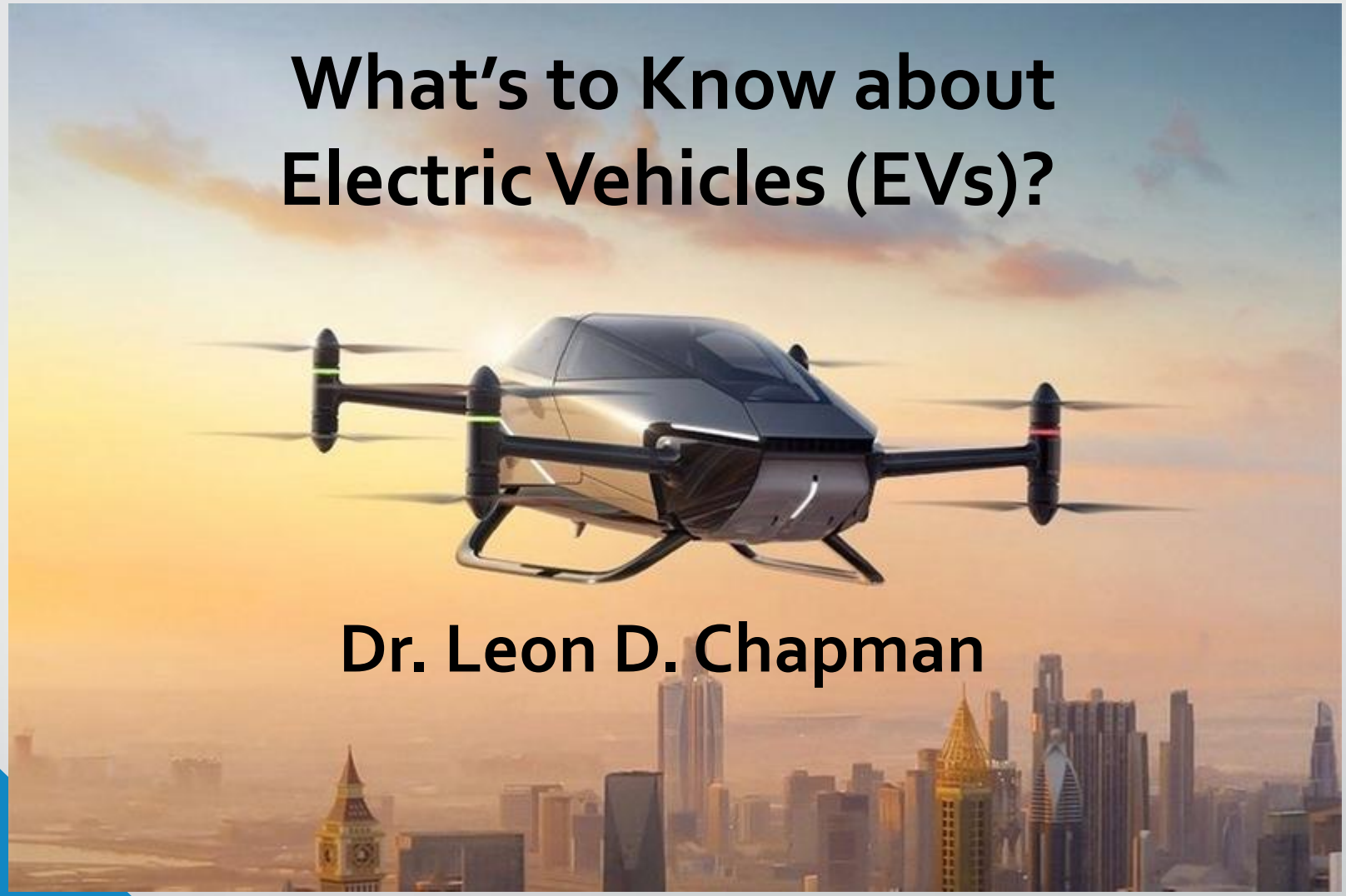
What's to Know about Electric Vehicles (EVs)?



Dr. Leon D. Chapman

What's to Know About Electric Vehicles (EVs)?

- What is an Electric Vehicle?
- History of EVs
- EVs vs ICE cars
- How Many Miles can an EV travel?
- EV costs / EVs available
- Batteries / Battery Pack
- Charging
  - Levels / Connectors / Plugs
  - Charging Speeds
  - Home / On-the-Road
  - Networks – Superchargers
- Apps for Tesla
- Goals for EVs
- Summary – Time to buy an EV?

What is an Electric Vehicle?

An electric vehicle (EV) is a vehicle that uses one or more electric motors for propulsion.

It can be powered by a collector system, with electricity from extravehicular sources, or powered autonomously by a battery (sometimes charged by solar panels, or by converting fuel to electricity using fuel cells or a generator).

EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft …. Wikipedia

This briefing will focus on automobile EVs

Some History of Electric Vehicles (EVs)

(https://gizmodo.com/electric-car-ad-1921-drivers-brutally-honest-rauch-lang-1849543806
https://en.wikipedia.org/wiki/History_of_the_electric_vehicle)

At the turn of the 20th century, one-third of all cars produced in the U.S. were electric. 1st EV in 1828.

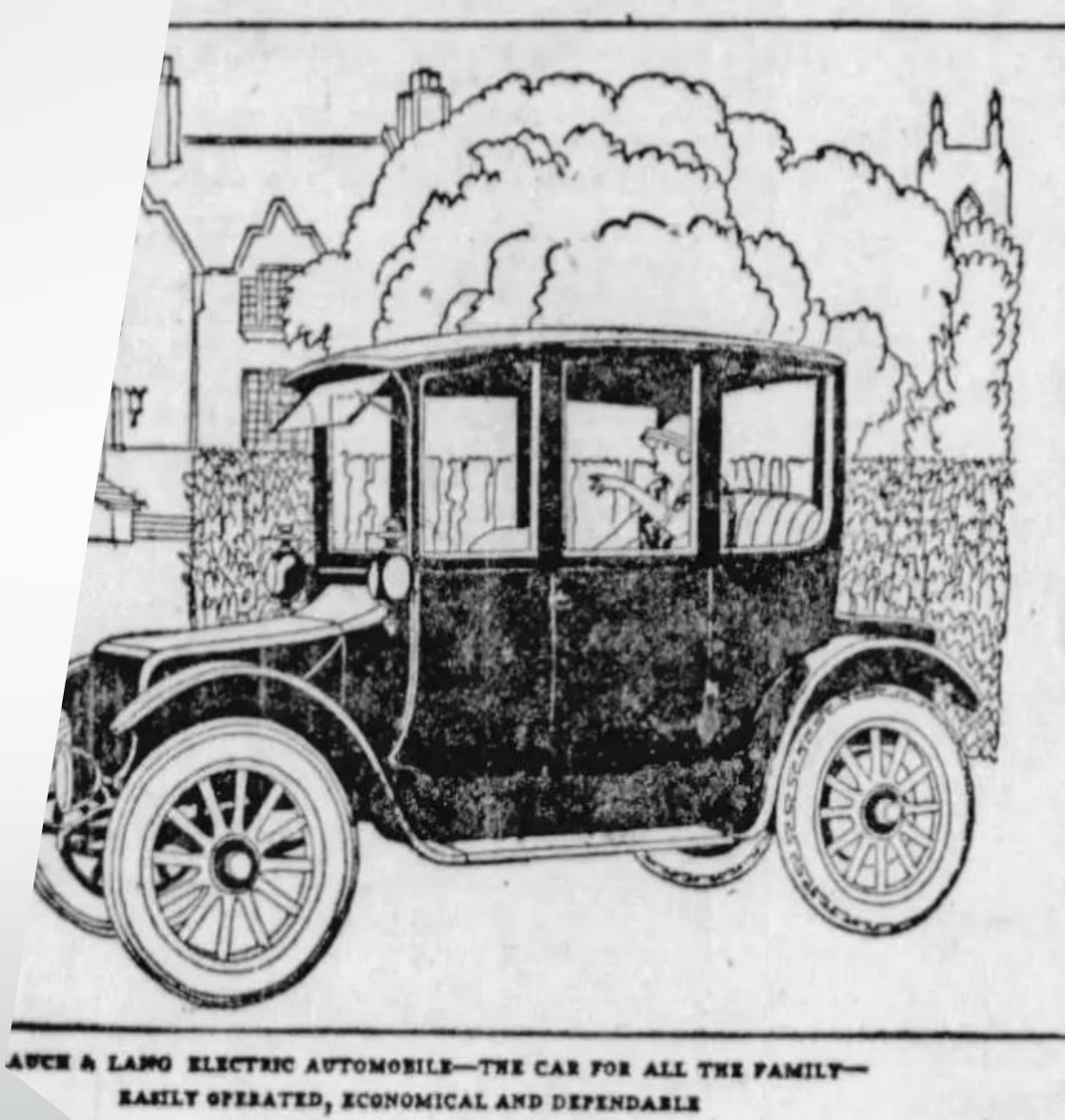
By the 1920s, gasoline-powered cars had grown to dominate the market because they offered greater range and speed.
Henry Ford assembly line – Dec 1, 1913

But one electric car company asked newspaper readers in 1921 to be brutally honest with themselves about what they actually needed in a car.

October 16, 1921 edition of the *Kansas City Star* with the headline "The Challenge of the Electric Automobile."

Some History of Electric Vehicles (EVs) - Continued

- Rauch & Lang purchased an advertisement in the October 16, 1921 edition of the *Kansas City Star* with the headline "The Challenge of the Electric Automobile."
- This Electric Car Ad From 1921 Asked Drivers To Be Brutally Honest With Themselves
- The ad implored potential car buyers to ask themselves hard questions about how they actually use their cars. (Note: 15-20 mph & 30–40-mile range)
  - Were you really going to take that long car trip you'd always been dreaming about?
  - Or did your car really exist as a way to get to work, visit the theater, or hang out with friends?
    - *These questions are very relevant today!*



Early Electric Vehicle Pictures

(https://en.wikipedia.org/wiki/History_of_the_electric_vehicle)

NIO ES8 has a swappable battery pack

Gustave Trouvé's tricycle (1881), world's first electric car

Electric car built in England by Thomas Parker, photo from 1895

Flocken Elektrowagen, 1888 (reconstruction, 2011)

Columbia Electric's (1896–99) "Victoria" electric cab on Pennsylvania Ave., Washington D.C., seen from Lafayette Square in 1905, driving in front of the White House.

German electric car, 1904, with the chauffeur on top

Example Electric Vehicles

- Our Focus

Internal Combustion Engine (ICE) Cars

Electric Vehicles

Chap's Tesla's – Model Y & X

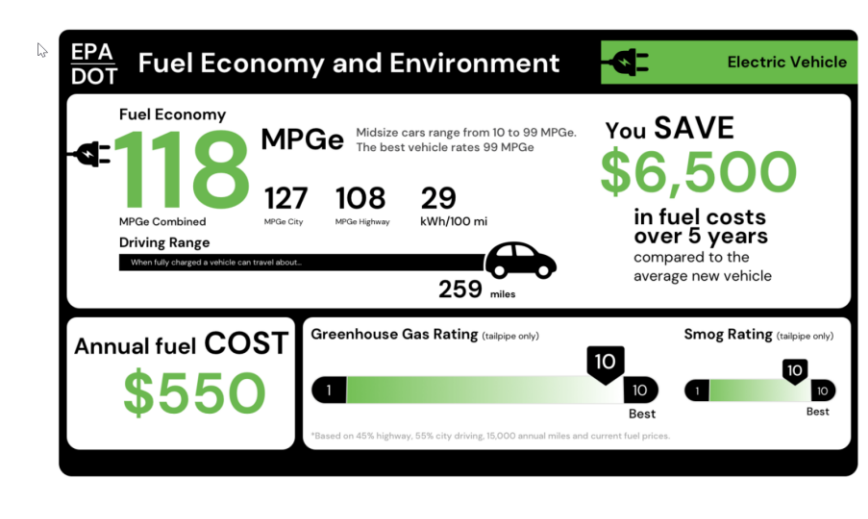
How Does MPG compare to MPGe?

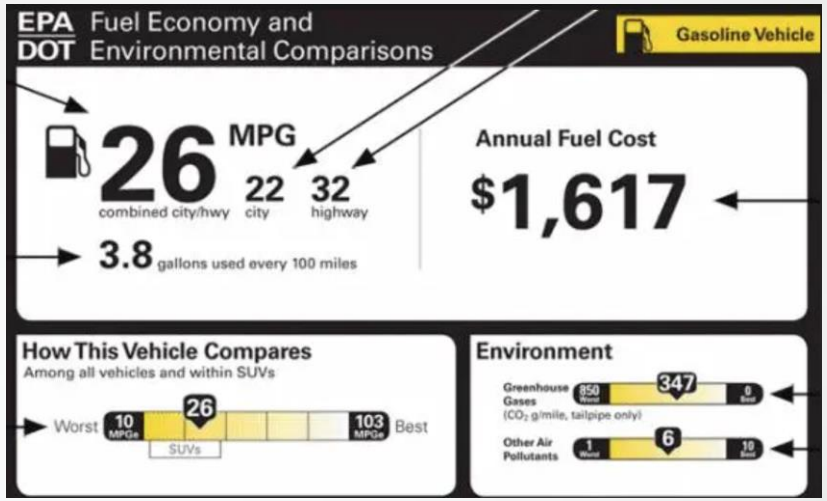
ICE cars are rated as Miles Per Gallon (MPG)

EV cars are rated as Miles Per Gallon Equivalent (MPGe)

MPGe is how many miles an electric vehicle can travel on the electrical energy equivalent.	When developing MPGe, the EPA determined that 33.7 kWh (kilowatt hours) of electric usage is equivalent to one gallon of gasoline.

How Does MPGe compare to MPG?



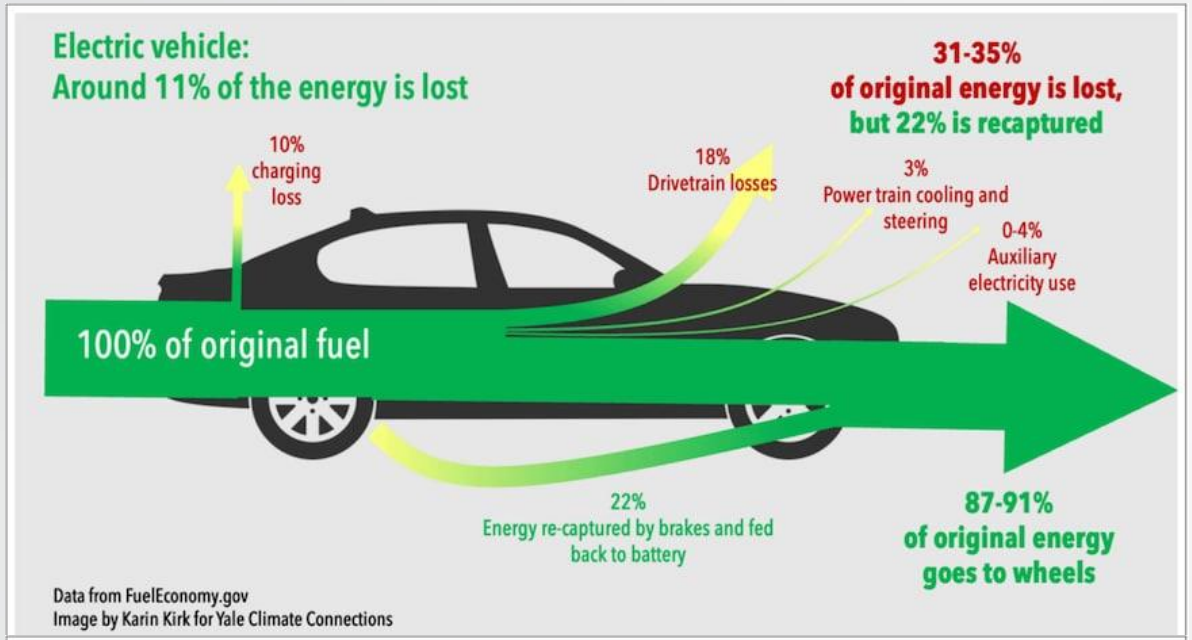


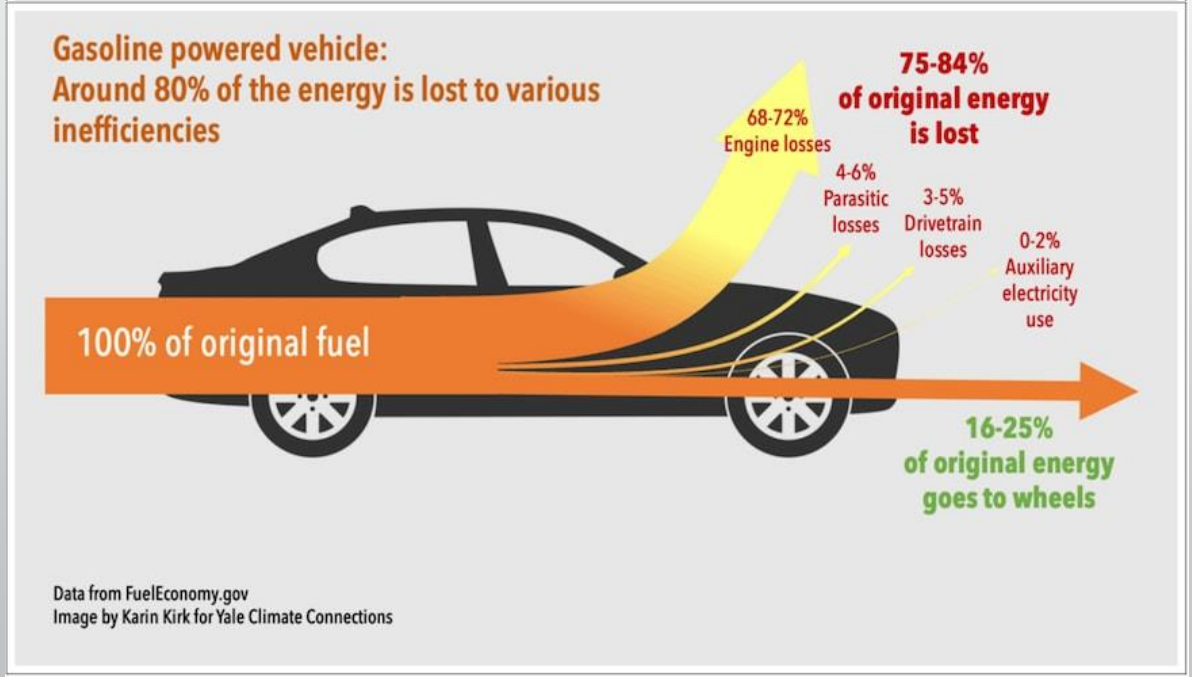
EV Fuel Efficiency Comparison Chart

This chart compares the fuel efficiency of a few recent EV models.

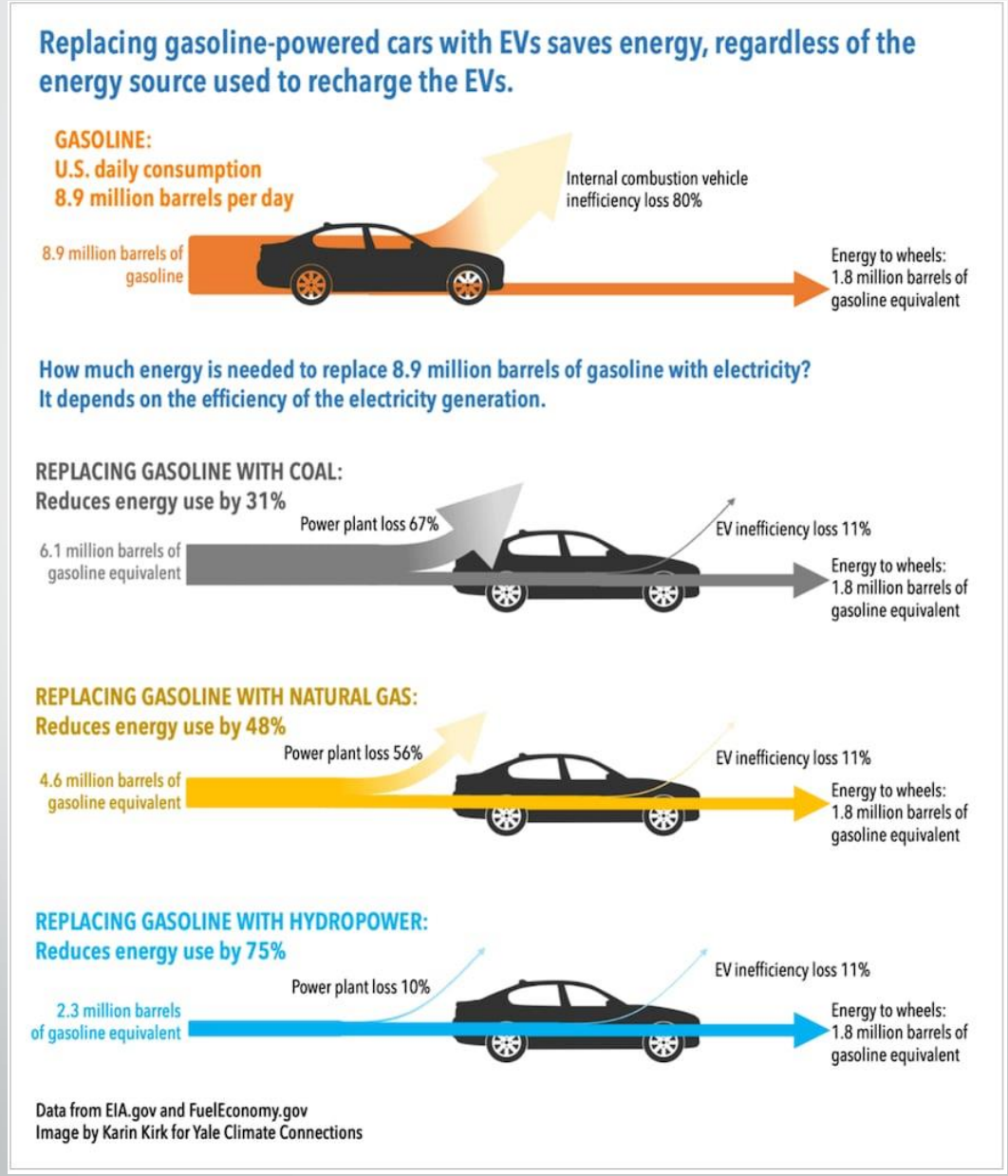
	Combined MPGe	kWh/100 Miles	Annual Fuel Cost	Range
2022 Tesla Model S	120 MPGe	28 kWh/100 miles	$550	405 miles
2022 Chevrolet Bolt EV	120 MPGe	28 kWh/100 miles	$550	259 miles
2022 Rivian R1S	60 MPGe	49 kWh/100 miles	$950	316 miles

EV vs ICE Efficiency





Replace ICE Cars with EVs Saves Energy



EV, HEV and PHEV – What's the Difference?

EV - Electric Vehicle, also know as Battery Electric Vehicle (BEV)

- Electric engine(s) only
- Most have a front and rear engine
- EUV – Electric Utility Vehicle

HEV – Hybrid Electric Vehicle

- Both Electric & Gas engines
- Battery recharged by regen braking and engine
- Example: Prius – gets 58/53 MPG

PHEV – Plug-in Hybrid Electric Vehicle

- Both Electric & Gas engines
- 30-40 miles on battery only & then runs on gas engine
- Must recharge the battery via Plug-in
- Example: Prius Prime (Plug-in) – gets 54 MPG / 133 MPGe
- Example: RAV-4 Prime (Plug-in) – gets about 38 MPG / 94 MPGe

How Many Miles can Current EVs Travel?

Visualizing the Range of Electric Cars vs. Gas-Powered Cars (visualcapitalist.com)

Year	Avg. EV Range	Maximum EV Range
2010	79 miles (127 km)	N/A
2011	86 miles (138 km)	94 miles (151 km)
2012	99 miles (159 km)	265 miles (426 km)
2013	117 miles (188 km)	265 miles (426 km)
2014	130 miles (209 km)	265 miles (426 km)
2015	131 miles (211 km)	270 miles (435 km)
2016	145 miles (233 km)	315 miles (507 km)
2017	151 miles (243 km)	335 miles (539 km)
2018	189 miles (304 km)	335 miles (539 km)
2019	209 miles (336 km)	370 miles (595 km)
2020	210 miles (338 km)	402 miles (647 km)
2021	217 miles (349 km)	520 miles* (837 km)

How Many Miles can Current EVs Travel?

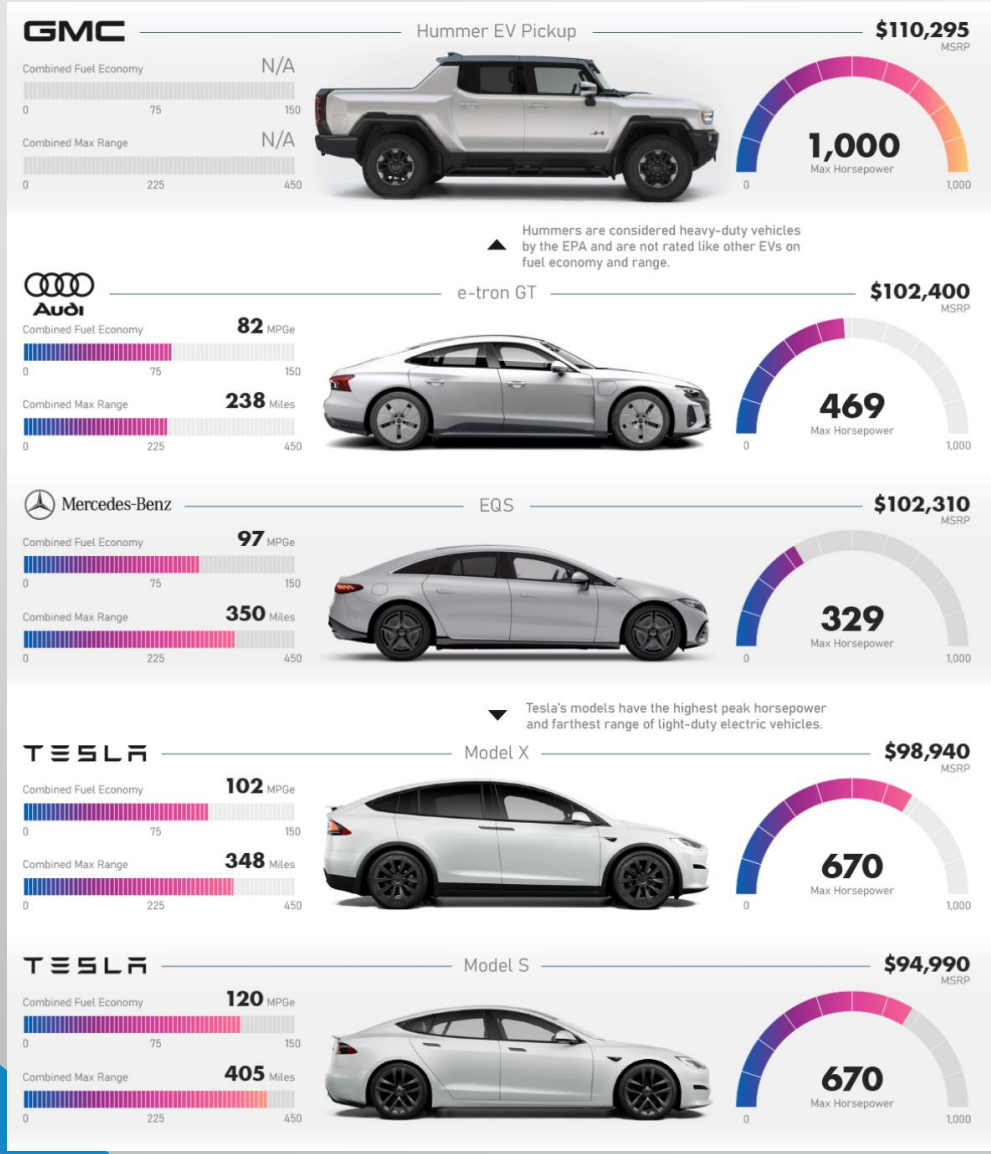
Visualizing the Range of Electric Cars vs. Gas-Powered Cars (visualcapitalist.com)

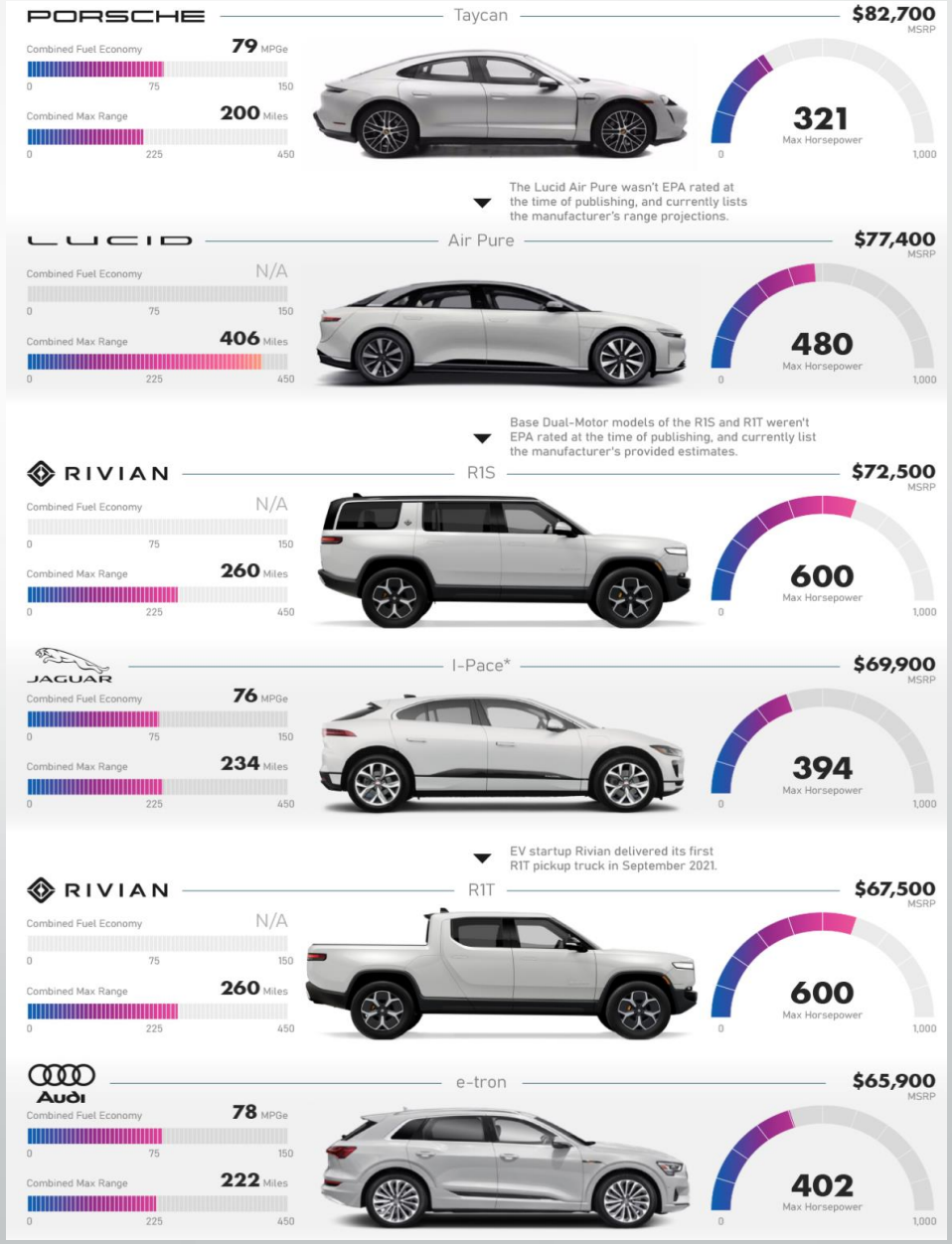
10 Longest Range EVs

Car	Range On One Full Charge	Estimated Base Price
Lucid Air	520 miles (837 km)	$170,500
Tesla Model S	405 miles (652 km)	$106,190
Tesla Model 3	358 miles (576 km)	$59,440
Mercedes EQS	350 miles (563 km)	$103,360
Tesla Model X	348 miles (560 km)	$122,440
Tesla Model Y	330 miles (531 km)	$67,440
Hummer EV	329 miles (529 km)	$110,295
BMW iX	324 miles (521 km)	$84,195
Ford F-150 Lightning	320 miles (515 km)	$74,169
Rivian R1S	316 miles (509 km)	$70,000

EVs in America – Apr 2022

[Visualizing All the Electric Car Models Available in the U.S. (visualcapitalist.com)](#)





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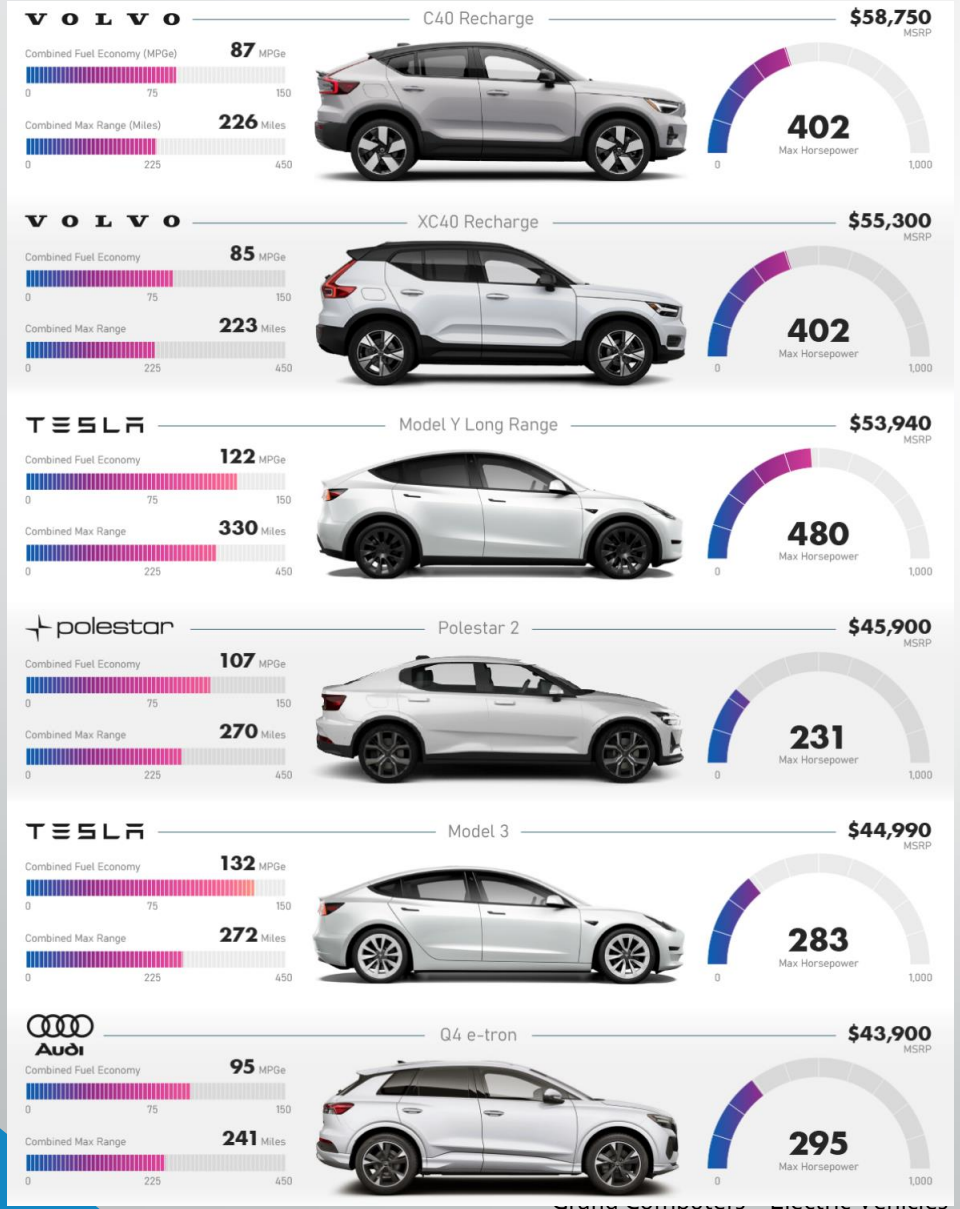

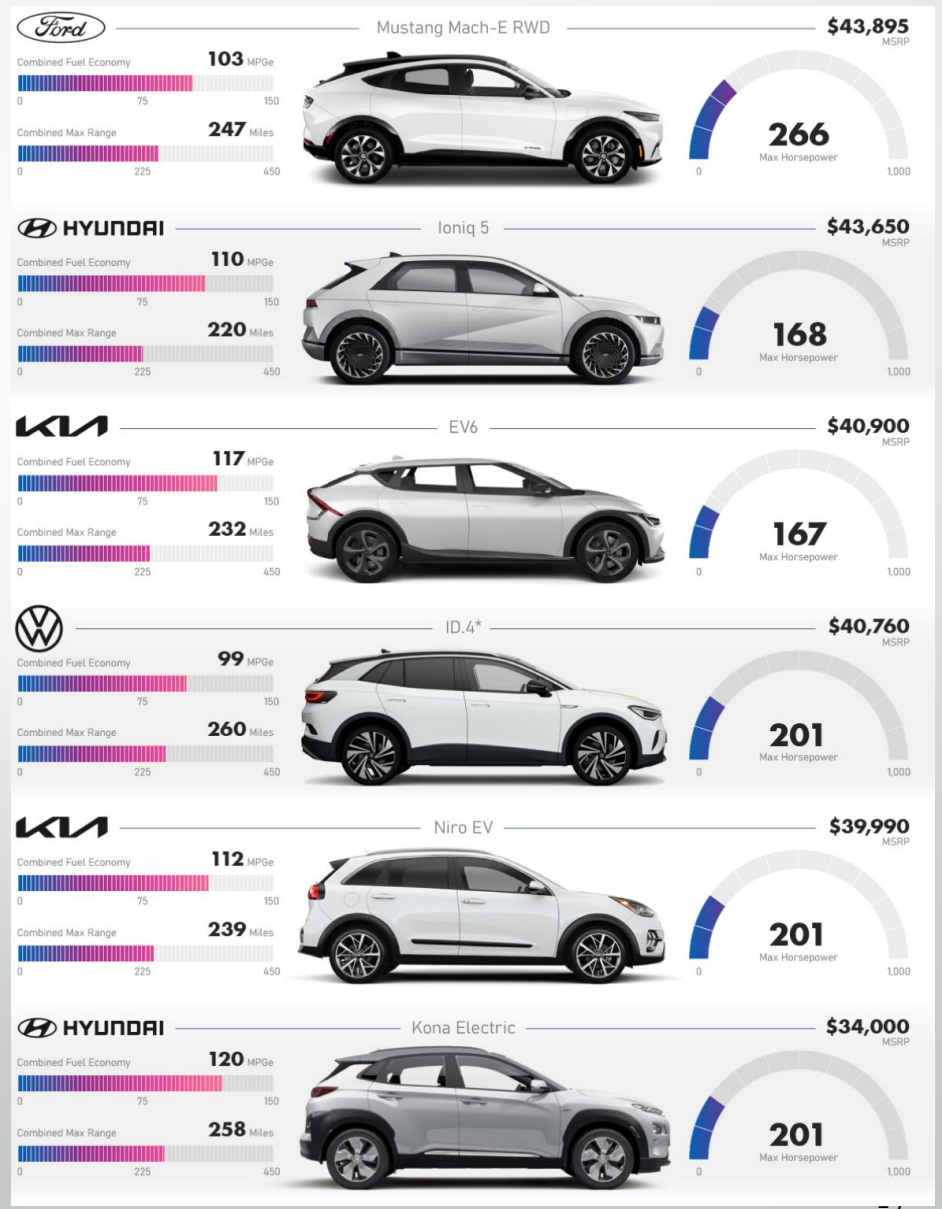

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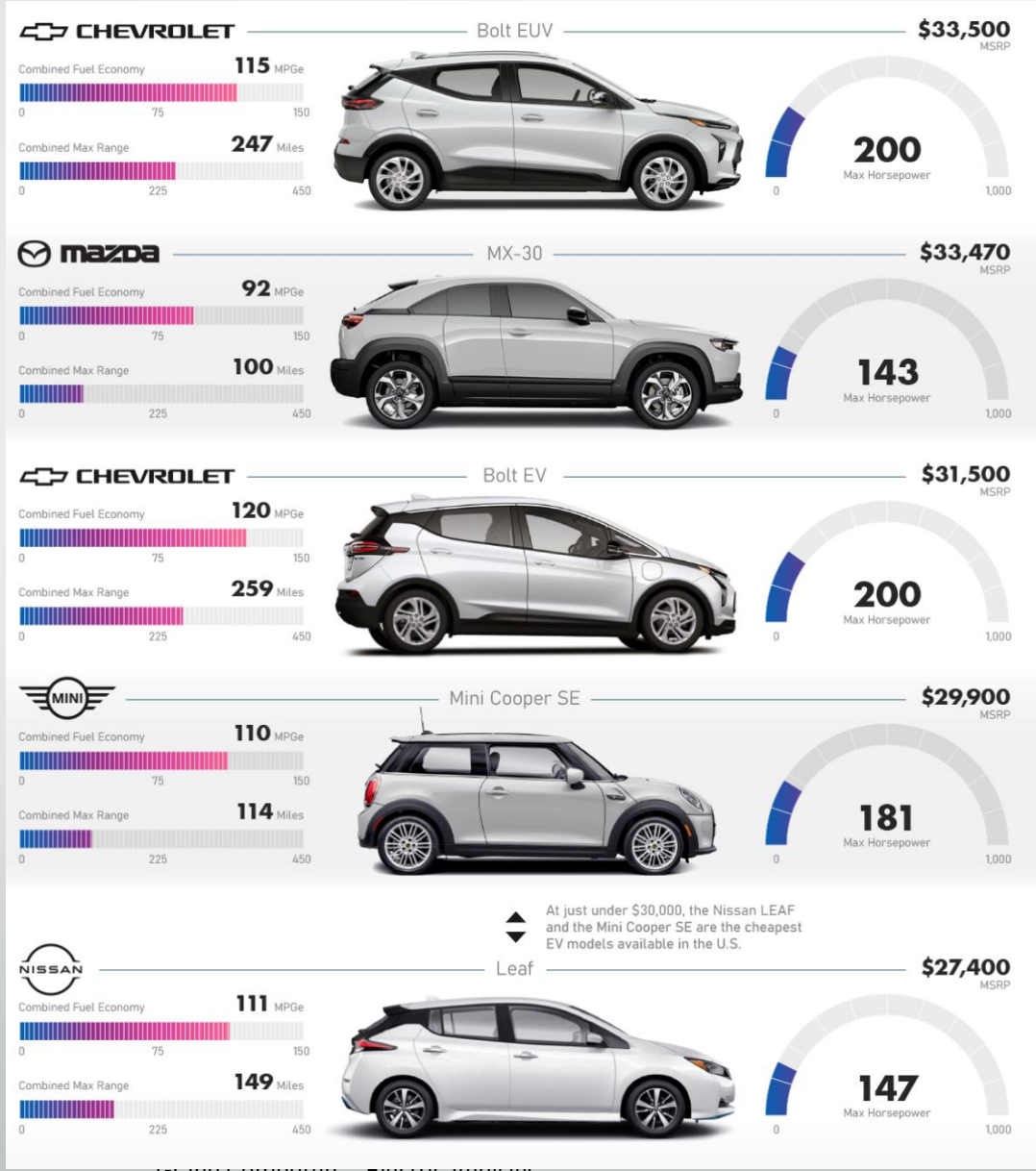


EVs in America – Pickups

https://robbreport.com/motors/cars/all-electric-pickup-truck-roundup-1234663301/

Rivian R1T

GMC Hummer EV Edition 1

Tesla Cybertruck

Ford F150 Lightning

EV Pickups

Rivian R1T

- Power: 835 hp
- Torque: 900 ft lbs
- Payload: 1,760 pounds
- Range: 314 miles
- Towing: 11,000 pounds
- Starting Price: $79,500 - $85,000
- 70 MPGe

GMC Hummer EV Edition 1

- Power: 1,000 hp
- Torque: 1,000+ ft lbs (estimate)
- Payload: 1,300 pounds
- Range: 350 miles
- Towing: 7,500 pounds
- Starting Price: $112,595
- 47 MPGe

EV Pickups - 2

Tesla Cybertruck

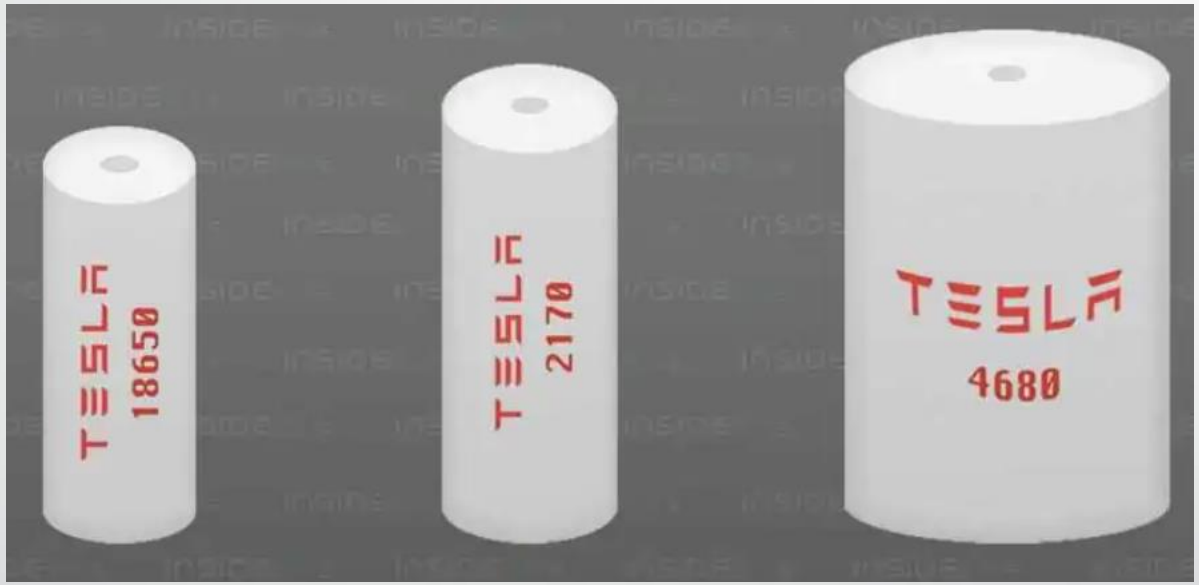
- Power: 800 hp
- Torque: 900 ft lbs
- Payload: 1,760-3500 pounds
- Range: 300-500 miles
- Towing: 11,000 pounds
- Starting Price: $40,000 - $78,000
- 70 MPGe

Ford F-150 Lightning

- Power: 563 hp
- Torque: 775 ft lbs
- Payload: 2,000 pounds
- Range: 300 miles
- Towing: 10,000 pounds
- Starting Price: $40,000 - $96,874
- 68 MPGe

Batteries in EVs

AAA AA D



Battery Pack – Tesla Model X

About 8-10,000 AA Batteries in this Pack

Battery Pack – Tesla Model X

About 8-10,000 AA Batteries in this Pack

Levels of Charging EVs

Charging Level	Setting	Supply Power	Representative Example	Where Charging Occurs
AC Level 1	Residential/ Parking Lot 5 mi/hour @ 1.7 kW	120vac/20A (16A continuous)		RESIDENTIAL
AC Level 2 (minimum)	Residential/ Commercial 10 mi/hour @ 3.4 kW	208/240vac/20A (16A continuous)		2/3 of charging
AC Level 2 (maximum)	Commercial (up to) 60 mi/hour @ 19.2 kW	208/240vac/100A (80A continuous)		
DC Level 1	Commercial up to 500v @ 80Adc (up to) 120 mi/hour @ 40 kW	208vac/480vac 3-phase (input current proportional to output power; ~20A-200A AC)		COMMERCIAL
DC Level 2	Commercial up to 500v @ 200Adc (up to) 300 mi/hour @ 100 kW	208vac/480vac 3-phase (input current proportional to output power; ~20A-400A AC)		1/3 of charging

Tesla EV Charge Speeds

- Up to 3 miles of range per hour charged
  - *Mobile Level 1 – 120v/20A – anywhere charge*

- Up to 44 miles of range per hour charged
  - *Home Level 2 Charger – 240v/48A*

- Up to 200 miles in 15 minutes of charge
  - *Supercharger Network – 150-800A*
  - *DC Fast Charging – 480v/400A*

Cost to Install Home EV Charger

- Tesla Wall Connector - $400
- Install 240 power to garage - $50-$2500
  - Depends on length of cable from cable box
  - Copper & labor is very expensive
- For 48 Amp charging (44 Miles/Hr)
  - Need 60 Amp Breaker
  - #6 Copper wire
- Rebates
  - Federal - $1000 max for equipment & installation costs
  - Utility - Maybe
  - Example: Car Manufacturer - $200 from Cadillac

Cost to Charge EVs at Home

Tesla Model X (MX)

- Model X has 100kWh battery
- Assume $0.15/kWh – avg US home cost to charge
- Cost from 0-100% is: 100kWh*$0.15/kWh = **$15.00**
- Range of MX is 348 miles
- Cost / mile = $15/348 = $0.043 or **$4.30 / 100 miles**

ICE car – Assume 25 MPG rating

- Cost for 100 miles = 4 Gal*$4.00/gal = **$16 / 100 miles**
- Cost for 348 Miles is: 348/25 = 14; 14gal*$4.00 = **$56**
  14gal*$3.00 = **$42**

Average Fuel Cost per year – Univ Michigan study

- ICE - $1,117
- EV - $485

Tesla Car Screen during Home Charging

Cost to Charge EVs at Supercharger

Tesla Model X (MX)

- Model X has 100kWh battery
- Assume $0.45/kWh *(was $0.25/kWh a year or so ago)*
- Cost from 0-100% is: 100kWh*$0.45/kWh = **$45.00**
- Range of MX is 348 miles
- Cost / mile = $45/348 = $0.13 or $13 / 100 miles

ICE car – Assume 25 MPG rating

- Cost for 100 miles = 4 Gal*$4.00/gal = $16 / 100 miles
- Cost for 348 Miles is: 348/25 = 14; 14gal*$4.00 = **$56**
  14gal*$3.00 = **$42**

Average Fuel Cost per year – Univ Michigan study

- ICE - $1,117
- EV - $485

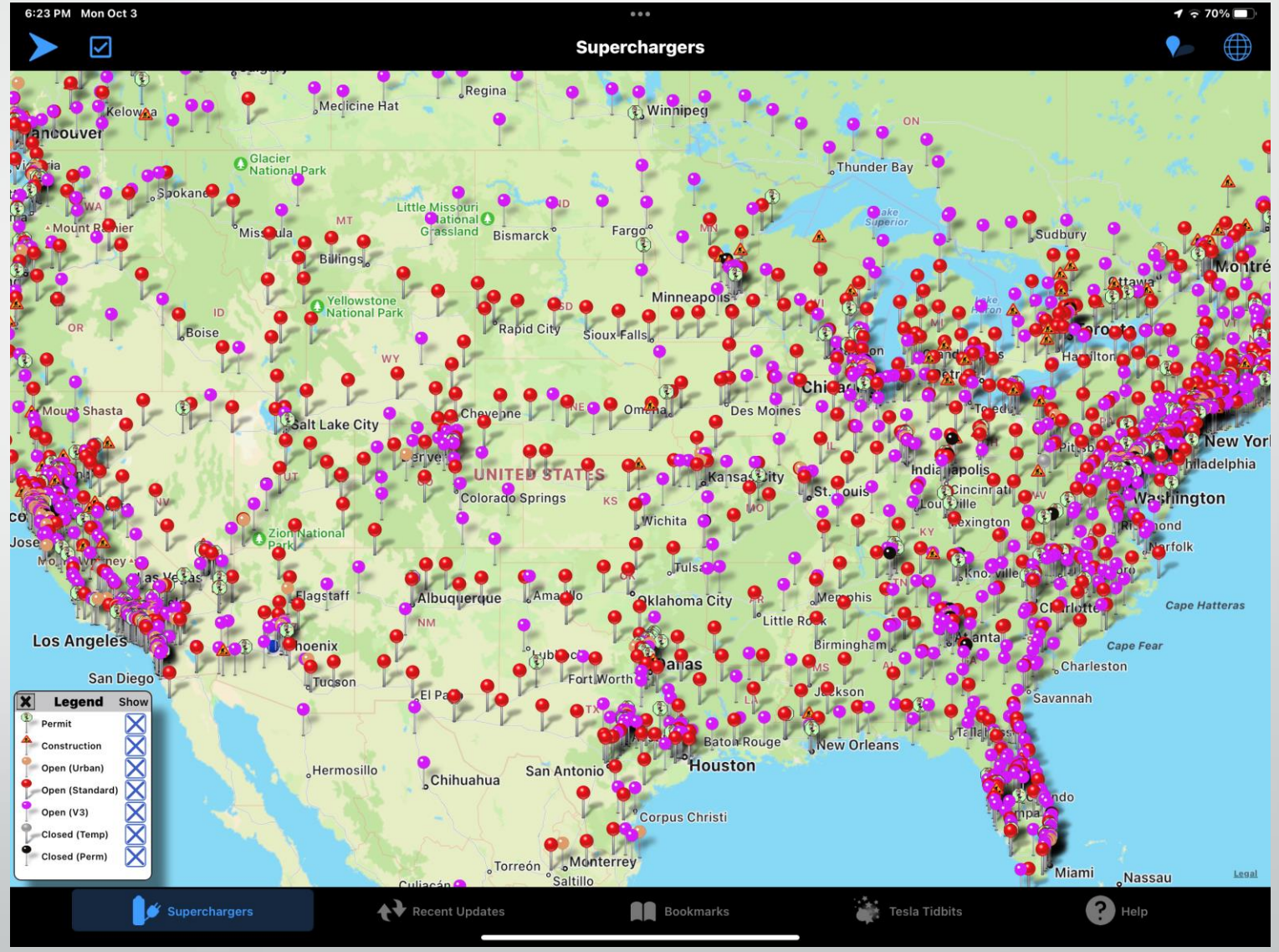
Cost to Home Charge an EV

How much does it cost to charge an electric car? | Tom's Guide (tomsguide.com))

	$0.4753 per kWh (HI)	$0.2747 per kWh (NH)	$0.1037 per kWh (WA)	$0.1595 per kWH (U.S. Av)
Nissan Leaf (40 KWh)	$18.29	$10.99	$4.15	$6.38
Tesla Model 3 RWD (57.5 kWh)	$26.29	$15.79	$5.96	$9.17
Chevy Bolt (60 kWh)	$27.40	$16.48	$6.22	$.957
Ford Mustang Mach-E (75.7 kWh)	$34.60	$20.79	$7.85	$12.07
Tesla Model Y (82 kWh)	$37.50	$22.52	$8.50	$13.08
Ford F-150 Lighting (98 kWh)	$44.81	$26.92	$10.16	$15.63
Hummer EV (200 kWh)	$91.46	$54.94	$20.74	$31.90

Tesla Supercharging Network

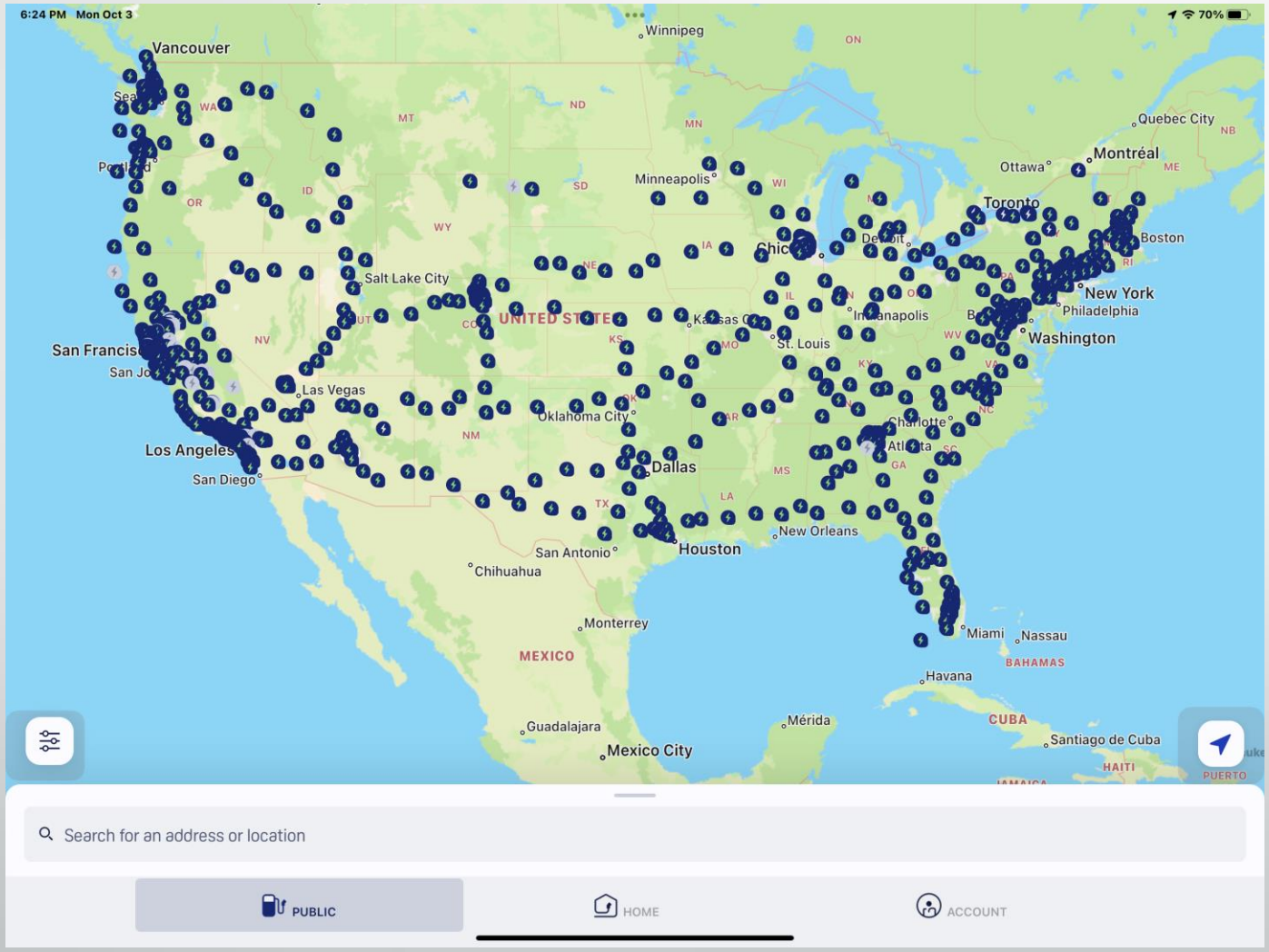
- Tesla Network started in 2012
- Today ~ 36,165 Superchargers
  - 9 chargers per station average
  - 1,498 locations in Sep 2022 in US
  - ~ 120 miles apart
- Best charging network by far



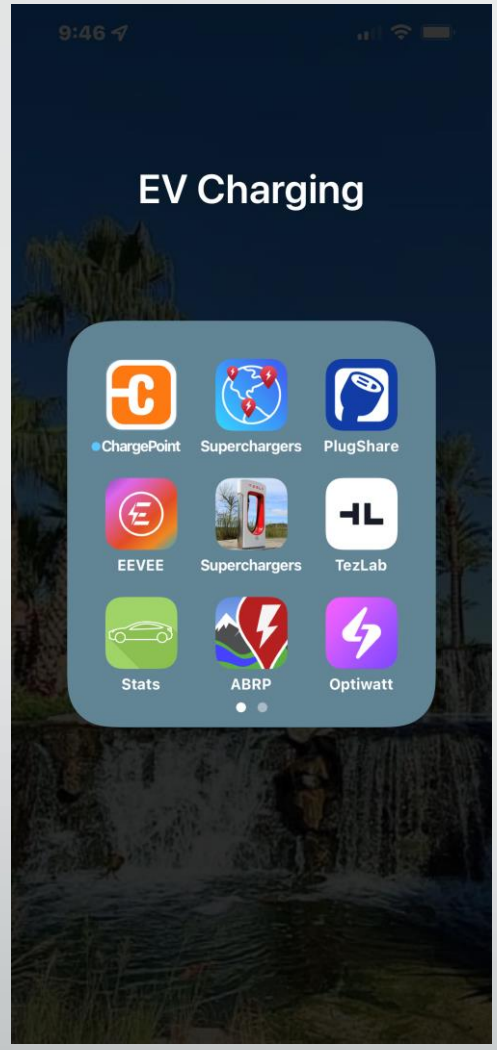
Tesla Supercharger Station

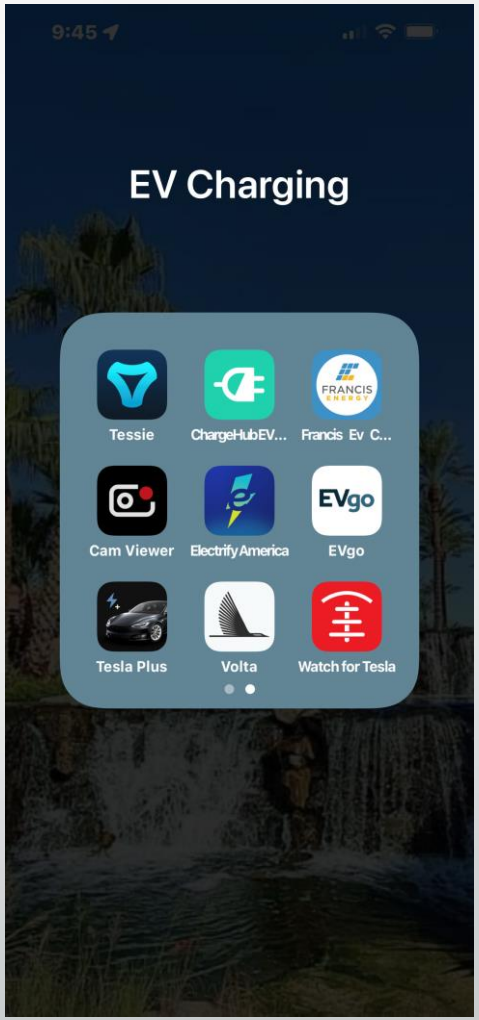
(Normally 8-12 chargers / station)

Electrify America Network (VW)



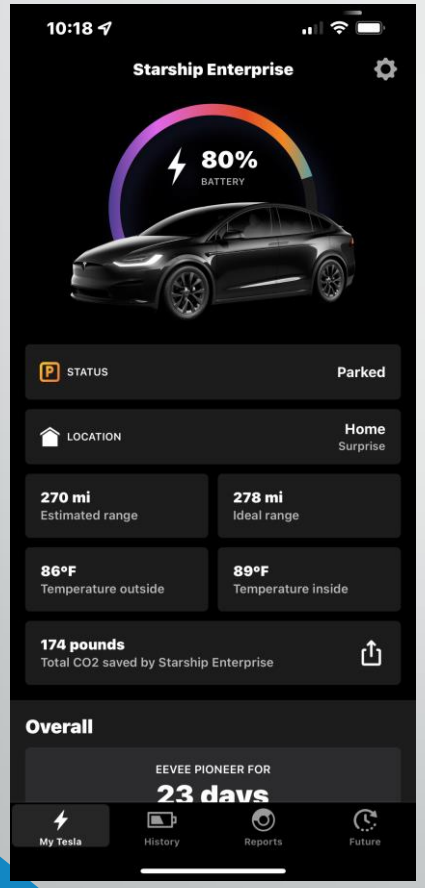
Apps for Tesla - iPhone





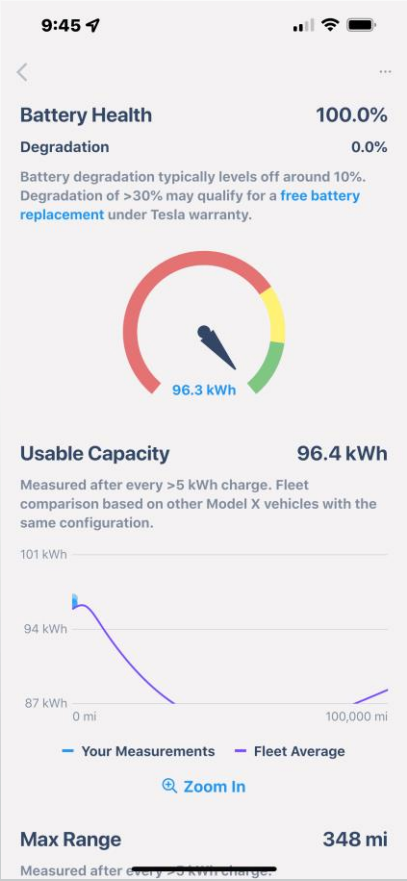
Apps for Tesla – Screen shots

EEVEE

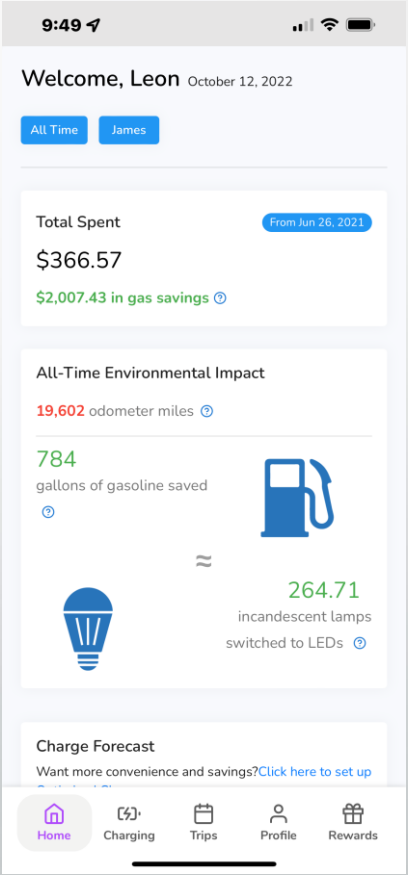


Stats

Tessie



Optiwatt



Goals / Mandates for Evs

GM, Ford, etc. will each have 15-40 EVs by 2030.

US Government Mandate

- No new ICE cars sold by 2035

California, Oregon, Massachusetts & New York & Canada

- Only sell New EVs by 2035 – no new ICE cars
  - *35% in 2025, 68% in 2030, 100% in 2035*
  - *Over a dozen states looking at similar mandates*

All car manufactures committed to full Electrification of their vehicles

- Toyota is the only one lagging – focus on their HEV / PHEVs

Uber Drivers

- Must switch to EVs by 2030

Europe Mandates no ICE cars sold by 2035

Summary – Time to Buy an EV?

We are in a major auto revolution like no other!

- ICE to EVs (5.5% of 2022 Q3 sales are EVs in US)
- Majority of sales are Tesla
- Amazon has over 1000 delivery EVs

EVs

- Hard to obtain today – long waits
- Expensive – marked up
- Fast! Performance like no other!

Hybrids (HEV) / Plug-in Hybrids (PHEV)

- Hard to obtain
- Cheaper – marked up
- Slow, but longer range
- Maybe 1st step

It's a matter of when – you will have an EV soon

Questions

What questions do you have for me?