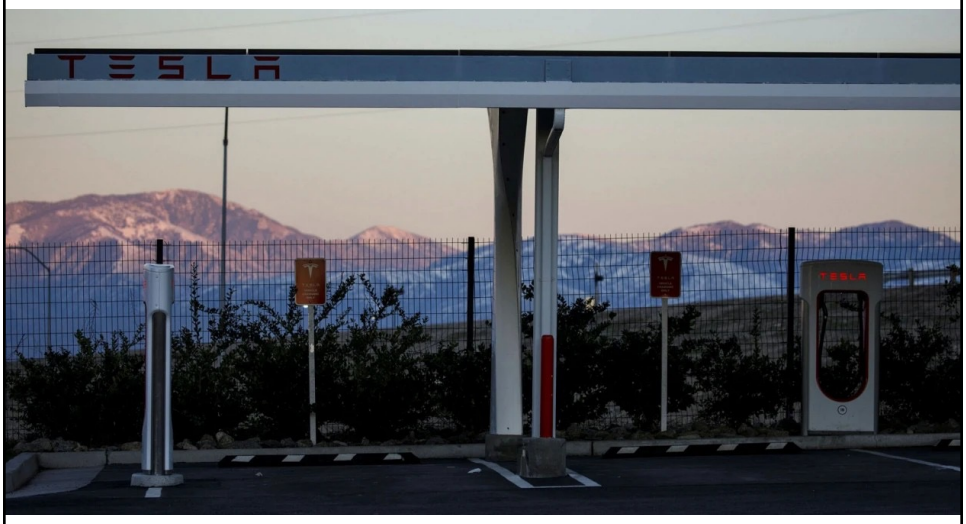
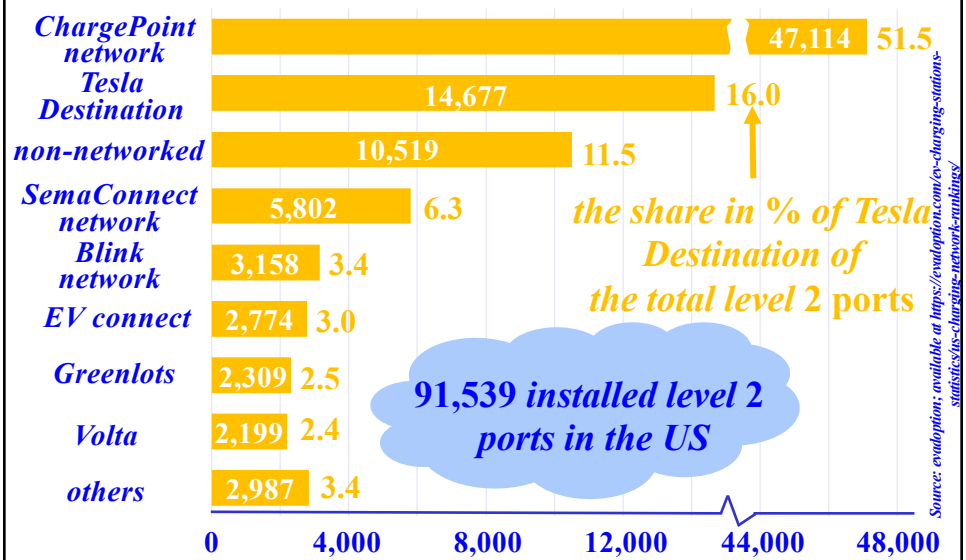
TESLA SUPERCHARGER STATION

Source: Bloomberg



LARGEST *US* LEVEL 2 NETWORKS: JANUARY 1, 2022



THE HIGHER NUMBER OF *EV*s PER PUBLIC CHARGING STATION

- The higher ratios of the number of *EV*s on the road to the number of charging stations is not *necessarily* a bad outcome since many charging stations are *currently under-utilized*; but, these high ratios signal the need for more private investment in *EVCI* and to achieve such an outcome, higher utilization per charger is required to improve the economics of charging station operations

THE HIGHER NUMBER OF *EV*s PER PUBLIC CHARGING STATION

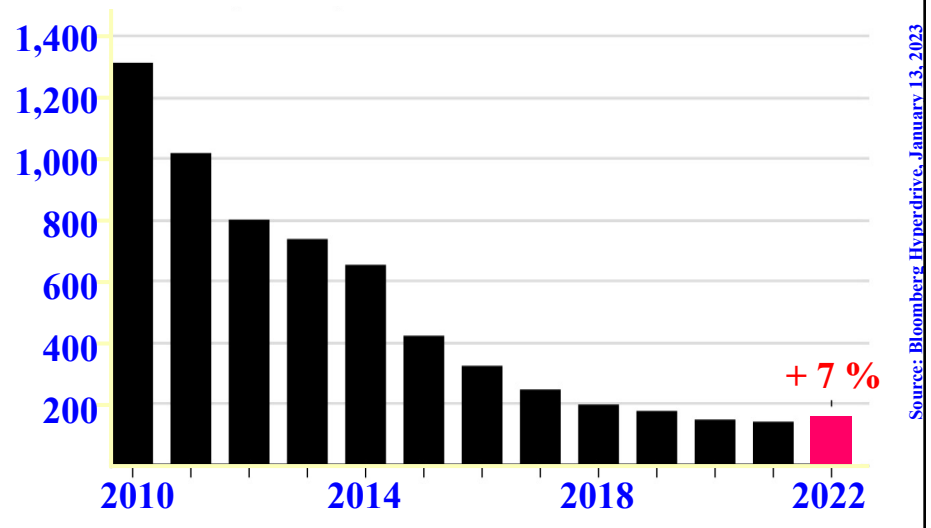
- Given the slow pace of development in *EVCI*, one may conclude that a successful business model is yet to be established for *EVCI* stations; such a situation is not surprising given the wide array of issues, such as *EVSE*, siting costs, electricity tariffs, charging speeds, government regulation, fee/pricing structure, support and permitting, that need to be considered and effectively addressed

THE HIGHER NUMBER OF *EV*s PER PUBLIC CHARGING STATION

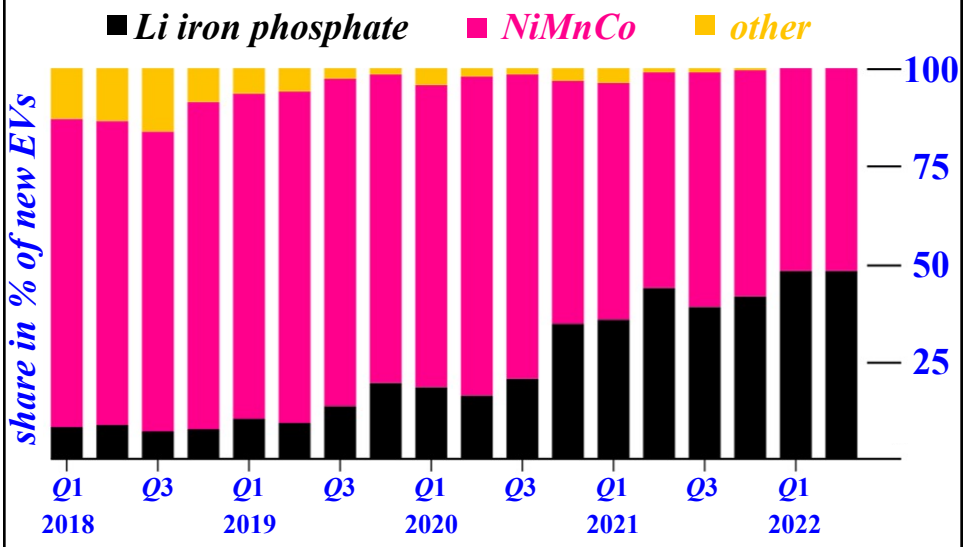
- We illustrate the complexity and challenges in the *EVCI* business model: consider the determination of the appropriate number of station chargers – an issue that requires to keep in balance competing objectives: charging station operators desire more charging sessions per day, but too many sessions imply that there are times when drivers must wait because of queues at occupied ports, resulting in *undesirable customer experience*; while operators aim for high utilization, it cannot be so high as to cause *customer frustration*

A BUMP–UP IN BATTERY PRICES IN 2022

volume–weighted average in 2022 $/kWh



THE INCREASED SHARE OF *LFP* BATTERIES IN *CHINESE EV*s



Source: Bloomberg Hyperdrive, 11/15/2022

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THE *EV FRUNK*

- Some *EV*s come with front trunks, which are typically referred to as *frunk*s
- *EV* carmakers remain split on the *frunk*:
  - some *EV* models for sale in the *US* have super-sized them to emphasize their *novelty* and *utility*

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THE *EV FRUNK*

- a third of models, however, skip the frunk altogether to free up cabin space on the basis that customers accustomed to *frunkless* cars will not necessarily need one when they go electric
- the remaining third uses the *frunk* to store the adapters for use in different *EVCI* station charging ports

THE *EV FRUNK*

- For example, *Ford* uses the frunk to attract new customers to their *EV*s: the almost $5 - ft^3$ storage of the *Ford Mustang Mach-E frunk* has been a hit with *EV* shoppers and *Ford* is marketing the refrigerator-sized front trunk that comes standard on two of its electric vehicles, complete with drain, as a sushi bar on wheels

THE *FORD MUSTANG MACH-E FRUNK*

Source: Photo by Ryan McManus in Bloomberg Hyperdrive, November 1, 2022

FORD's *MUSTANG MACH-E FRUNK* FITS TAILGATING NEEDS

Source: Bloomberg Green Daily, November 5, 2022

AN *ULTRA LOW EMISSION ZONE* SIGN AT *TOWER HILL, CENTRAL LONDON*

Source: Yui Mok photo/PA Wire, published in Bloomberg Hyperdrive, November 25, 2022

TOWARDS CLEANER AIR IN *LONDON*

- *London* charges drivers of *ICEV*s £ 12.5 ($ 15) a day to drive in the *Ultra Low Emission Zone* that spans London's central and inner boroughs; failure to pay results in a fine of £ 160
- London expanded the *ULEZ* to the city's outer reaches in August 2022 to combat air pollution to improve air quality and speed up the *EV* transition

THE ELECTRIFICATION OF SCHOOL BUSES

Source: US PIRG Education Fund and Environment America Research & Policy Center, "Electric School Buses and the Grid," 2022; available at https://environmentamerica.org/sites/environment/files/reports/US_V2G%202022%20scrn.pdf

THE ELECTRIFICATION OF SCHOOL BUSES

- School buses constitute the largest form of *US* public transportation, with nearly 25 million students riding on them to school and back
- At present, fewer than 1 % of the nation's school buses are *fueled by electricity*
- The application of *EV* advances to school bus technology and the effective use of the federal government funding under the *Infrastructure Investment and Jobs Act* (*II&JA*) of 2021 are key

THE ELECTRIFICATION OF SCHOOL BUSES

drivers to make the adoption of *ESB*s – *electric school buses* – a viable option for school districts

- *ESB*s equipped with *V2G* technology can reduce *GHG* from both the transportation and power generation sectors – the two *US* economy sectors that contribute most of *GHG* emissions
  - the replacement of the large number of school buses by *ESB*s, by itself, results in a sizeable

THE ELECTRIFICATION OF SCHOOL BUSES

reduction of *GHG* emissions;

- the effective deployment of *ESB*s' batteries can further reduce utilization of polluting resources and wholesale electricity market prices to aid energy transition and encourage deeper renewable energy resource penetrations; and,
- in addition to these environmental benefits, the wider deployment of *ESB* fleets equipped

THE ELECTRIFICATION OF SCHOOL BUSES

with $V2G$ technology improve the health of the population in their locations

- The wider deployment of ESB fleets equipped with $V2G$ technology can benefit the grid and the electricity consumers with the services such fleets provide to the grid through the effective utilization of their aggregated batteries in terms of
  - various demand response and demand

THE ELECTRIFICATION OF SCHOOL BUSES

management applications such as peak clipping, valley filling and load shaping;

- emergency support to enhance the electricity reliability during peak demand periods; and
- reduction of the investment made by utilities due to the provision of these support services and thereby bring in new revenue streams to the school districts

THE ELECTRIFICATION OF SCHOOL BUSES

- The realization of such benefits will require the formulation of supportive policies and their enactment into legislative initiatives at all levels of government – local, county, state and federal – together with the implementation of tariff modifications by regulatory agencies, and the cooperation of school districts
- Specifically, the formulation of effective incentives will create a major push to the wider and more effective deployment of *ESB*s

CON EDISON ESB DEMONSTRATION PROJECT

- *Con Edison* reported its findings of a demonstration project with the objective to determine the technical and economic viability of using *V2G*-equipped school buses to support the grid at times of high demand for electricity
- *Con Edison* worked with bus manufacturer *Lion Electric*, *White Plains* school bus contractor *National Express* and project developer *First Priority Group*

CON EDISON ESB DEMONSTRATION PROJECT

Electrified (*FPGe*) and energy technology company *Nuvve Holding Corp* to undertake the three-year study that was performed with 5 *ESB*s that took elementary school students in *White Plains, NY*, to their classes each day

- Three of the buses were retrofitted with power converters to allow them to perform *V2G* bi-directional charging

CON EDISON ESB DEMONSTRATION PROJECT

- The study showed that electrification of school buses can provide benefits to school districts, transportation providers and utility customers without deleterious impacts on the batteries:
  - the utilization of the batteries for both transportation and grid support causes the batteries to degrade just as much as for transportation only

CON EDISON ESB DEMONSTRATION PROJECT

- bus availability and transportation performance of *EBS*s were almost the same as that of the diesel buses
- roughly 85 % of the battery energy reached the grid – 15 % losses were in line with the *Con Edison* criteria

- The project demonstrated the feasibility of the *V2G*-equipped *EBS*s to support the grid at

CON EDISON ESB DEMONSTRATION PROJECT

times when demand for power is high, which is usually on hot summer *NY* afternoons

- Overall, the results indicate the huge potential to deploy *ESB*s on a large scale to discharge power into the grid at times of peak loads and the associated benefits for school districts, transportation providers and utility customers that the electrification of school buses can provide

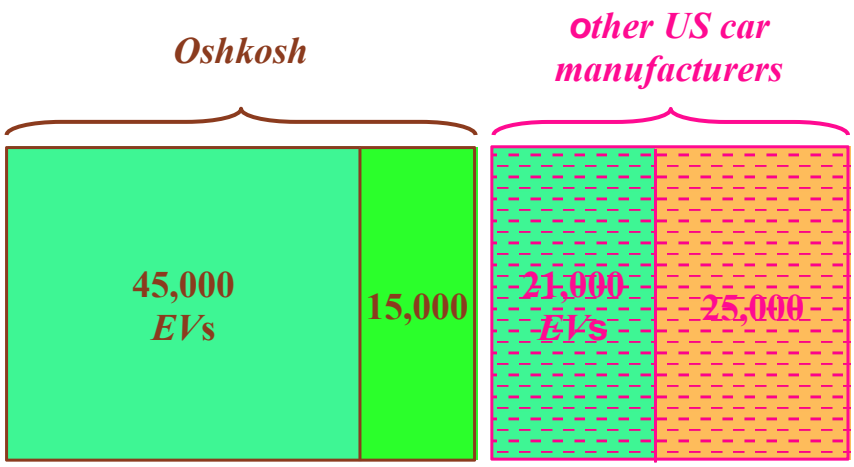
US POSTAL SERVICE PLANS TO ELECTRIFY

- On December 20, 2022, the *USPS* unveiled its plans to include the purchase of 66,000 *electric* delivery vehicles that will constitute one of the biggest electric fleets in the *US*
- *USPS* estimated costs of *$* 9.6 billion for the *EV*s and the *EVCI* construction benefit from *$* 3 billion support provided by the *Inflation Reduction Act*

US POSTAL SERVICE PLANS TO ELECTRIFY

- The purchases from 2 suppliers consist of
  - 60,000 *next generation delivery vehicles* or *NGDV*s from defense contractor *Oshkosh*, of which 45,000 will be electric, *i.e.*, *ENGDV*s
  - 46,000 mainstream *OEM* vehicles, of which 21,000 will be *EV*s

THE FUTURE *USPS* FLEET



Source: Jacob Bogage, "Postal Service will electrify trucks by 2026 in climate win for Biden," Washington Post, December 20, 2022; online at https://www.washingtonpost.com/business/2022/12/20/usps-ev-vehicles/

US POSTAL SERVICE PLANS FOR ELECTRIFICATION

- The *USPS* has over 217,000 *ICEV*s that make up the largest part of the civilian fleet owned by the federal government
- The *USPS* must replace its 30-*year-old* fleet of vans/trucks which have no air conditioning, air bags and other standard safety features and has a very poor fuel efficiency – its current value is a mere 8.2 *mpg* for the boxy white vans

USPS PLANS: IMPLICATIONS

- *USPS* plans represent a concrete and significant step towards a *zero-emission* fleet by the federal government
- The *Biden administration* intends to use the *USPS* fleet as a *role model* for *USPS competitors* to adopt *zero-emission vehicles* (*ZEV*s) on a speedier basis
- More generally, the deployment of electric models for the boxy, white mail vans can provide useful examples to *US* drivers to adopt *ZEV*s

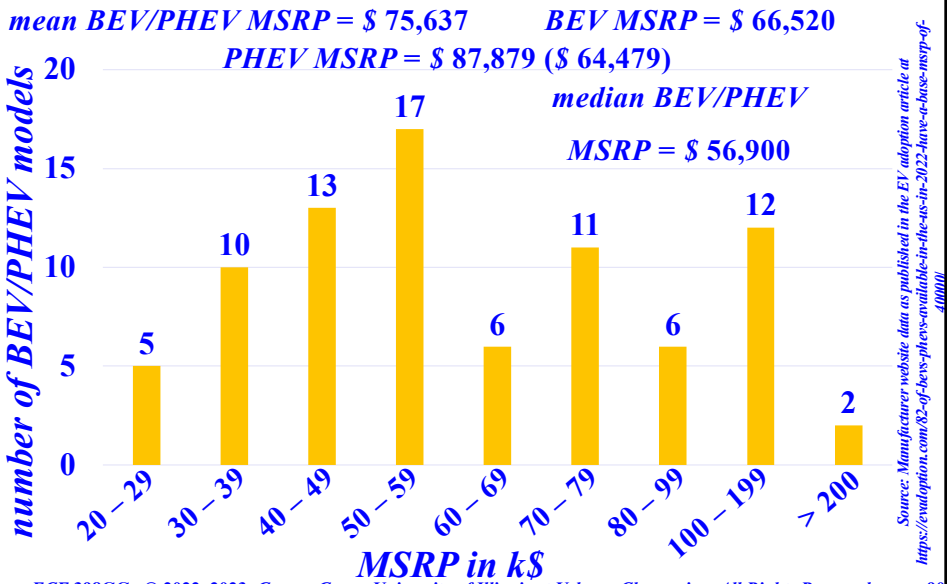
AFFORDABILITY OF *US EV*s

- The analysis by *EV Adoption* of *US EV* prices indicates that 67 of the 82 available *EV* and *PHEV* models in the *US* in 2022 have a *base manufacturer's suggested retail price* (*MSRP*) above *$* 39,999
- The actual purchase prices exceed the base *MSRP* as they include non-standard features, additional options and upgrades, delivery charges, sales tax and fees

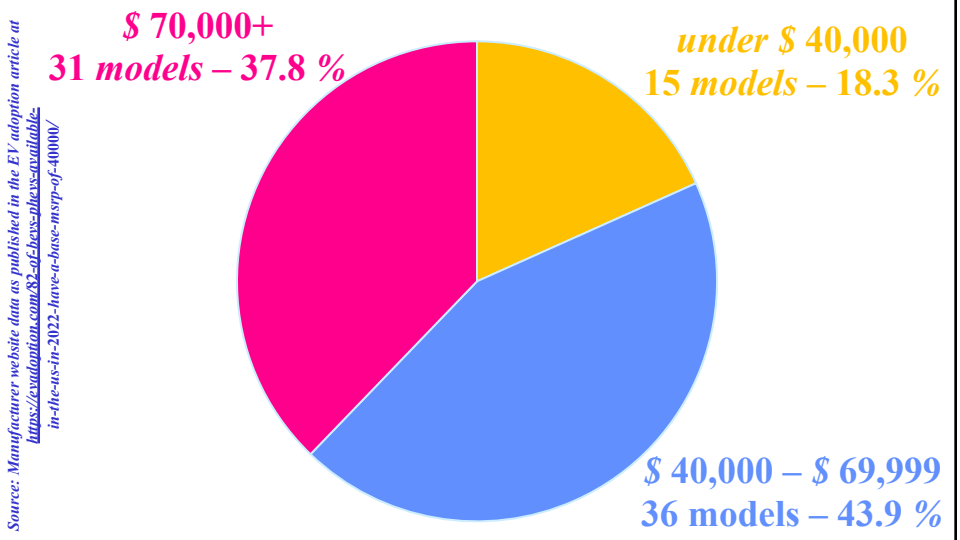
AFFORDABILITY OF *US EV*s

- In addition, dealers/showrooms may charge so-called *dealer market adjustments* – additional markups that are typical for luxury vehicles
- The average transaction price for an *EV* in the US in *September* 2022 was *$* 65,291 according to the *Kelley Blue Book*
- The lack of *EV*s available at or below *$* 30,000 is a huge barrier to the mass adoption of *EV*s

US EV 2022 *MSRP* DISTRIBUTION BUCKETS



A MORE AGGREGATED *MSRP* DISTRIBUTION



Source: Manufacturer website data as published in the EV adoption article at https://evadoption.com/82-of-bevs-nhevs-available-in-the-us-in-2022-have-a-base-msrp-of-40000/

PG&E's *BI-DIRECTIONAL EV* RESIDENTIAL CHARGING PROGRAM

- *PG&E* entered into a partnership with *GM* to create a *bi-directional EV program* able to supply homes and small businesses with the electricity stored in the *EV*s located on site; a pilot program in Summer 2022 tested *V2G* and *V2H* – vehicle-to-home – systems
- The key objective of the *PG&E* – *GM* pilot program was to determine the extent of the capability of the

*EV*s ARE ENTERING RENTAL COMPANIES' FLEETS

- *Tesla*, *GM* and *Polestar* – the all-electric automaker controlled by *Volvo* and its *Chinese* owner *Zhejiang Geely Holding Group* – have signed fleet deals with rental companies that exploit the *economies of scale* of *OEM*s from the increased sales to fleets
- For example, *GM* has agreed to supply 175*k* *EV*s to *Hertz* over the next 5 years; *Hertz* also secured 100*k* *EV*s from *Tesla* and another 100*k* *EV*s from *Polestar*

*EV*s ARE ENTERING RENTAL COMPANIES' FLEETS

- These fleet deals benefit both the buyers/sellers:
  - *EV*s command an extra $ 30 – 35 a day at the rental company counter, despite the lower fueling and maintenance costs
  - the *EV* resale values are also stronger than those for many *ICEV*s
  - marketing studies indicate that rental companies can prime the market for *EV* sales since car buyers are twice as likely to consider an *EV* once they have driven one

PG&E'S *BI-DIRECTIONAL EV* RESIDENTIAL CHARGING PROGRAM

V2G and *V2H* systems to improve the *PG&E* distribution grid reliability

- *CA Senate Bill* 676 required the *CPUC* to formulate strategies and metrics to integrate *EV*s into the grid by 2030; the *PG&E – GM* pilot program is an initiative under the *CPUC*-approved framework for the integration of *EV*s into the grid to comply with the *Senate Bill* 676 requirements

PG&E'S *BI-DIRECTIONAL EV* RESIDENTIAL CHARGING PROGRAM

- Testing tasks comprised the installation of *EV* chargers and bi-directional hardware & communication software used to coordinate among the home/business network, *EV*s and the *PG&E* distribution grid
- *PG&E* developed a mechanism to specify the price signals to use the *EV* batteries to serve home/business demand and grid load with the explicit consideration in the rates for electricity supplied to the customer of the worth of a charged *EV* to provide mobility

PG&E'S *BI-DIRECTIONAL EV* RESIDENTIAL CHARGING PROGRAM

- The creation of the tariff for the bi-directional *EV* charging program modified the two current *time-of-use rate tariffs* for *EV*s:
  - home-charging *EV*-2A, under which the electricity to charge the *EV* is combined with that to serve the customer electricity needs;
  - home-charging *EV*-2B, under which the electricity to charge the *EV* is separated from that for the customer needs and requires the installation of an additional meter

PG&E AND *FORD* ASSESS THE *F*-150 *EV* FOR GRID SUPPORT

Source: PowerGrid International, March 11, 2022; *available at https://www.power-grid.com/der-grid-edge/how-could-fords-new-f-150-ev-support-the-grid/?utm_source=powergrid_weekly_newsletter&utm_medium=email&utm_campaign=2022-03-17*

On the heels of *PG&E*'s announcement of a collaborative effort with *GM* to assess the ability of *GM EV*s to act as on-demand electricity sources for homes, the utility started a joint effort with *Ford* to study the capability of *F*-150 *Lightning EV* trucks to provide reliability services in terms of backup energy for customers' homes.

GM HUMMER EV

Source: *BNEF data in Bloomberg Hyperdrive issue of April,* 12, 2022

- 9,000 + *lbs*
- 329 *mi range*
- 100 *mi charge in* 12 *m with an* 800-*V DCFC*
- $112,595

THE NEW *NISSAN ARYA EV*

Source: Chicago Tribune, https://www.chicagotribune.com/visuals/ct-viz-2022-chicago-auto-show-photos-20220210-emfn7ie6zjelziqrohsauferwu-photogallery.html#nws=true

HYUNDAI IONIQ5 2022 EV

Source: Chicago Tribune, https://www.chicagotribune.com/visuals/ct-viz-2022-chicago-auto-show-photos-20220210-emfn7ie6zjelziqrohsauferwu-photogallery.html#nws=true

WULING HONGGUANG WAS *CHINA*'S BEST–SELLING *EV* IN 2021

Source: Getty images in the New York Times, September 26, 2022

BYD TANG PHEV MODEL

Source: Bloomberg photo in Bloomberg Hyperdrive, 11/14/2022

BYD EVs AT THE *WUHAN, CN,* AUTO SHOW IN JULY 2022

Source: Getty images in the New York Times, September 26, 2022

THE *VOLVO EX* 90

Source: Bloomberg photo in Bloomberg Hyperdrive, 11/10/2022

ROLLS-ROYCE's ELECTRIC *SPECTRE* COUPE

Source: Rolls-Royce

THE NEW *TESLA* SEMI

- *Tesla*'s all-electric semi truck has completed its first 500–*mile* journey on a single charge with an 81,000–*lb* load in *December* 2022
- The successful test run is a major milestone for the future of trucking as none of the competitor manufacturers – *Mercedes*, *Volvo* or *Nikola* – has achieved long-range test runs on this scale
- *Tesla* initially announced its plans to build a semi in 2017 with a target release date of 2019

THE NEW *TESLA* SEMI

- *Tesla* initially announced its plans to build a semi in 2017 with a target release date of 2019
- The adoption of electric trucks will take considerable time but the buyers are interested in *all-electric semi trucks* to meet their emission target goals
- The key challenges are to scale up production levels of the manufacturing sector to meet the eventual demand and to incorporate into the *EVCI* the charging needs of the demands of the semis

THE NEW *TESLA* SEMI

Source: Tesla Photo, available online at https://electrek.co/2022/12/02/tesla-semi-900-kwh-battery-pack-but-more-answers-needed/

SIGNIFICANT IMPACTS OF THE *IRA*

- The nature and scope of the *IRA* tax credit and incentive provisions are such that the *IRA* is *primarily an industrial policy legislation* rather than a climate change mitigation instrument
- The *IRA* tax credit provisions are for *EV*s that are assembled in *North America*, with batteries produced/manufactured in *North America* and using raw materials sourced from *US*, *Canada* or *Mexico*

SIGNIFICANT IMPACTS OF THE *IRA*

- Beyond the tax subsidies to *EV* buyers at the point of purchase, *IRA* has provisions for *tax credits* to *US*-based battery cell and pack manufacturers: these tax credits provide 35 *$/kWh* for battery cell assembly plus 10 *$/kWh* for battery packs
- These incentives have led to a series of major investments by various foreign companies to establish *US*-based manufacturing of batteries

SIGNIFICANT IMPACTS OF THE *IRA*

and *EV*s as well as raw material sourcing to take advantage of the subsidies the *IRA* provides

- Over 13 *billion $* of investment in *raw* battery material production and battery and *EV* manufacturing has been announced since August 16, 2022:
  - *Honda* and *Toyota* earmarked almost 7 *billion $* for *EV* battery plant investments
  - An *Australian* development company started

SIGNIFICANT IMPACTS OF THE *IRA*

up the first *US Cobalt* mine in 30 *years*

- *Volkswagen* and *Mercedes-Benz* contracted to secure *Canadian* mining/refining resources
- *BMW* announced a 1.7 *billion $* expansion of its *South Carolina SUV* factory

- A detailed study by *UBS* indicates that the wave of investment unleashed by the *IRA* tax credits may make battery cell manufacturing highly profitable in the *US* and lead to a battery boom

IRA's SIGNIFICANT INVESTMENT IMPACTS: AUGUST – NOVEMBER, 2022