# Electric Vehicles

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# Need for EVs

- Climate change is happening
  - Copious scientific evidence
  - Ignore Luddites and so-called “experts” vested in status quo
- Burning fossil fuels is polluting the atmosphere with greenhouse gas
- There is no “silver bullet” to solving the problem
  - Requires working all aspects of present and future solutions
- Gas-powered automobiles and delivery vans account for 16% of CO2
  - Burning fossil fuels cannot be ameliorated
  - Don’t burn long polymers needed for materials and chemicals
  - Hydrocarbons aren’t recyclable

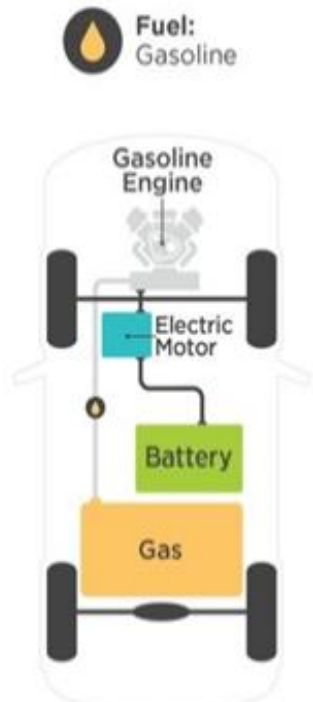
# Types of EVs

- Hybrid HEV
  - Smaller gas engine with electric motor for starting torque
  - Increased mileage, but increased cost, still pollution
- Plug-in Hybrid PHEV
  - Battery operation till charge runs out, then gas engine to charge
  - Inadequate range for all battery operation, increased cost for engine
- Battery only BEV
  - No gas stations, no pollution
  - No scheduled maintenance, 4 moving parts vs. 135 for ICE

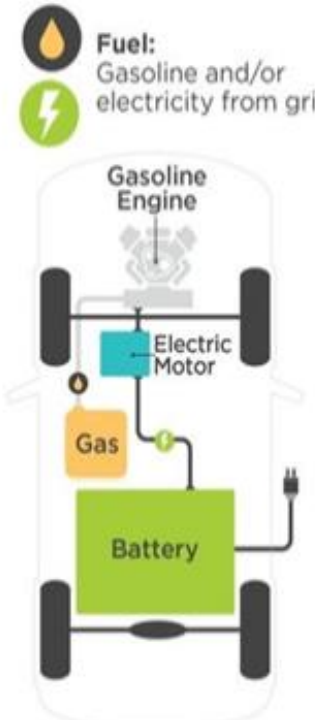
# Types of Electric Vehicles

If you're looking to purchase an electric vehicle, use this cheat sheet to help you determine the various options. Drivers can choose between three types of electric vehicles (EVs). EVs are classed by the amount of electricity that is used as their energy source.

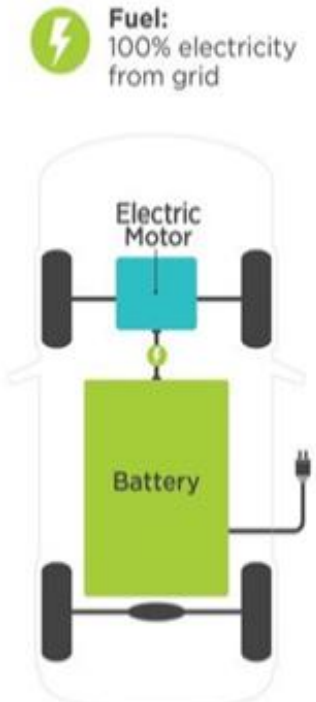
*Source: Electric Power Research Institute*




**HEV**
HYBRID ELECTRIC VEHICLE




**PHEV**
PLUG-IN HYBRID ELECTRIC VEHICLE




**BEV**
BATTERY ELECTRIC VEHICLE

# Advantages of BEVs

- Drive much better than ICE cars
  - Continuous torque for smooth ride
    - No gear shifting, no waiting for engine RPM to increase power
  - One pedal driving
  - Low center of gravity for handling
- No scheduled maintenance
  - No transmission, radiator, spark plugs, belts; 3 moving parts vice 143 for ICE
- Regenerative braking for increased range, minimal brake wear
- No gas stations
  - Overnight recharging at home, very occasional charging on the road
- No obnoxious adolescent noise
- No air pollution, no smell, no large volume of explosive liquid

# My EV Specs

- 2023 Nissan Ariya Premier
  - 87 kWh battery, 289 mile range, 0-60 in 7.2 sec, weight 4608#
  - 130 kW fast charge rate for 20-80% in 40 min.
  - ProPilot Assist for lane keeping and adaptive cruise
  - 8-year, 100K mile warranty on battery
  - $55K top of the line after CA incentive, with no federal incentive
- 2019 Chevrolet Bolt EV
  - 65 kWh battery, 259 mile range, 0-60 in 6.0 sec, weight 3589#
  - 50 kW fast charge rate for 100 miles in 30 min.
  - 8-year, 100K mile warranty on battery
  - $28K top of the line after federal, CA, PG&E incentives

# Bolt Storage

18 - 1ft x 1ft Crates in rear

# Car Makers BEV Commitment

- Chevrolet plans to stop all ICE cars and trucks by 2035
  - Equinox, Blazer, and Silverado in 2023, Buick and updated Bolt in 2024
  - 30 new global EVs by 2025
  - Blazer EV is Motor Trend's 2024 EV car of the year
- Ford will be all-electric in Europe by 2030, but will still make some ICE cars in US
  - E.g., Mustang, larger trucks
  - Cancelled Escape, Edge, and Transit ICE cars to make room for EVs
  - Taurus with solid-state sodium batteries announced
- Honda just announced 30 new BEVs by 2030 and to be all electric
  - Prologue and Acura with Chevrolet Ultium platform

# Currently Available BEVs

- GM: Bolt, Equinox, Blazer, Hummer, Lyriq, Silverado
- Tesla: S, E, 3, Y, Cybertruck
- Ford: Mustang, Lightning
- Nissan: Leaf, Ariya
- Kia: EV6, EV9, Niro
- Hyundai: Ioniq5, Ioniq6
- Lucid: Air
- BMW: i3, i4, i5, i7, iX
- Many others: Mercedes, Porsche, Volvo, Rivian, Fisker, Chinese, ….

# Arguments Against EVs

- 10:1 ratio of negative to positive YouTube articles
- Luddites and self-described experts invested in status quo
  - ICE component manufacturers (e.g., transmissions, engines)
  - Mechanics with life-long careers at stake
  - Petroleum manufacturers and dealers and their sponsored “experts”
- Curated perspectives, selecting and ignoring facts to prove a point

CarbonBrief.org Report: “Factcheck: 21 Misleading Myths about Electric Vehicle”, 10/24/23
YouTube Video: “Ex-TopGear Star Sets Electric Car “Experts” Straight. Shocking Truth About EVs
YouTube Video: “Are EVs Really better for the Climate” - Just Have a Think
YouTube Video: “Debunking the Myths about EVs” – Fully Charged Show

# Arguments Against EVs

- Pedestrian risk
- Fire safety
- Rare earths mining and depletion
- Automotive jobs (creative destruction)
- High cost
- High weight
- Range anxiety
- Inadequate charging stations, grid can’t cope
- Manufacturing and electricity generation pollution

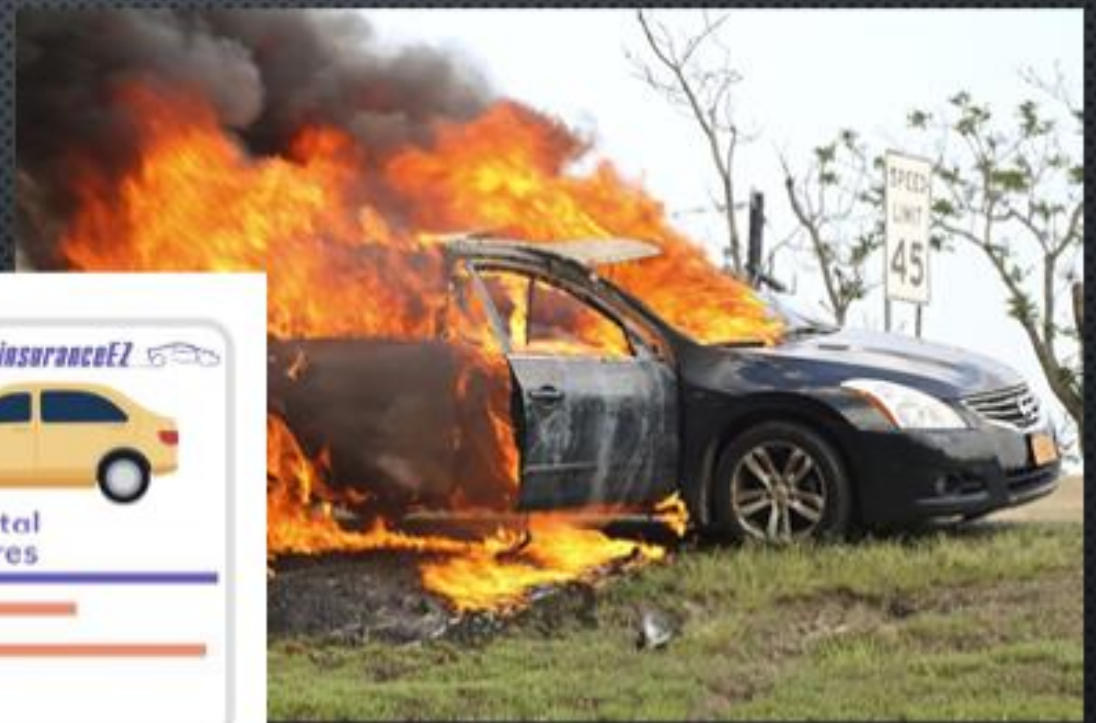
# Do BEVs catch fire more often than ICE?

- A recent study by US insurer AutoinsuranceEZ found that hybrid cars had the worst fire record, while EVs were the least likely type of car to catch fire
- Per 100,000 sales, hybrid cars had 3474.5 fires, ICE cars had 1,529.9 fires, and EVs had just 25.1 fires
- Initial GM Bolt fires were due to manufacturing defect, now cured
  - GM replaced all Bolt batteries with new battery with new warranty
- EV battery fires smolder and start slow, ICE fires are often explosive
  - EV fires are harder to extinguish, training required

**Your risk of a fire is far greater in a gas powered car.**

**Electric: 25/100,000**

**Gas: 1500/100,000**



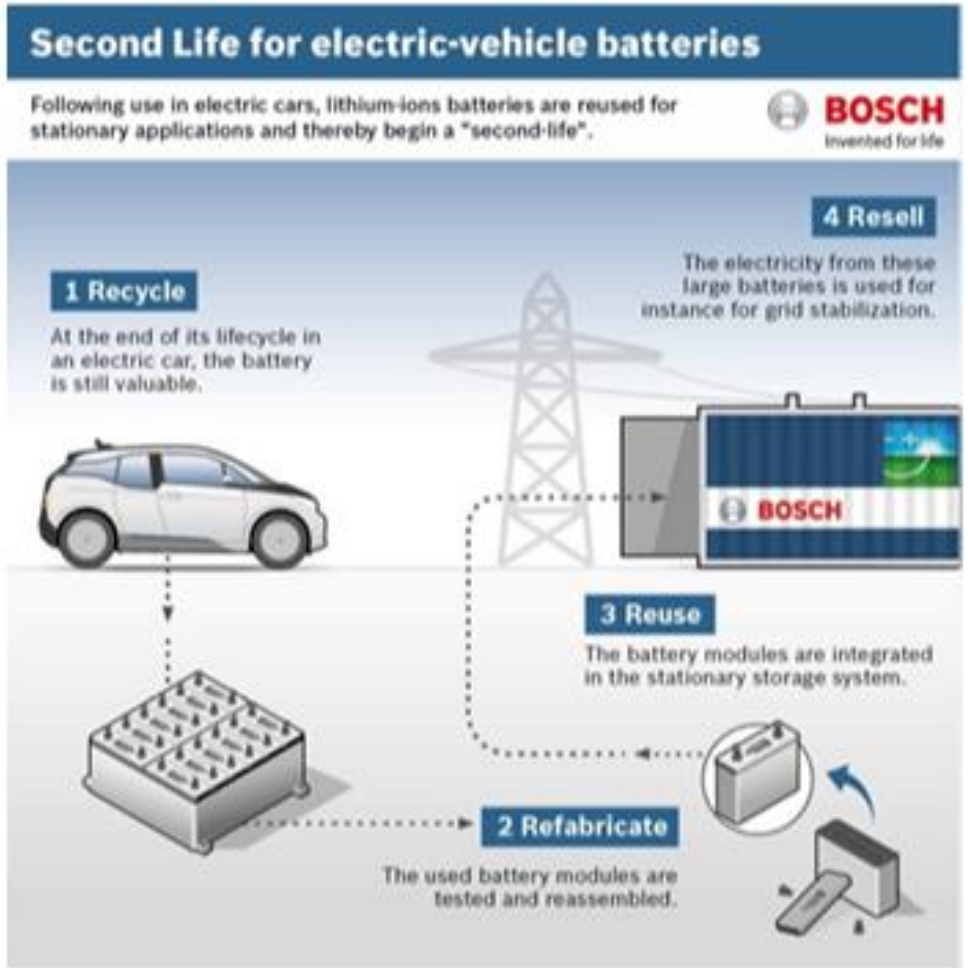

## CAR FIRES BY VEHICLE TYPE


| Rank and Fuel Type | Fires (per 100k Sales) | Total Fires |
|---|---|---|
| 1 Hybrid | 3,474.5 | 16,051 |
| 2 Gas | 1,529.9 | 199,533 |
| 3 Electric | 25.1 | 52 |

# Impact of Rare Earth and Lithium Mining

- 90% of minerals in EV batteries can be recycled
  - Also, batteries can be re-purposed at end of life (70%)
  - None of the gasoline burned in ICE cars can be recycled
- Use of cobalt in batteries has been slashed and is fully reusable
  - Cobalt is also used to remove sulphur from oil
  - Cobalt is a by-product of other mining – forecasted cobalt surplus
  - Has nothing to do with child labor in Africa
  - LiPo batteries have no cobalt
- Ample supplies of Lithium in US to support EVs
  - Lithium can be extracted from existing geothermal wells without mining
  - Direct lithium extraction from brine without evaporation ponds is coming
  - Alternative batteries coming based on sodium

# 90 to 95% of the minerals in EV batteries can be recycled at the end of their life





**VW opened what it calls a pilot battery-recycling plant in Salzgitter, Germany, earlier this year, and hopes to open similar plants around the world. The plant can recover up to 95% of raw materials from a battery pack for potential reuse, including lithium, nickel, cobalt, and manganese, in a closed loop.**

# Jobs After Replacement of ICE Industries

Californians spend about $60 billion on gasoline each year; most of which goes to out-of-state or out-of-country companies.

**By transitioning to more electric vehicles powered by clean energy, consumers save money and spend those savings in the economy, multiplying the benefit economy-wide to provide a significant boost to service industry spending.**

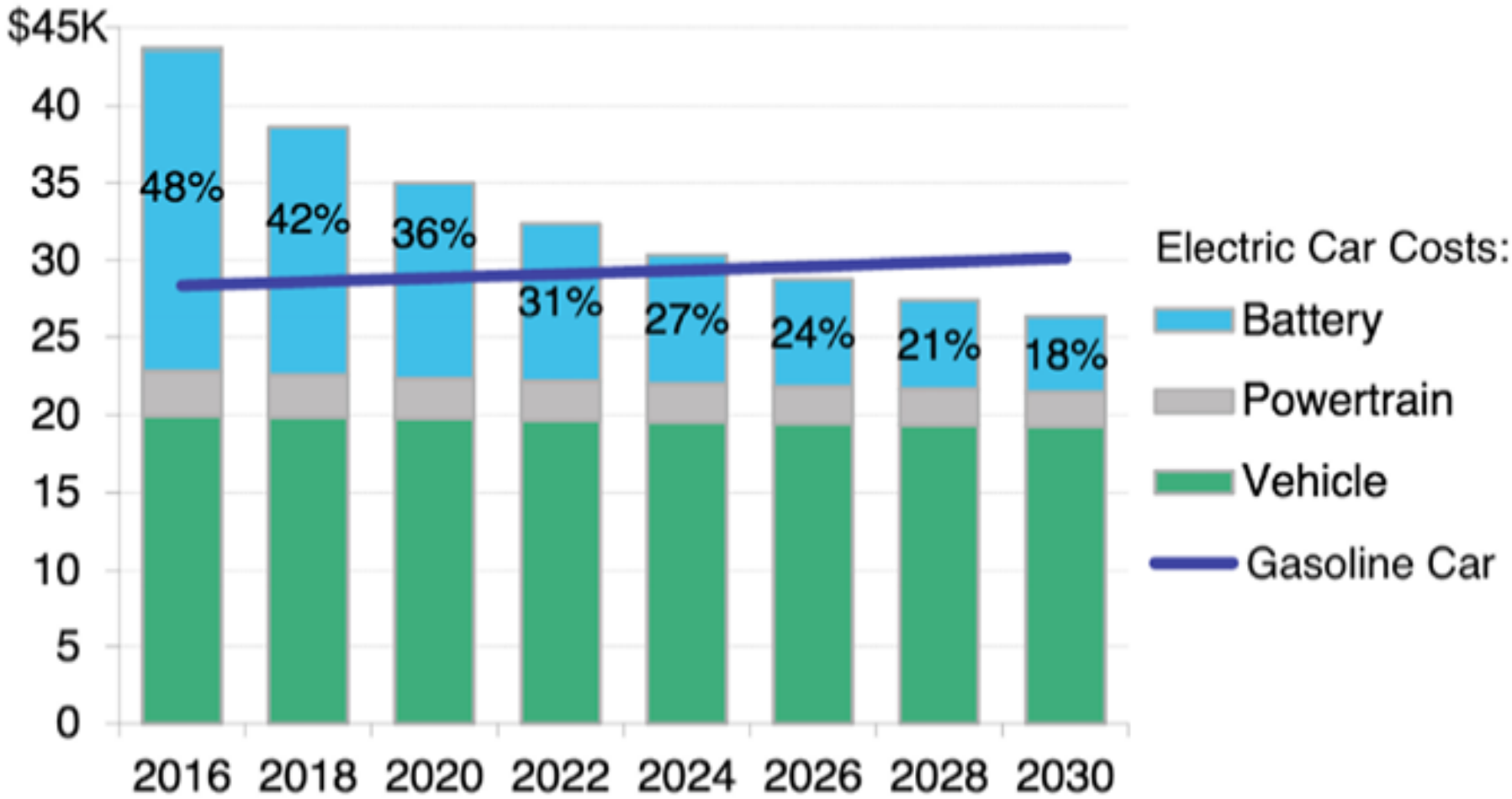
A new study finds electric vehicle adoption could create more than half a million jobs and over $300 billion in new real income by 2030 here in our state!

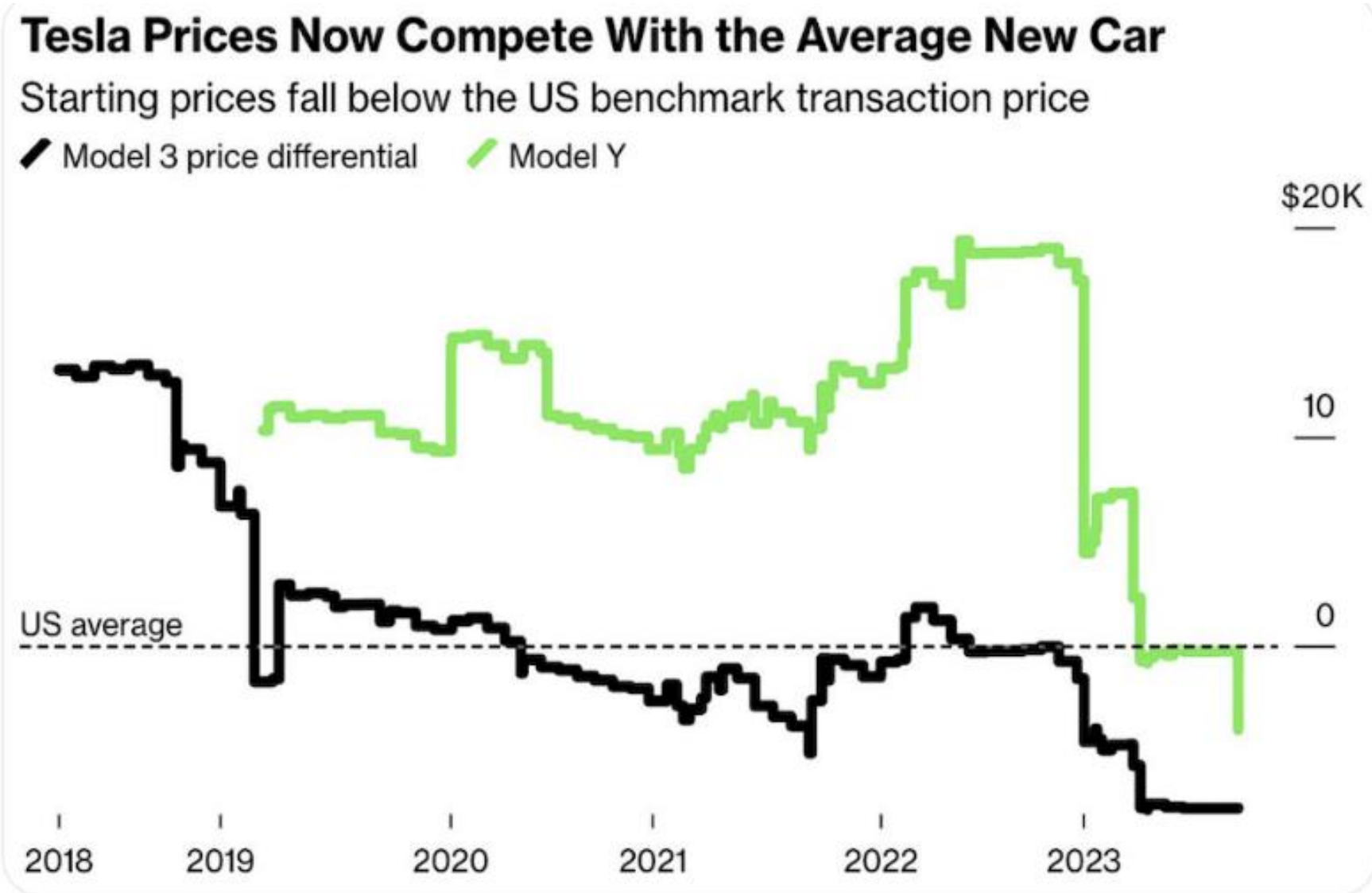
# EV Cost

- Early models were aimed at luxury buyers until economies of scale
- Battery costs are rapidly dropping, now below $100/kWh
- Operating cost of EV is substantially less than ICE
  - No scheduled maintenance
  - Fewer parts to fail, brakes last longer
  - No consumables other than electricity
  - 80% of current EVs charge at home, often via solar panels

# Electric Cars Will Win on Price

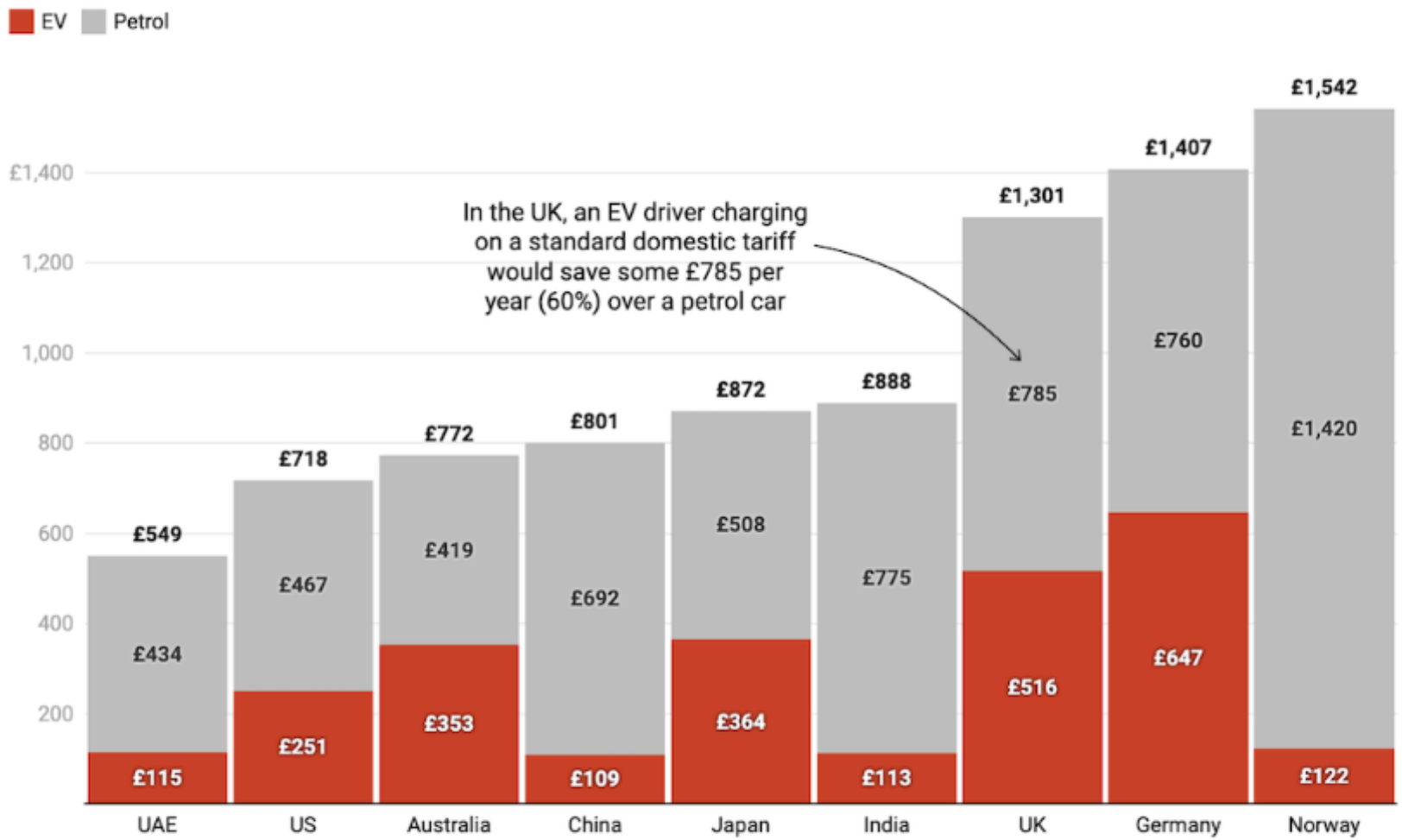
Falling battery prices undercut gasoline cars by mid-2020s




Tesla Prices Now Compete With the Average New Car
Starting prices fall below the US benchmark transaction price
Model 3 price differential
Model Y
$20K
10
0
US average
2018
2019
2020
2021
2022
2023

# EVs are significantly cheaper to drive than petrol cars

Running costs, £ per year




Carbon Brief analysis

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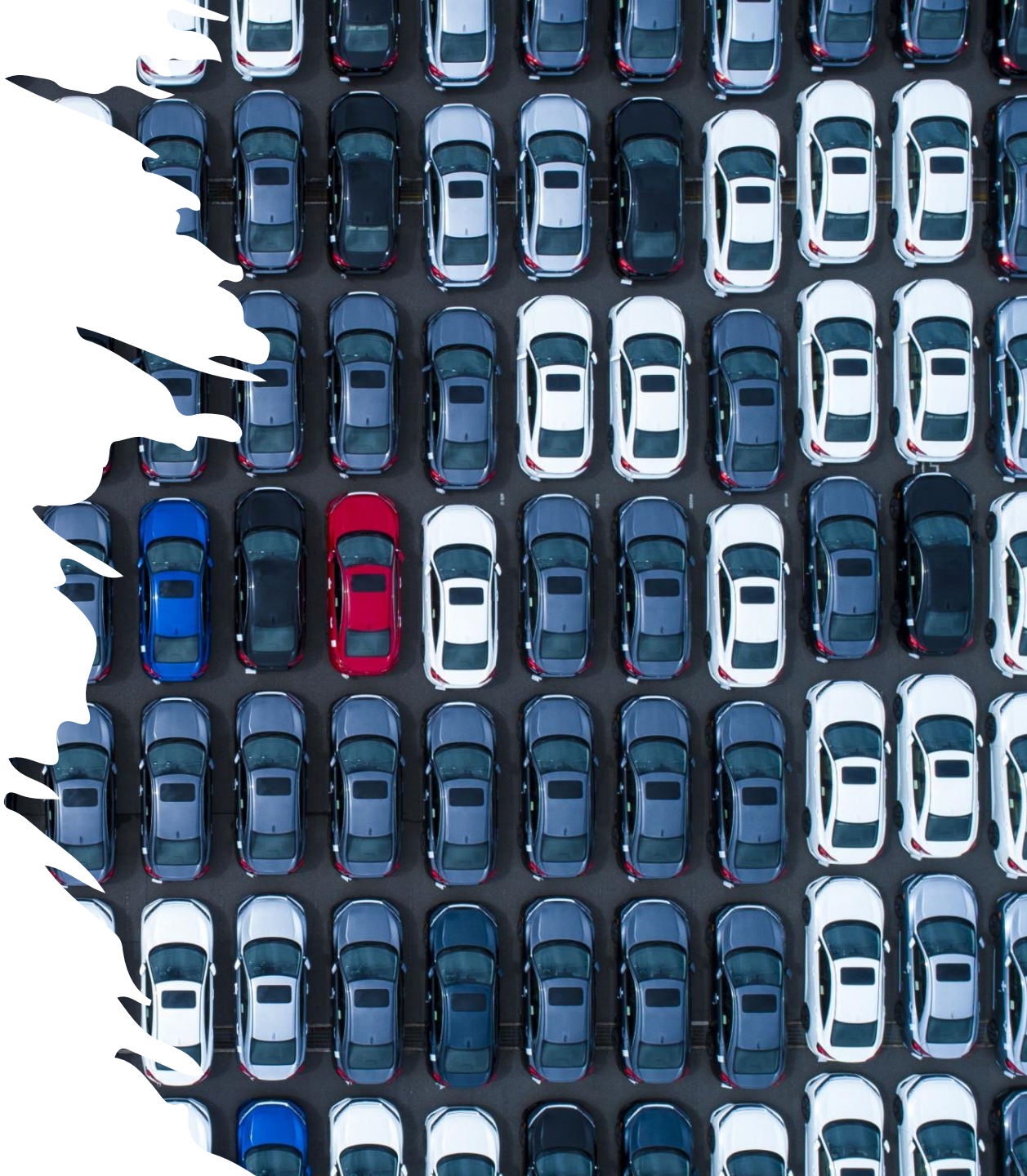
# EV Sales Last Quarter

- USA: 10% of new cars
- CA: 25% of new cars
- China: 40% of new cars
- Europe: 30% of new cars
- Norway: 90% of new cars
- Globally: 18% of new cars

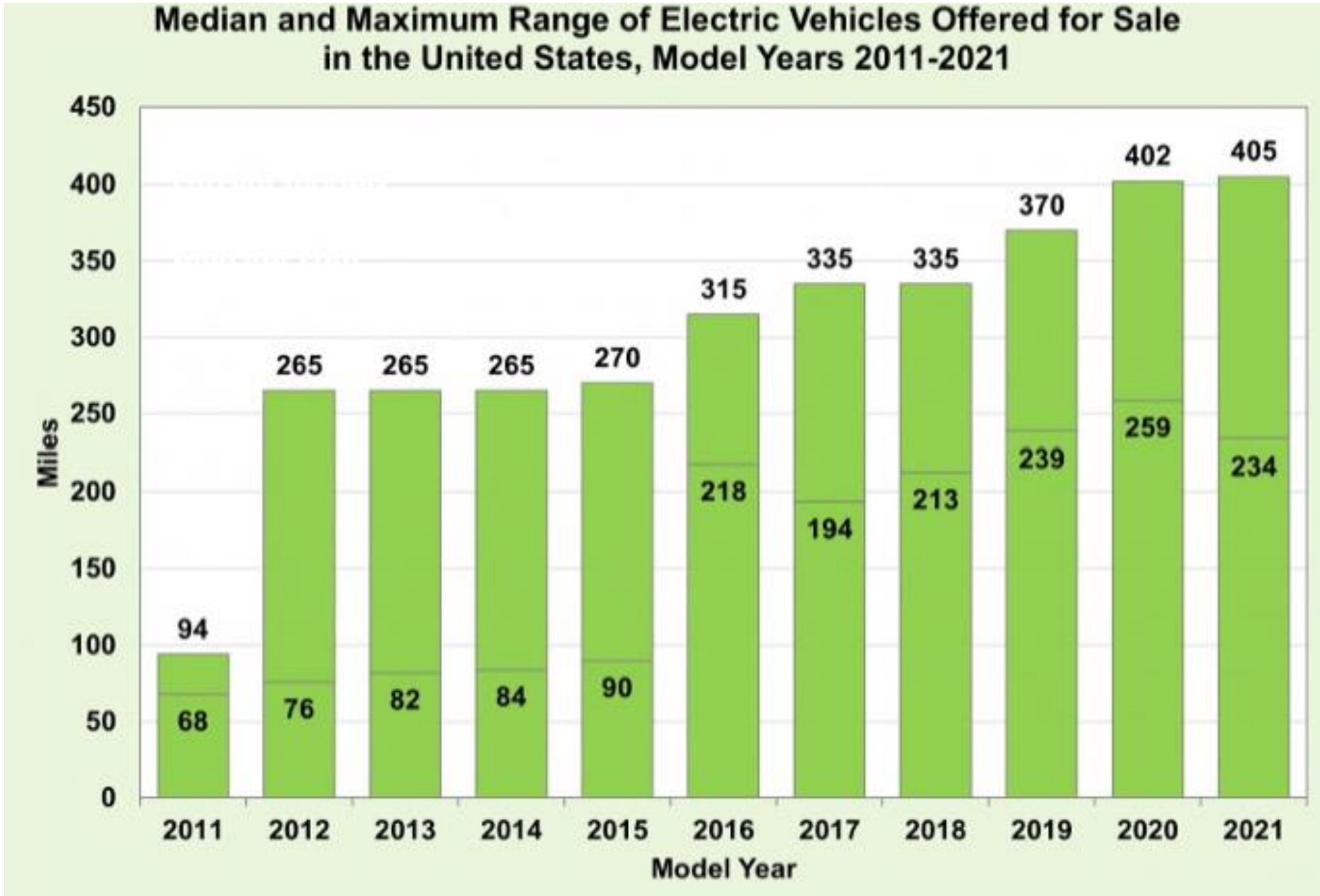


# EV Weight

- Bolt EV with 65 kWh battery 3600#
- Ariya EV with 87 kWh 4600#
- Jeep Grand Cherokee 5000# plus 135# fuel
- Top 10 heaviest vehicles in UK are ICE, 11$^{th}$ is Tesla

# Range Anxiety

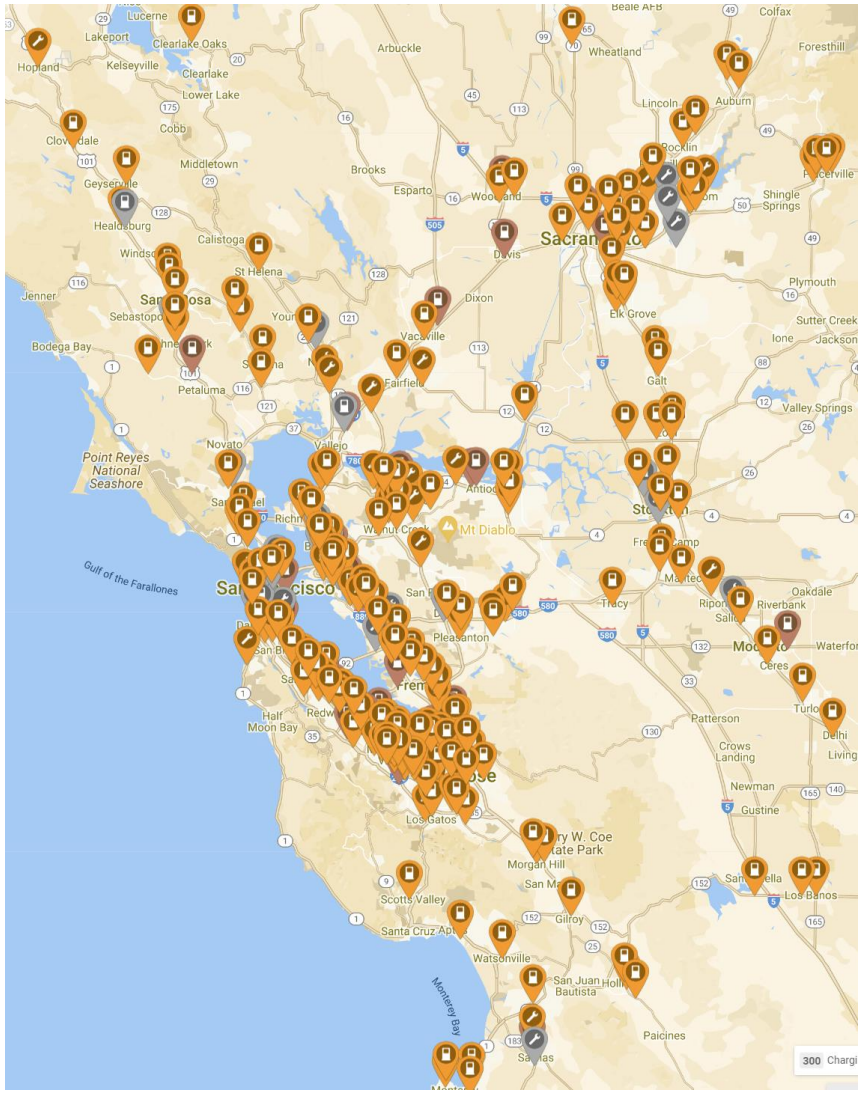
- “I won’t consider an EV until their range is at least ~~300~~ ~~400~~ 500 miles”
- Practical range is greater than daily peak not counting rare trips
  - If you drive more than 200 miles daily, you have my sympathy
- I take my Ariya or Bolt to Sparks regularly – 230 miles
  - Single charge at home, return home with 50-60 miles range left
  - Could charge in Sparks if needed
- On long trips (*e.g*, LA), I stop every 150-180 miles for 30-45 min
  - Lunch, potty stop, nap
  - I might make two trips/year requiring charging away from home

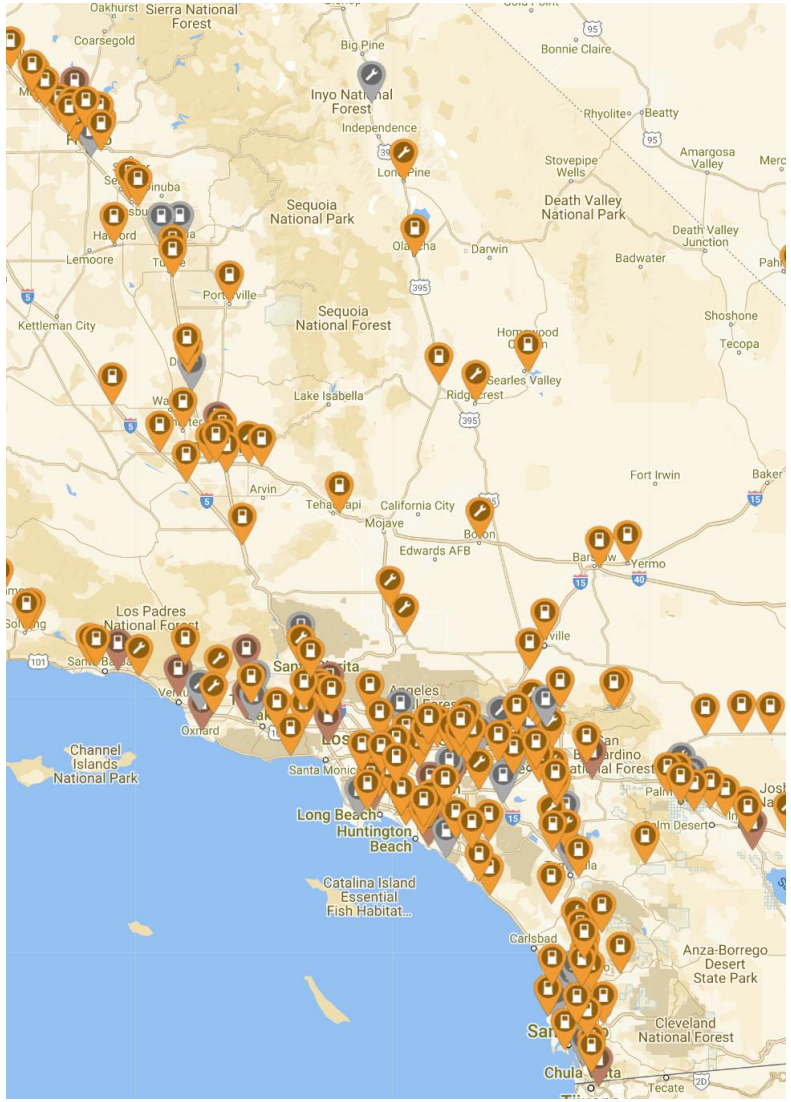

Median and Maximum Range of Electric Vehicles Offered for Sale in the United States, Model Years 2011-2021
Miles
450
400
350
300
250
200
150
100
50
0
94
68
265
76
265
82
265
84
270
90
315
218
335
194
335
213
370
239
402
259
405
234
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Model Year

# Current Charging Station Availability

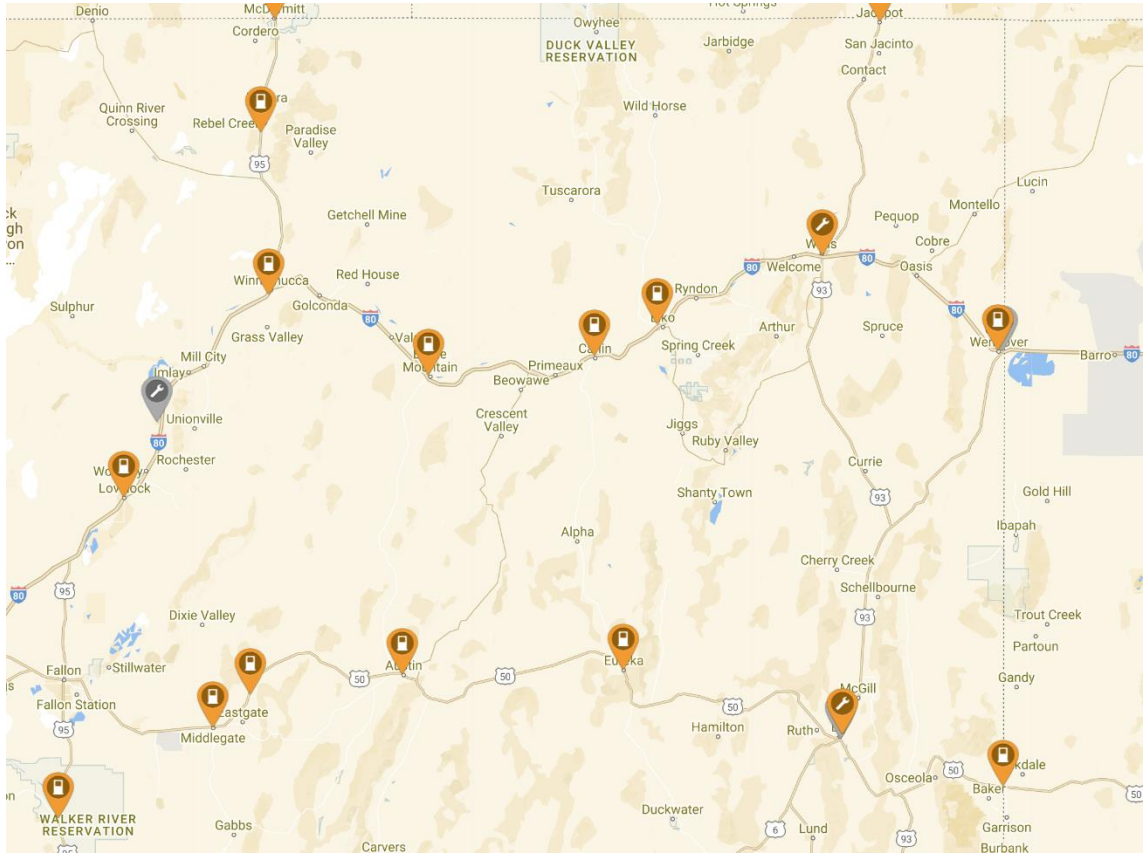
- Tesla Superchargers
  - Most reliable network, high speed, available, dedicated to Teslas (currently)
- Electrify America
  - High speed (150-350 kW), funded by VW, stations spaced along major highways
  - Chargers frequently out of service, derated, or occupied
  - Apps are often flaky
- EVgo, ChargePoint
  - Scattered seemingly randomly, but near malls, restaurants
  - Mostly lower speed (50 kW) but higher speed (350 kW) coming
  - Stations frequently out of service, derated, or occupied
- Several excellent trip planning tools showing station availability
  - Required for long distance trips

# High Speed Charging Stations (non-Tesla)

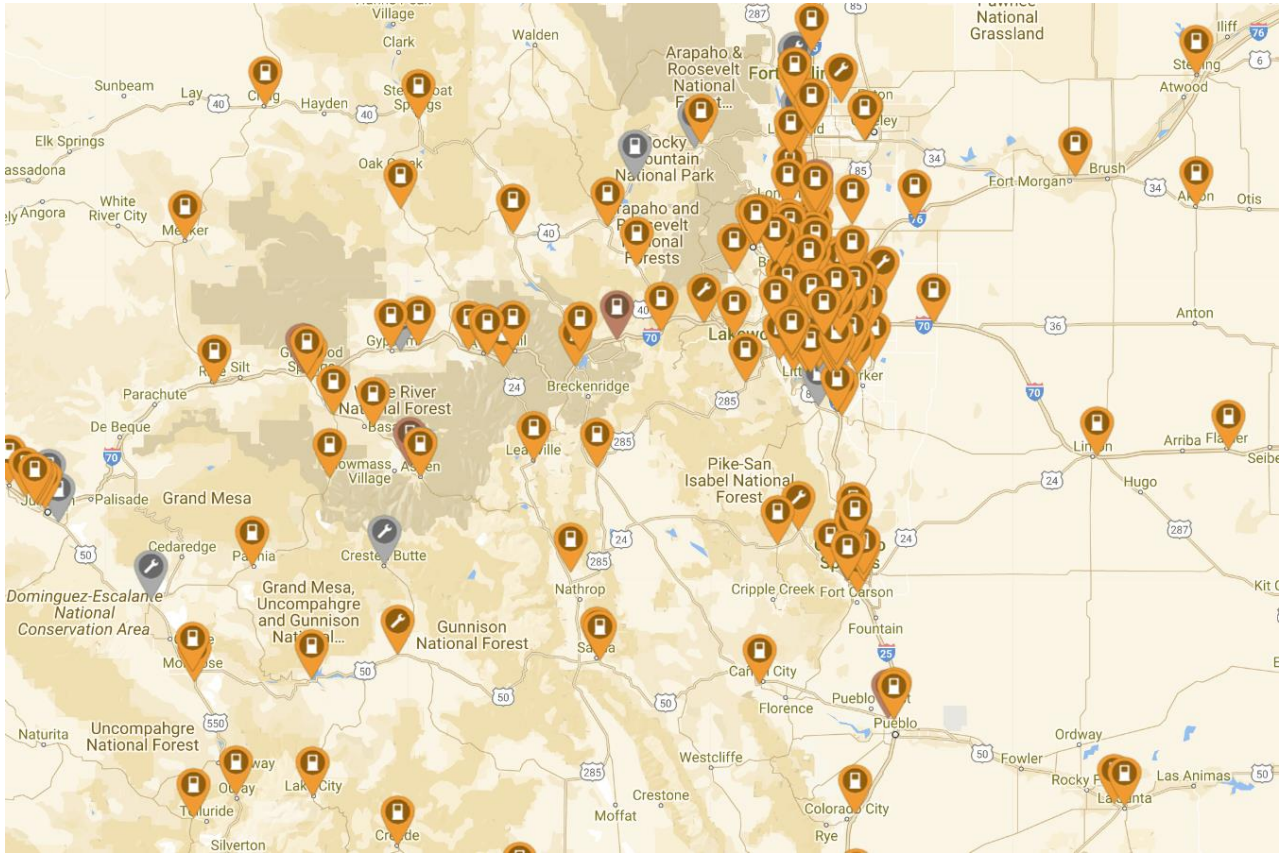


# More High Speed Charging Stations




Nevada




Colorado

# Charging Rates

- Bolt
  - Level 2 (garage) 7kW = 28 mph
  - DC Fast charge 45kW = 180 mph
  - 20-80% on fast charge = 52 min.
- Ariya
  - Level 2 (garage) 7 kW = 25 mph
  - DC Fast charge 120 kW = 400 mph
  - 20-80% on fast charge = 25 min.
- 350 kW charging, 100kWh battery
  - DC Fast charge 350 kW = 1100 mph
  - 20-80% on fast charge = 11 min.

# Trip in Ariya to Laguna Woods

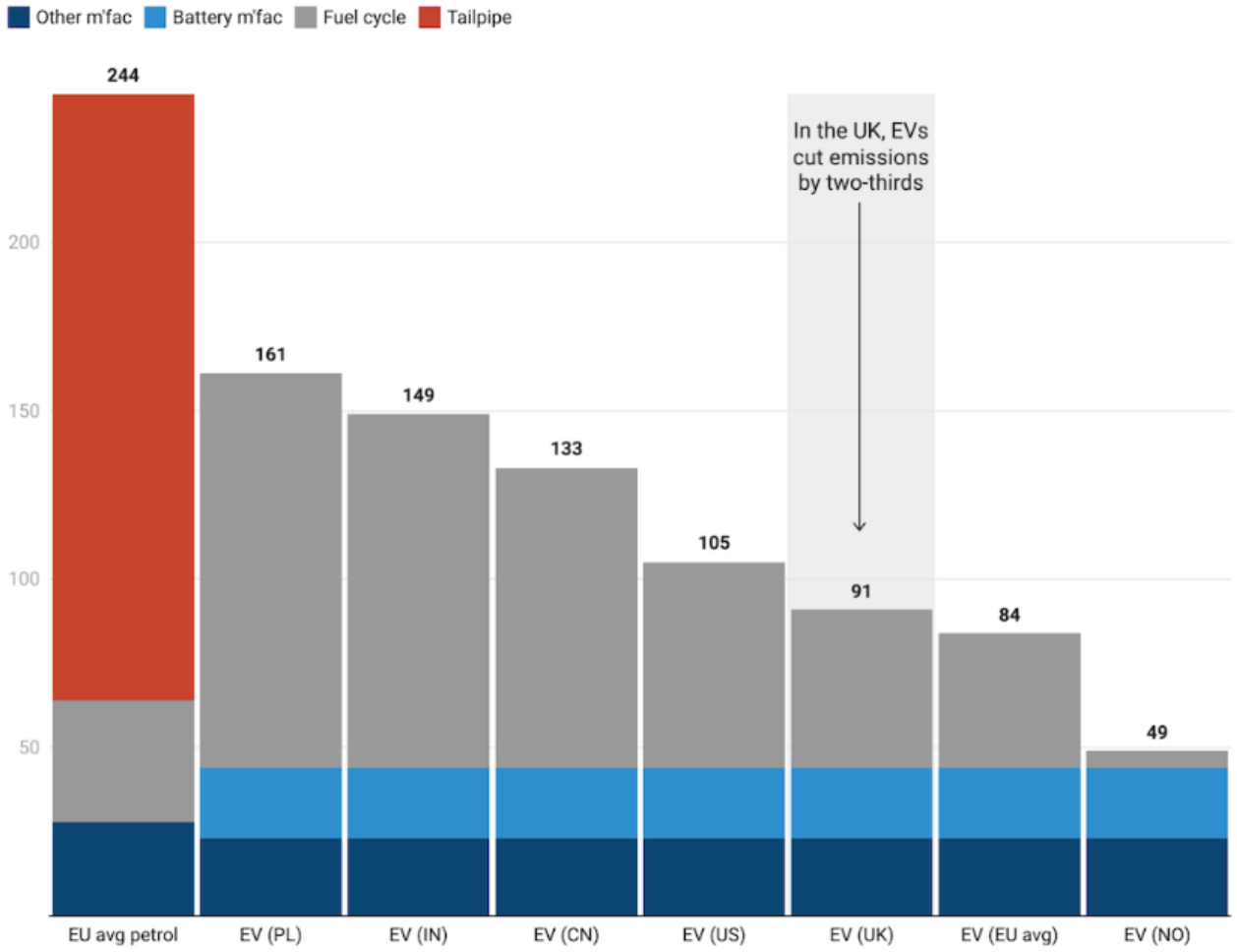
| Actual | Elevation | Distance | Efficiency | SOC Arrive | SOC Depart | | Charge time | Speed | Travel TIme | |
|---|---|---|---|---|---|---|---|---|---|---|
| Home | 1500 | 0 | | | 100.00% | | | | | |
| Madera EA | 500 | 185 | 3.7 | 44.00% | 95.00% | 0 | 40.50 | 65.00 | 2.85 | |
| Bakersfield EA | 500 | 135 | 3.4 | 49.00% | 85.00% | 0 | 43.50 | 65.00 | 2.08 | |
| Laguna Woods | 300 | 180 | 3.4 | 21.00% | 95.00% | | | 65.00 | 2.77 | |
| | | | | | | | 84.00 | | 7.69 | |
| | | Total Dist 500 | | | | total time to Laguna | | | 9.09 | |

# EV *vs* ICE Pollution

- Manufacturing Lithium batteries and electricity generation cause CO2
  - Not incurred in ICE vehicles
- CO2 from manufacturing in EVs is exceeded quickly by petrol in ICE
  - EV production not counting batteries generates slightly less CO2 than ICE production
  - Petrol burning CO2 not incurred in EVs
- CO2 from electricity generation depends on power source
  - Large use of coal in Virginia means EVs take over 9 years to get ahead
  - In CA, renewables mean EVs are better than ICE after 1-2 years
  - Increasing use of solar and wind accelerates the EV advantage
  - The grid is getting cleaner, burning petrol is not
- Refining petroleum is a major source of hazardous air pollutants
  - Second highest ranked sector for emissions, behind only power plants
  - Usually not considered in comparing EV to ICE pollution

# EVs cut carbon significantly, even when they mainly run on coal power

Lifecycle emissions, grammes of CO2 per kilometre




Source: Carbon Brief analysis

CarbonBrief
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# EV Conversions

- An industry is developing that does conversion of ICE cars to EVs
  - Legacy cars and current cars
- Recent SEMA convention in LA had large area devoted to conversions
  - YouTube “Out of Spec Reviews”, 11/3/23
- YouTube channel by Bill Carlson – Project Lightning
  - Replaced 1981 DeLorean drive train with Bolt battery, motor, steering, brakes
  - Result has 260 mile range, 0-60 in 5 sec (stock was 9 sec)
  - 150 pounds lighter than stock Delorean with full Bolt 65 kWh battery
  - Stock DeLorean has 36% weight in front, conversion has close to 50:50

# Recommended Videos on YouTube

- https://www.youtube.com/watch?v=LeHakmL6eEc
  - Ex-Top Gear Star Sets Electric Car”Experts” Straight
  - (Stop Burning Stuff) - Fully Charged Show
- https://www.youtube.com/watch?v=Vi7U6Cj_2aI
  - Are EVs Really Better for the Climate?
  - (Just Have a Think) – David Borlace
- https://www.youtube.com/watch?v=6RhtiPefVzM
  - EVs worse for environment? Myth busted
- https://www.youtube.com/watch?v=gXdLA63zZFE
  - Debunking the myths about Evs
- https://www.carbonbrief.org/factcheck-21-misleading-myths-about-electric-vehicles/
- https://www.youtube.com/watch?v=oXr3UgM9SVU
  - Direct Lithium Extraction approaches

# Net Energy Monitoring (NEM)

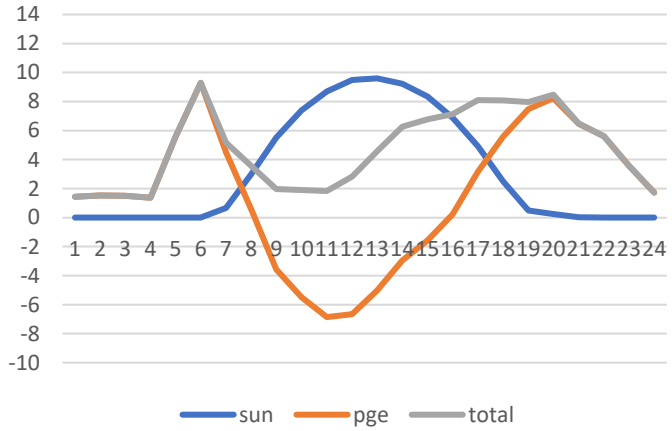
- Grandfathered system NEM2.0 for 20 years
  - Power fed to grid offsets power taken from grid on daily basis during year
  - Excess power generated by end of year is paid back at wholesale rate ($0.07)
- New NEM3.0
  - Net power fed to grid on daily basis is credited at wholesale rate (25%)
  - Encourages addition of batteries to send power to grid only at 5 to 7 PM
- NEM2.0 had payback period of 5-6 years, NEM3.0 is 10 years
  - Disincentivizing new solar installations, customers lose 60% of savings
  - Time of Use plans motivated sending power to grid during peak demand
- AB205 provision for fixed fee on power bill plus lower usage-based fee
  - Further disincentivizing of new solar installations
  - Fee tied to customer income??

# Tesla PowerWall 2.0

- Specs
  - 13.5 kWh usable
  - 5 kW continuous power, 7 kW peak 10 sec
  - 24 amp continuous current
  - Round trip efficiency 90%
  - Warranty 10 years

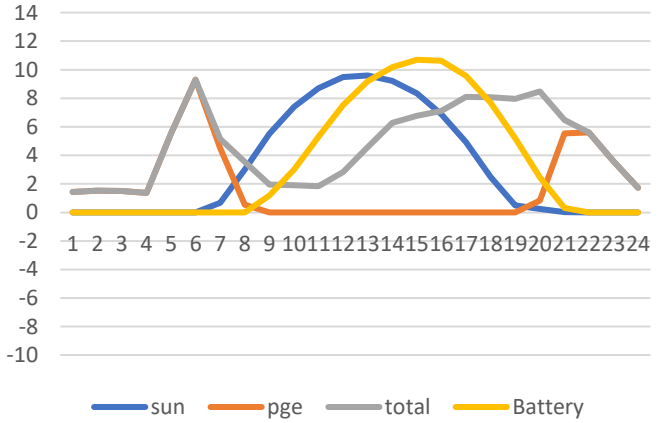
# Battery Impact on NEM Solar

6/17/21
102 deg




6/17/21
102 deg

3 batteries

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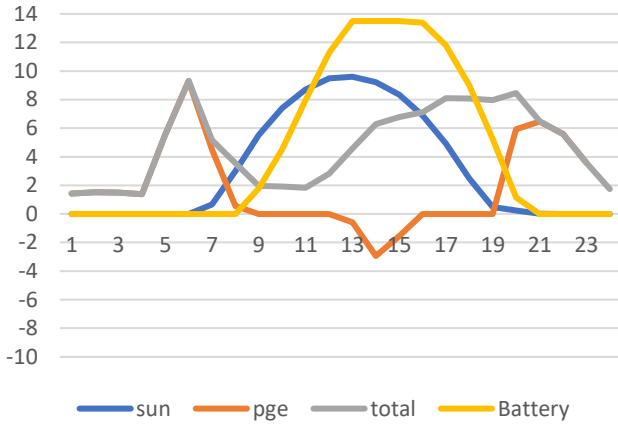
102 deg

2 batteries

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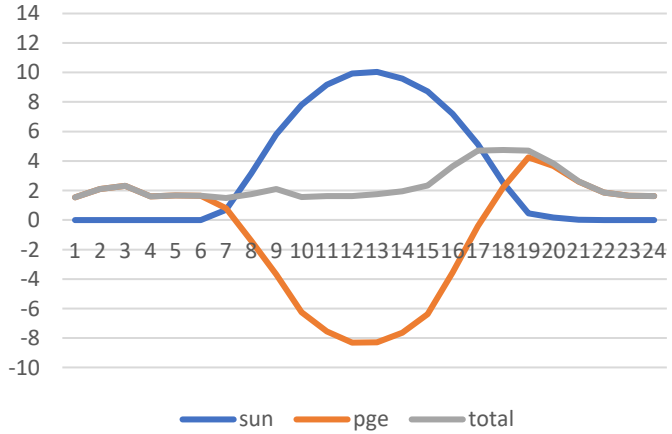
84 deg

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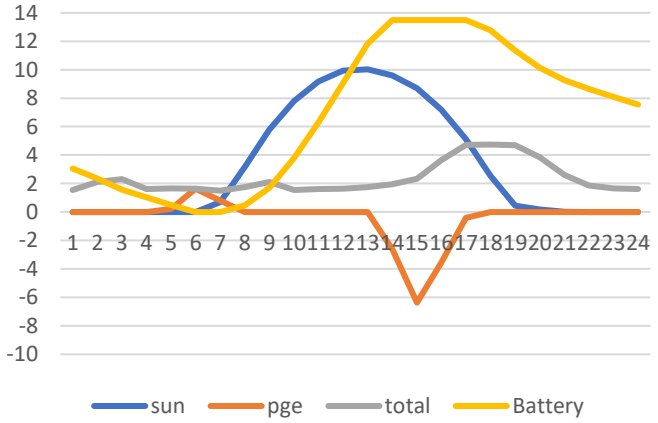
3 batteries




6/15/21
84 deg

2 batteries