

Looking Into Electric Cars

Session 4 : Batteries

Baby Blues By Rick Kirkman and Jerry Scott



Looking Into Electric Cars

Session 4 : Batteries

Breaking news

In 2013, the average price of a lithium-ion battery was \$780 per kilowatt-hour, according to the Bloomberg New Energy Foundation (BNEF). Fast forward by a decade, and the average battery cost is \$139/kWh, which **BNEF** says is a record low—12 percent lower than prices in 2022. This decline can be attributed partly to the expanded production capacity and the decreasing costs of raw materials and components.

Inside EVs Nov 2023

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Since someone asked about my battery usage. I hope this is the correct question.

I have Driven 14,640 miles in the last 12 months.

In that 12 months:

Used 4472 kWhs

With my current incentives I paid

\$ 170

Without those incentives

\$1017

(estimating with market cost at that time.)

(That would have been less since I might have gone elsewhere for less expensive charging. But it was the most convenient at the time.)

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Session 4 : Batteries



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Recap - with just the frame batteries, motor and wheels : all EVs look pretty much the same.

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The heart of an EV is the battery

But what battery ?

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How a sand battery could transform clean energy



The definition
of a battery
has changed.

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How Hundreds of 24-Ton Bricks Could Fix a Huge Renewable Energy Problem

Startup Energy Vault is building two massive gravity battery systems that could solve a massive issue with renewable energy.

April 23, 2023 3:49 p.m. PT



There are lots
of good
functional
batteries out
there.

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Is a Dam in Rural Portugal a Key to Our Alternative Energy Future?

When the Portuguese electric power grid needs more electricity, a large multinational power company releases millions of gallons of water from a dammed reservoir.

Jan. 3, 2023



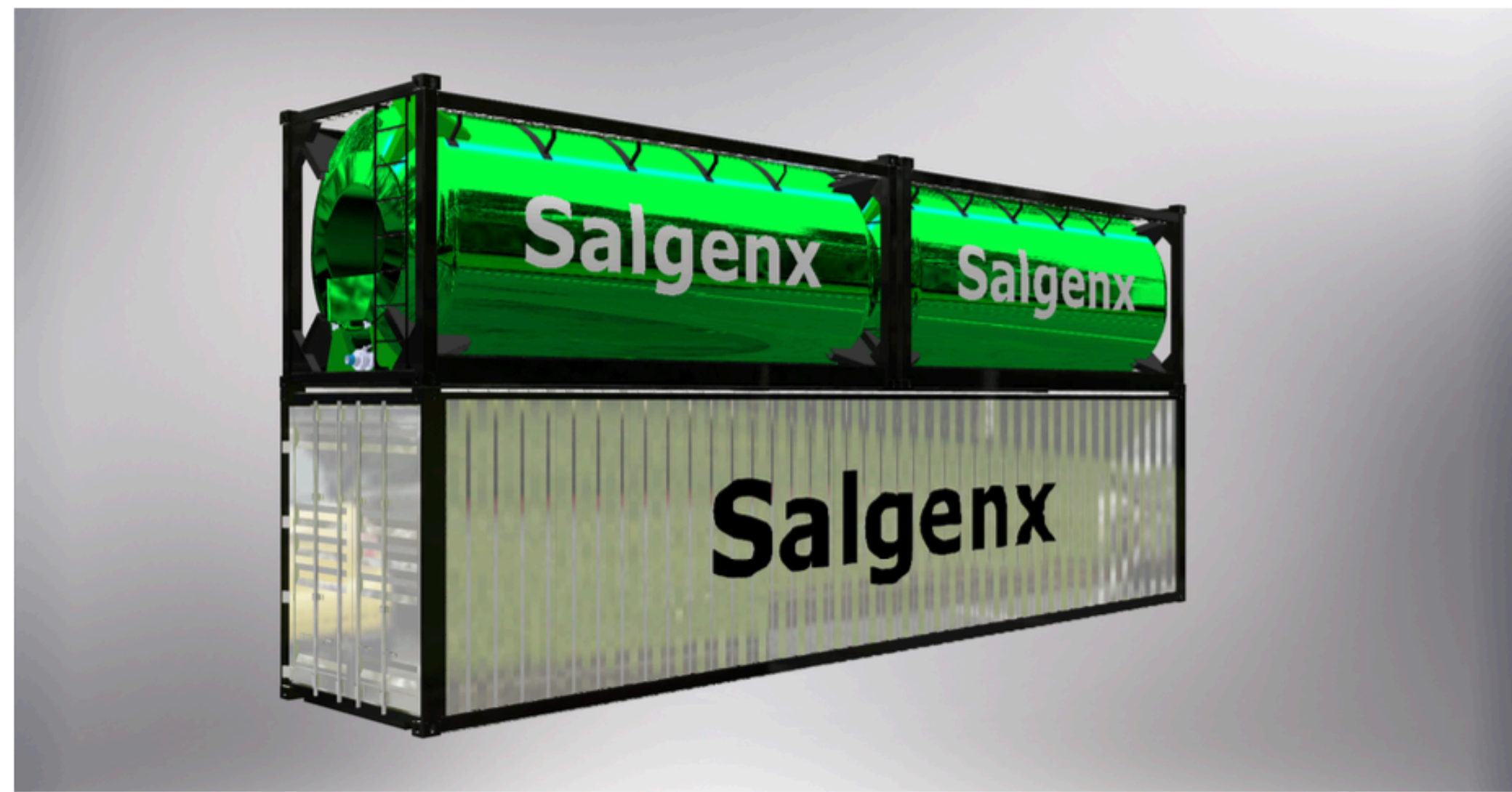
The one I lost : Empty electric trucks with empty batteries load up with water and coast downhill regenerative braking. They drive back up hill, V2G the batteries empty and do it again.

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US startup unveils saltwater flow battery for large-scale storage

US-based Salgenx has developed a scalable redox flow battery with two separate tanks of electrolytes, one of which is saltwater. Unlike other flow batteries, the new device is membrane-free, promising big gains at the levelized cost of storage level.



But what makes a good battery for an EV ?

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What makes a good
battery ?

It comes down to
two things

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What makes a good
battery ?

Lots of Kilowatt
hours

It comes down to
two things

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What makes a good
battery ?

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It comes down to
two things

Lightweight and
small

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What makes a good
battery ?

Lots of Kilowatt
hours

BIG

It comes down to
two things

Lightweight and
small

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What makes a good
battery ?

Lots of Kilowatt
hours

BIG

It comes down to
two things

Lightweight and
small

SMALL

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Size and weight are the big
thing

But needs to be the small
thing

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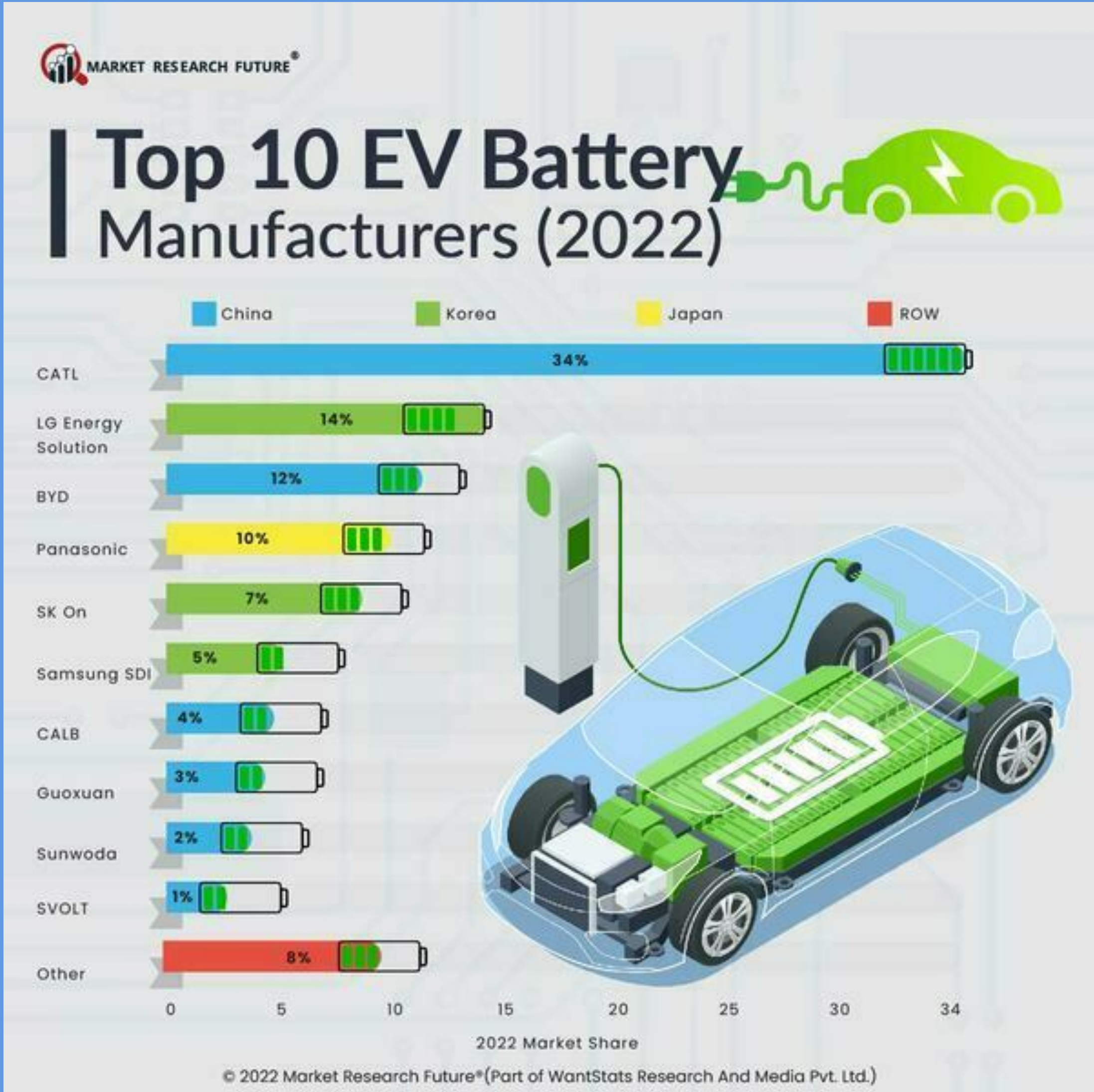
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Those two things make those
batteries are expensive.

But the price is going down.

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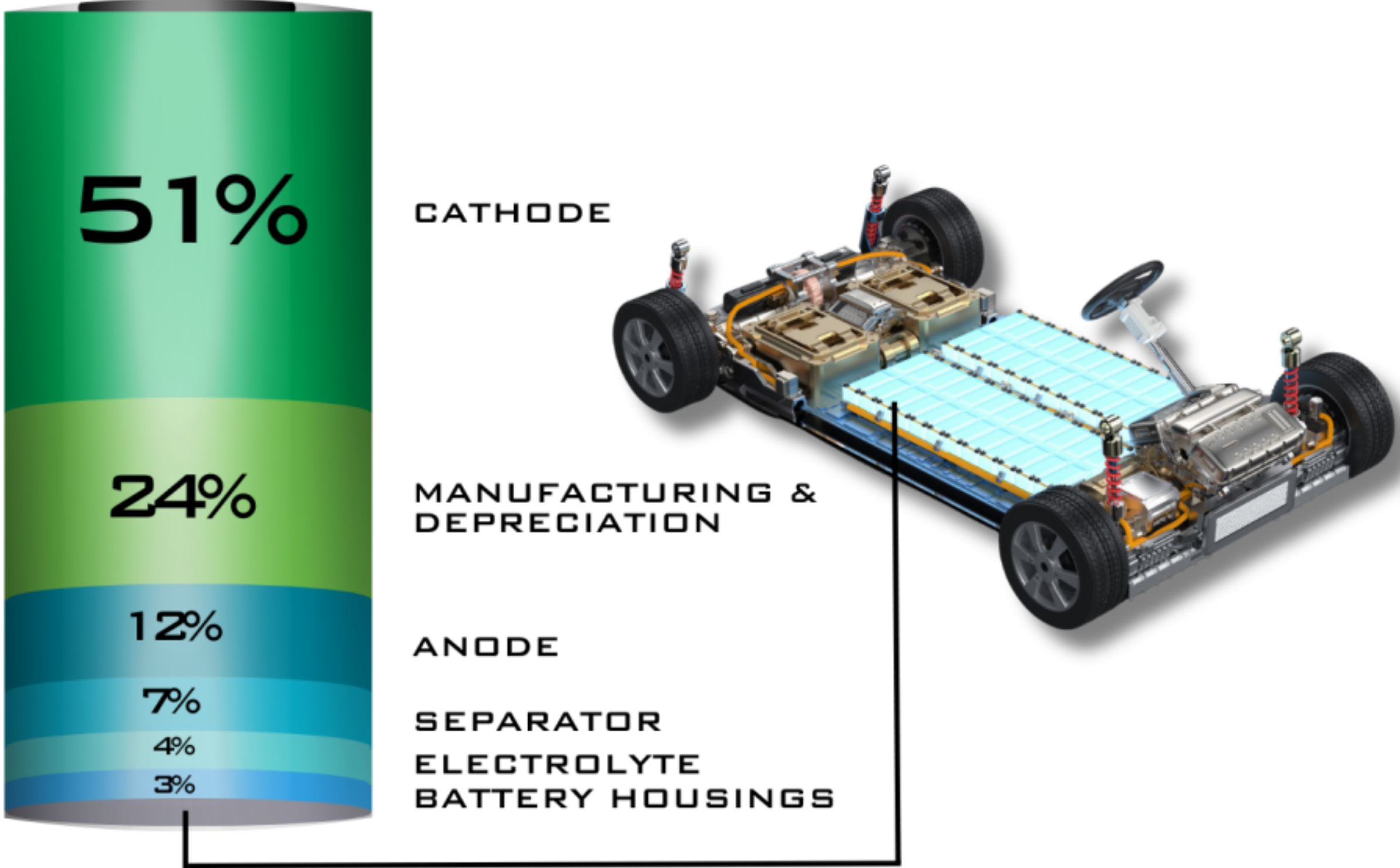


Market research future

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THE COST OF AN EV BATTERY CELL



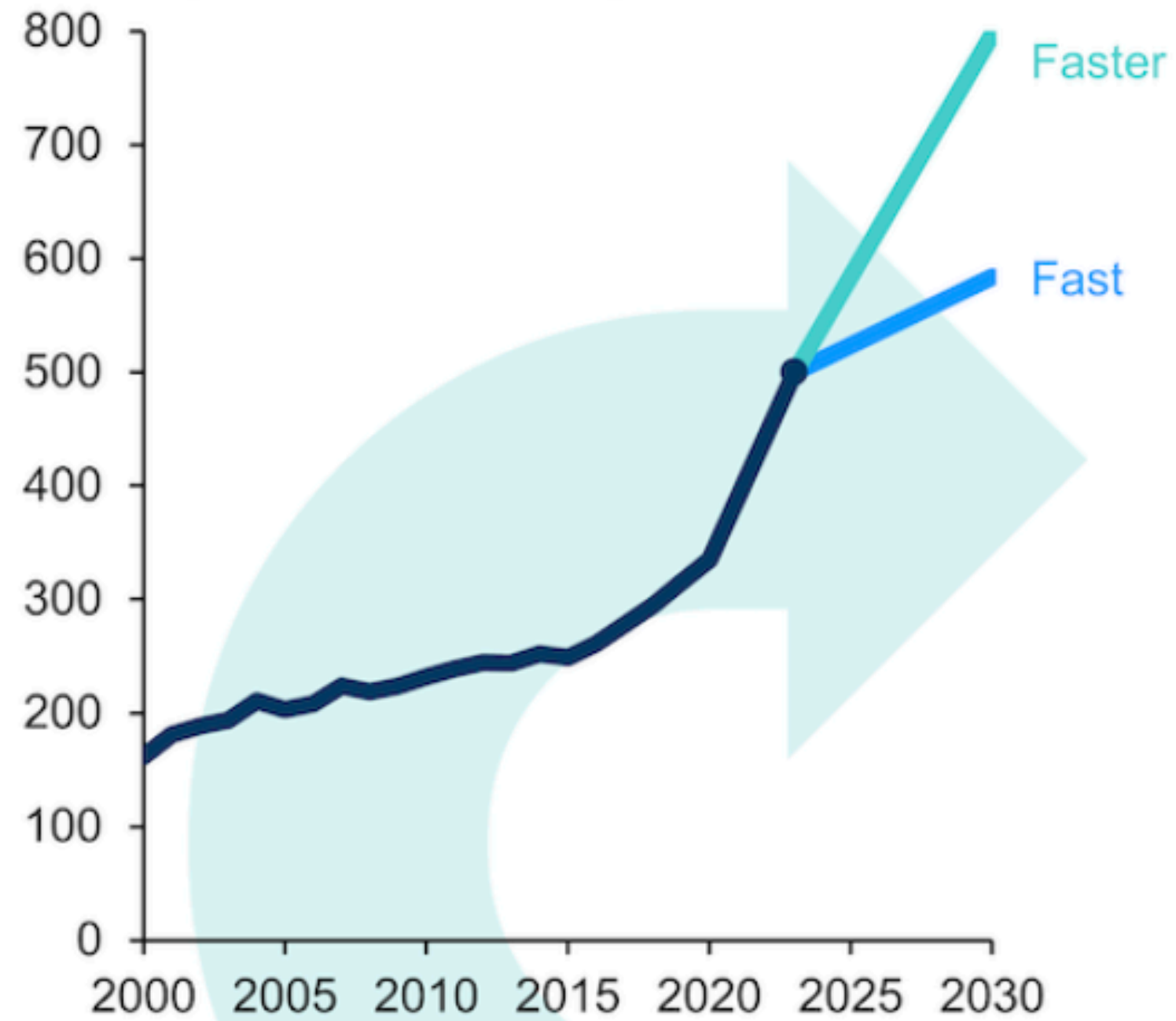
Leith Cars

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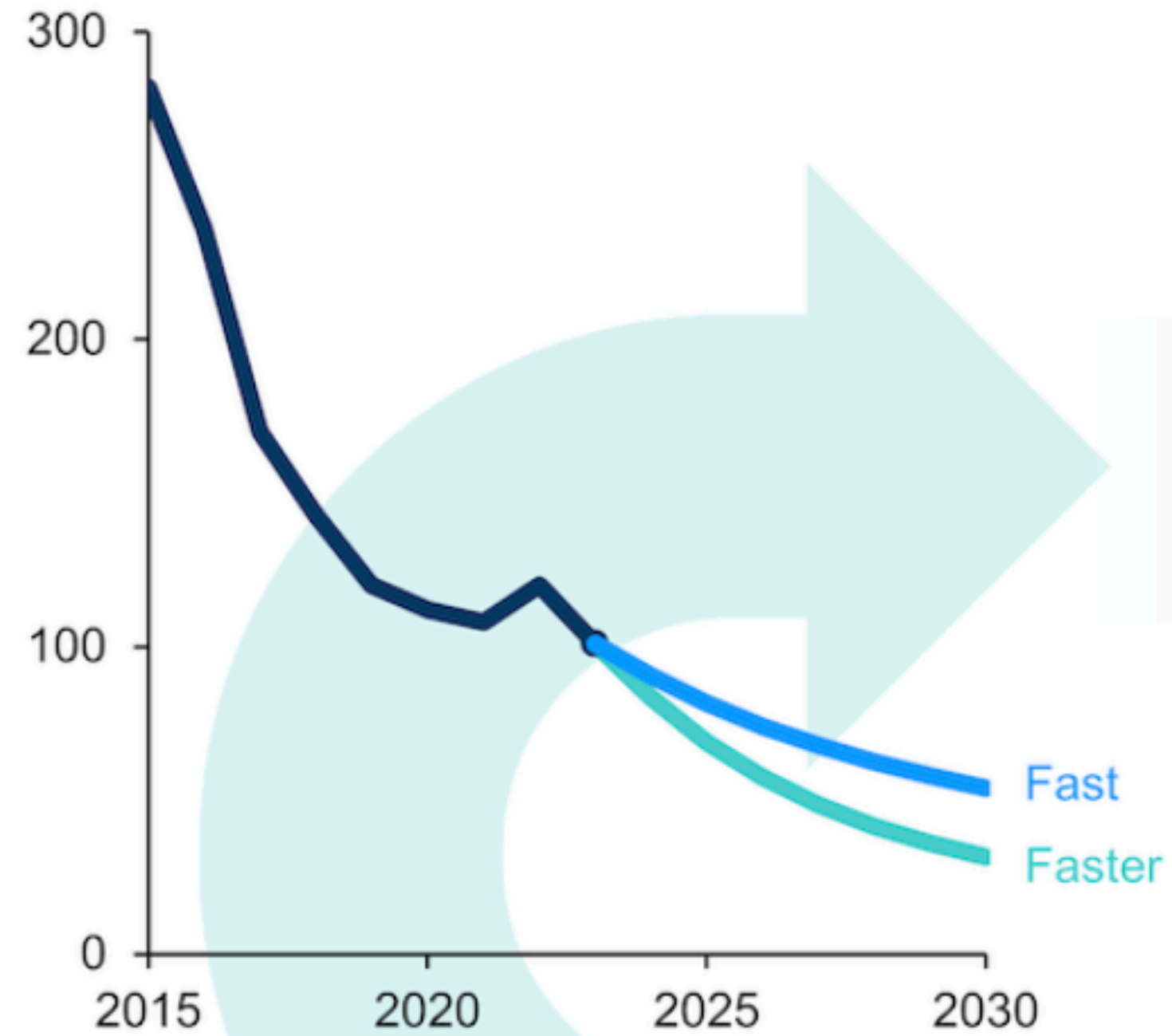
Battery energy density keeps rising...

Top-tier battery cell energy density outlook, Wh/kg



...while battery cost keeps falling...

Battery cell cost outlook, \$/kWh



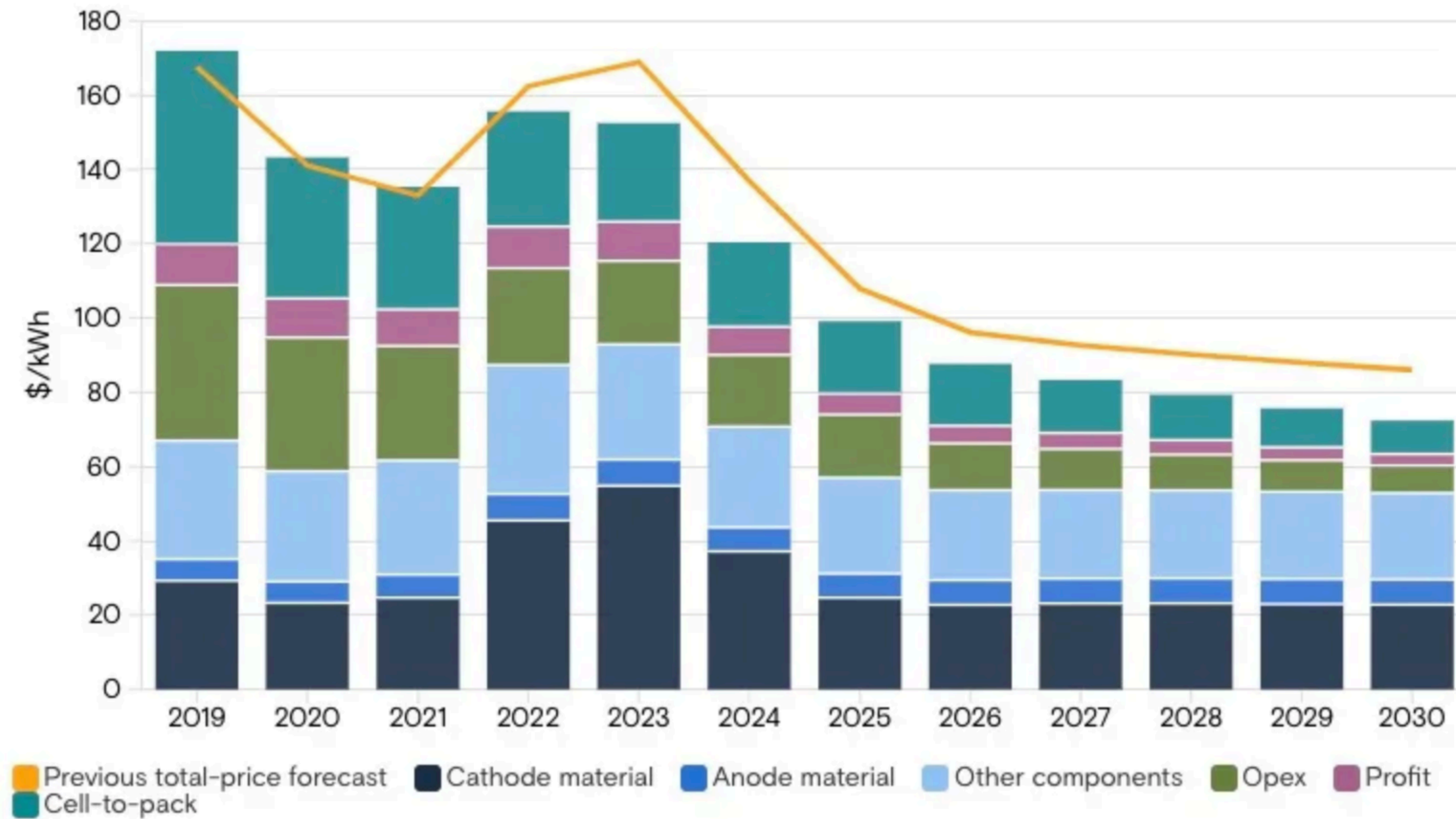
CleanTechnica

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Battery prices are forecast to fall 40% by 2025 (from 2022)

Global average battery pack prices



Source: Company data, Wood Mackenzie, SNE Research, BNEF, Goldman Sachs Research
Data from 2023 are forecasts



FordAuthority

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Study: Salton Sea area could produce enough lithium for 375 million electric car batteries



The hot brine located in a vast underground reserve beneath the Salton Sea likely contains enough lithium to build batteries for 375 million electric vehicles,

Desrt Sun

This is good for two reasons. 1- lots of batteries. 2- North American sourcing means tax credit eligibility.

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TOYOTA'S BATTERY TECHNOLOGY ROADMAP

	TODAY 2023	NEXT-GENERATION 2026-2027		FURTHER EVOLUTION 2027-2028		
	Battery for bZ4X	Performance	Popularisation	High-Performance	Solid-State 1	Solid-State 2
	Monopolar		Bipolar		N/A	N/A
Electrolyte type	Liquid			Solid		
Chemistry	Li-Ion		LiFePO* ¹	Li-Ion		
Driving range (WLTP)	500km	> 800km	> 600km	> 1,000km	> 1,000km	> 1,200km
Cost	-	-20% vs bZ4X	-40% vs Bz4x	-10% vs NG performance version	TBD	TBD
Fast charge time* ²	~30 min.	~20 min.	~30 min.	~20 min.	~10 min.	TBD

*¹ Lithium iron phosphate *² SoC = 10-80% NOTE: Established driving range includes aerodynamic and vehicle weight improvements

Kelley Blue Book

Battery changes are coming but will not arrive for several years. Usually 5 years from proven concept, to testing to production scale.

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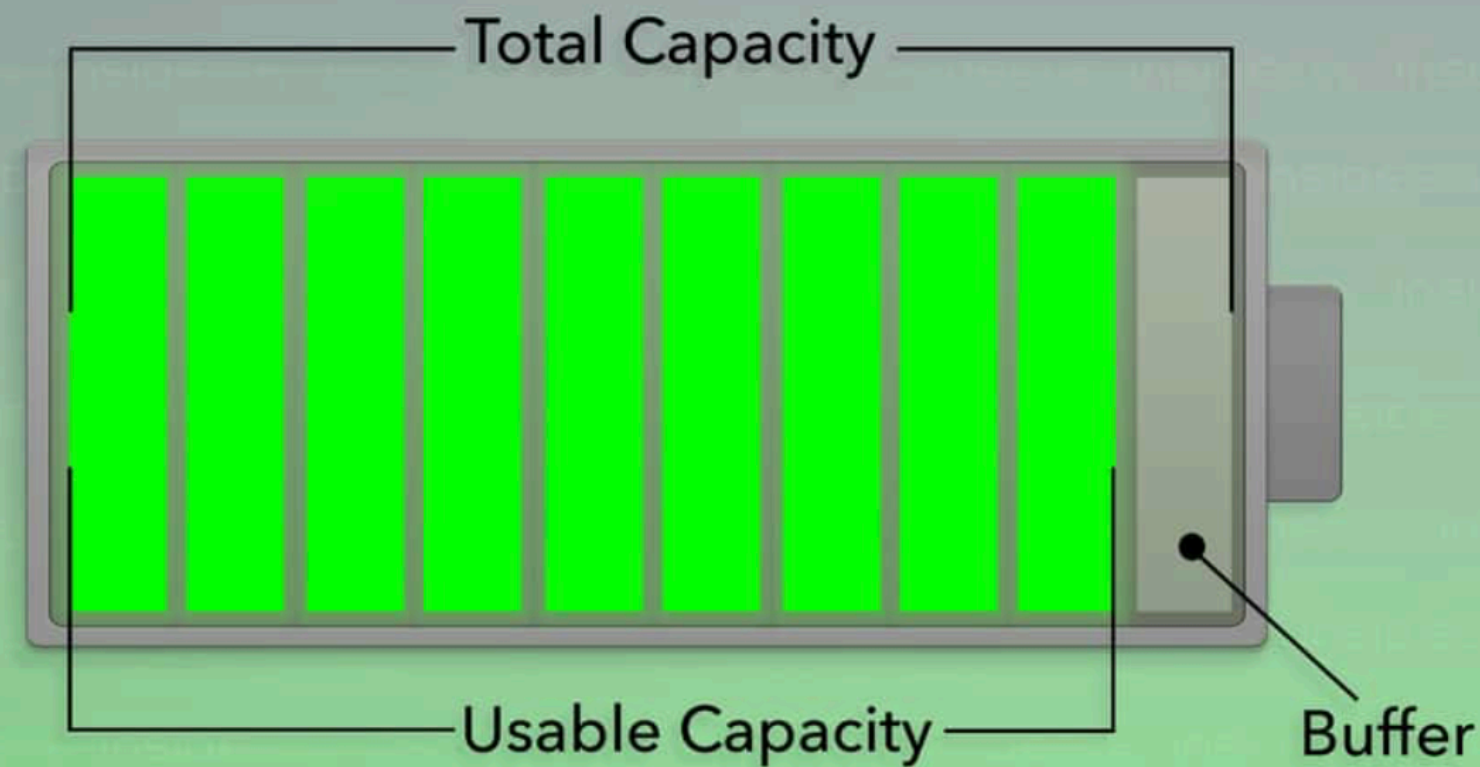
**Sadly Battery degradation
is real**

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What Is 'Usable' Kilowatt-Hours On A Battery Pack?

Manufacturers often list both the total and usable battery capacity, and understanding the difference is important for any EV owner.



EV 101

But First

All EVs list the size of the battery. The amount you can use. Some also list the actual size. The VW has an 82kWh battery with 77 kWh usable. It has a built in buffer which I presume helps minimize degradation. If you watch a lot of how much range does XXX EV have, the cars are driven past empty all the time. Do not do that with your car - you will hate yourself in the morning.

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Do car batteries degrade like my mobile phone?

Car batteries are the same sort of battery as those found in your phone or laptop, but they are designed, built, and maintained so that they last. Some of this comes down to design choices meant to optimize lifetime in EV batteries, and some of it is due to the **battery management system** that cars have to protect from heat, high voltage, and extreme state of charge. [Read all about it!](#)

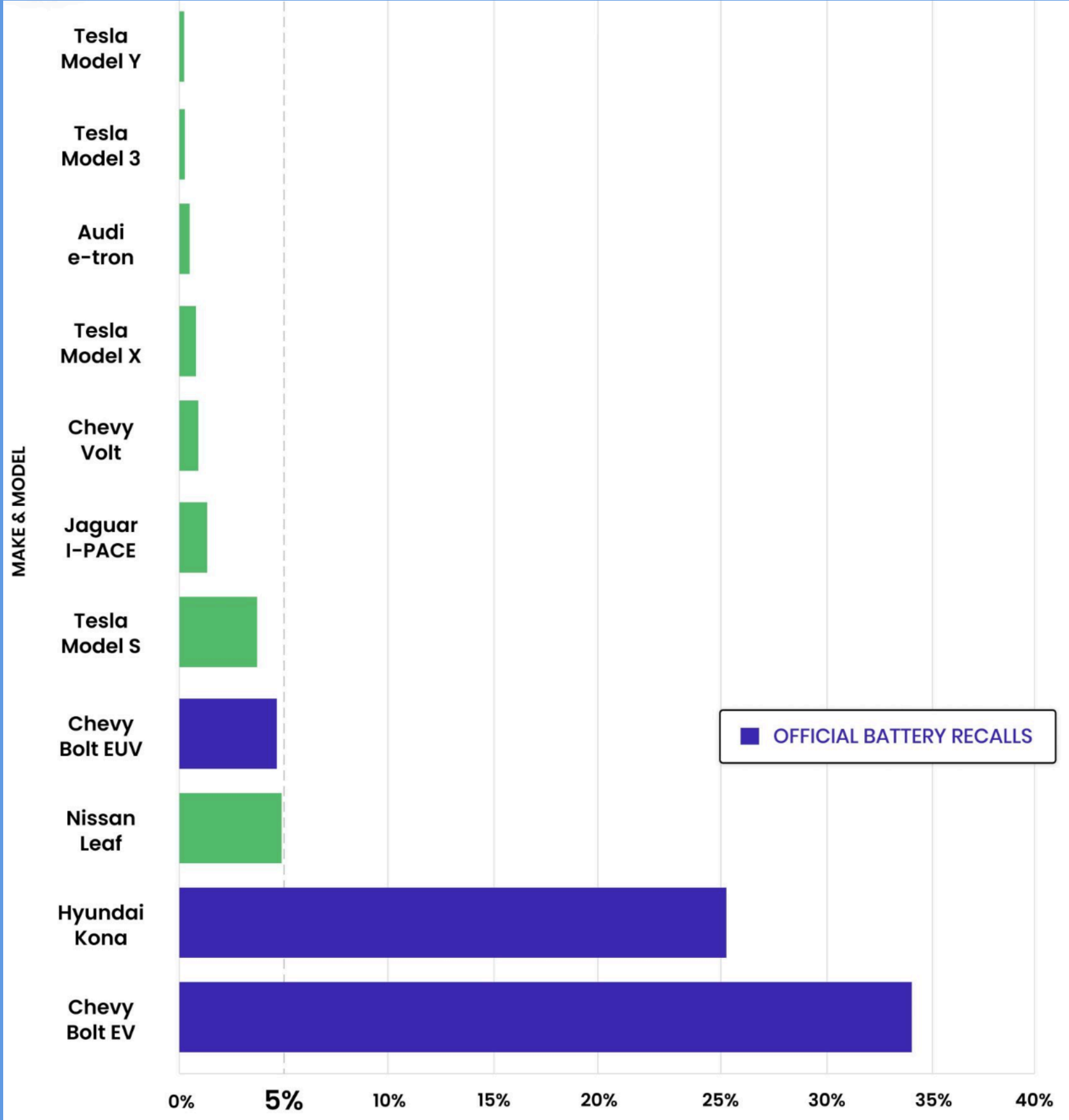
It would be nice if phones had
battery management.

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EV battery health concerns appear overblown, according to new data

By [William Johnson](#) March 27, 2023



Teslarati/Recurrent

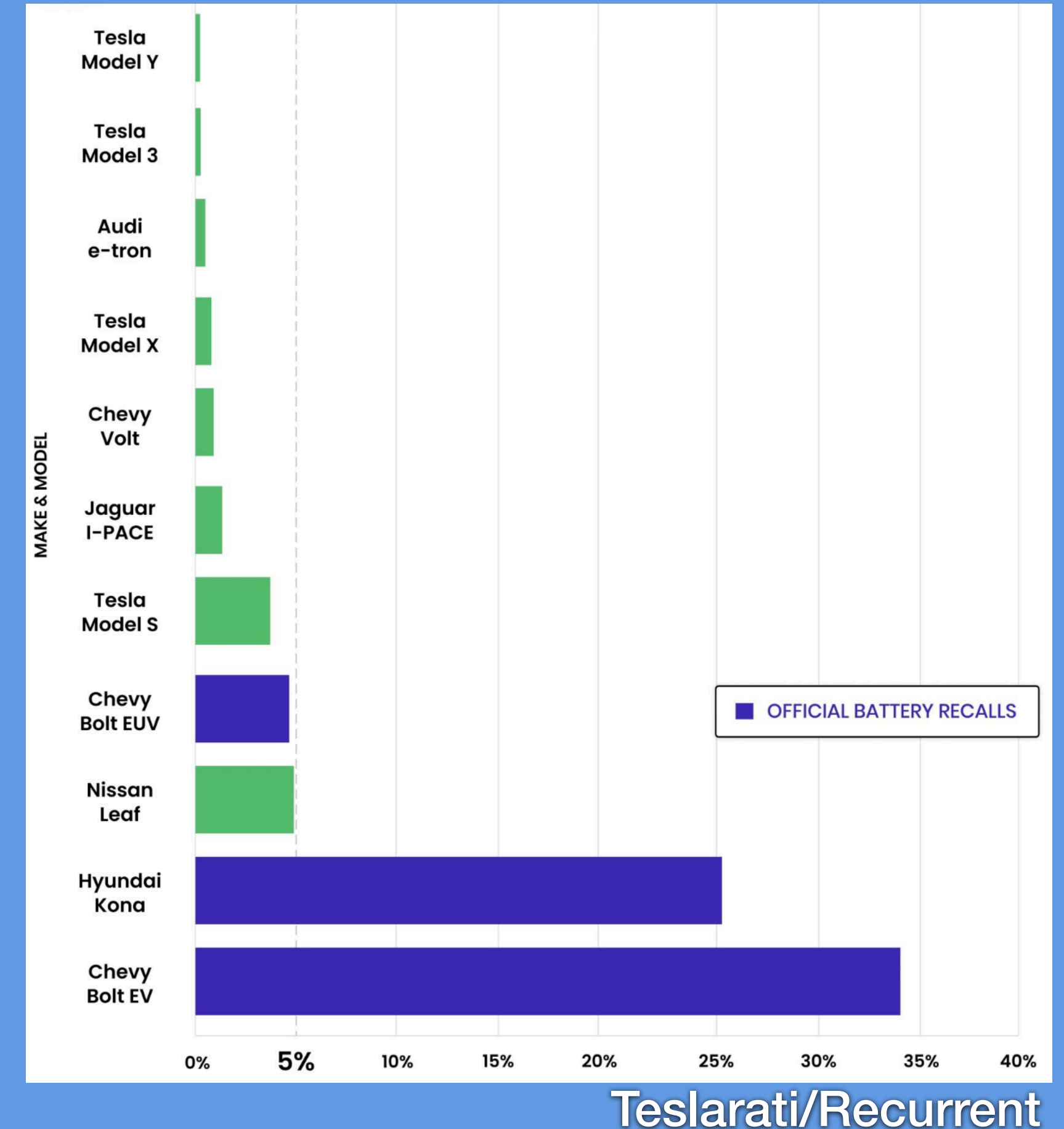
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Recurrent surveyed just over 15,000 EV owners and compiled some of the most detailed battery health data ever assembled, showing that EV batteries are lasting far longer than critics and owners have anticipated. Of their massive group of owners, only 1.5% had replaced their batteries outside of a recall or warranty period. Most of those were older Nissan Leafs lacking liquid battery temperature control systems.

Recurrent is a group to improve accuracy and trustworthiness of used EV information

Note: all the purple is the recall and warranty period. The Tesla model S and the Leaf are the oldest EVs

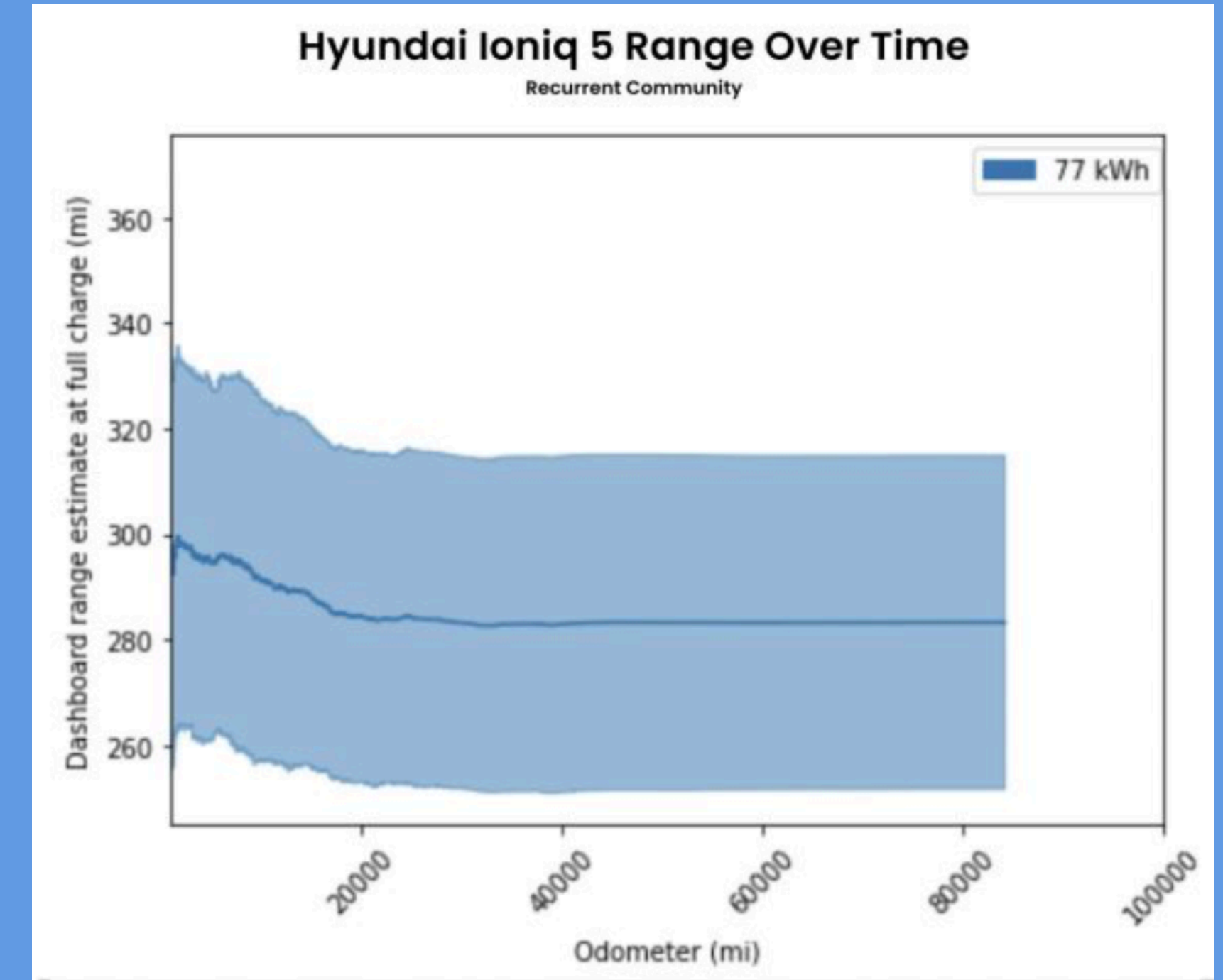


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Recurrent attributes this phenomenon to two main technologies; battery management systems and battery temperature control systems, both of which have dramatically improved the longevity of batteries. These systems not only allow owners to limit how much their battery is charged, which can substantially damage a battery's health, but they also ensure they are constantly operating at a safe and "healthy" temperature.

The drop in the Ioniq 5 is common. Initial drop the stabilizes over time.



Teslarati/Recurrent

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How often do Tesla batteries need to be replaced

Your Tesla is due for a battery replacement once it has lost 20% of its range. Tesla owners reportedly only lose 5% after 100,000 miles.

Tesla CEO Elon Musk claimed in a Tweet that a Tesla battery can last between 300,000 to 500,000 miles. If you're driving within the national average of 273 miles per week, expect your battery life to last anywhere from 21 to 35 years.

The point is a Tesla battery replacement will rarely (if ever) happen. There's a higher chance you'll need to replace your electric vehicle before you replace your battery.

Teslas are noted most often because of their high number and older age.

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After studying 12,500 Teslas, Recurrent concluded that “the results show no statistically significant difference in range degradation between Teslas that fast charge more than 90% of the time and those that fast charge less than 10% of the time.”

Recurrent did caution, however, that an EV battery could be damaged by fast-charging during extreme heat, extreme cold, or when the battery is very close to empty or full.

Recurrent is a group to improve accuracy and trustworthiness of used EV information

NewsYahoo

The near empty or near full is very important

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The [U.S. Department of Energy](#), meanwhile, predicts today's EV batteries ought to last a good deal past their warranty period, with these packs' service lives clocking in at between 12 and 15 years if used in moderate climates. Plan on a service life of between 8 and 12 years if your EV is regularly used in more extreme conditions.

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How it works is a battery tends to lose a chunk of its capacity quite quickly, but then tends to be stable for several years (potentially more than a decade with Tesla's batteries). In my case, my Model 3 SR+ started with around 240 miles of range and then dropped to about 200 miles of range within a year. Since then, though, for the past 3 years or so, it seems to have held steady. Other Tesla owners who read *CleanTechnica* have reported similar experiences.

This is about 15% and seems high - most often hear 5 %.

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From my own experience. Our Tesla Model 3's battery capacity actually increased with an over-the-air update in 2019. We occasionally have to charge our battery to 100% for long trips and have found we have experienced no degradation at all after 4 years and 120,000 km (about 80,000 miles) of driving using a range of charging experiences (slow charging, fast charging, home charging, public charging). My friend Nathan, [an Uber driver](#), has done over 240,000 km with no battery degradation.

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Further muddying the data is the fact that EV battery longevity is a moving target. In these past ten years, there have been numerous tweaks to battery cell chemistry, cell structure design, and battery management systems. The packs from ten years ago are very different from the packs in Tesla vehicles today.

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How long will the battery last ?

My personal speculation is the older batteries are often from cars with smaller batteries and shorter ranges. These batteries were probably taken through longer cycles and more often. I would expect newer cars that can be used mostly in that 60% range and charged less frequently will fare better than their forerunners . And battery life will be longer.

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Portrait of the life of a battery

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Portrait of the life of a battery

Story is not true - it's an example.

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Portrait of the life of a battery

Story is not true - it's an example.

Yes I made this up

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My Current EV with touted
275 mile range.
If I abuse the battery and its
range goes down to 210
miles, that would be about a
25% battery loss.
(More than anticipated in a
previous slide)

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This is very unlikely, but sounds horrible. Look at it this way. 275 is the range for the VW ID4 Pro, the range for the base model VW ID4 is 210 miles new. And I would recommend it for lots of people who take long trips (review session 2)

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Horror stories of the \$40,000 battery replacement. WHY !?!?! \$40,000 is the price of the car that it has turned into. Its still a great car and at this stage degradation slows down.

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I love this car.
And the VW with “only”
210 miles of range beats the
crap out of it for lots of uses.
(Actually I should sell it - but
I can’t bring myself to it yet.)

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Both would be great “second cars”. But the VW ID4 would be a safer car for that new young driver driving to school, etc.

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battery replacements are quite rare (1.5% of cars)

Sorry I lost the attribution for this.

But the above explains half of why they are rare. The car is still too useful. The other half is it takes a lot to get a battery to degrade that far. Do the 60% rule and a few other easy things and your battery won't get there.

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battery replacements are quite rare (1.5% of cars)

It would seem that replacements would be mostly for defects in manufacture and from motor vehicle accidents. Neither of which should have a cost to the customer. (However there are horror stories on the web)

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Other uses - recycling - take one old battery and pull out all the good cells - recycle the bad. Good cells can replace the bad in another and viola - a 100% good battery.

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Old EV Batteries Get a Second Life Storing Solar Energy

“We’re at a point where we really can scale this.”

[Gabriela Aoun Angueira](#)



Mother Jones

Other uses - recycling
take one old battery
pull out all the good
cells - recycle the bad.
Good cells can replace
the bad and viola - a
100% good battery.

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Other uses -

When not used in a car, size and weight no longer matter. And can be used for all kinds of alternate uses. Power outage backup for a house. Any place that can use storage for energy use at a later time.

I wouldn't even consider selling the i3 if could link to my house.

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Recyclers gearing up rapidly for bonanza in auto batteries



A boxful of small batteries waits to go into the recycling process May 11 at Cirba Solutions' EV battery recycling plant in Wixom, Michigan. CLARENCE TABB JR./THE Detroit News

Bad cells
would be
recycled.

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Recyclers gearing up rapidly for bonanza in auto batteries



A boxful of small batteries waits to go into the recycling process May 11 at Cirba Solutions' EV battery recycling plant in Wixom, Michigan. CLARENCE TABB JR./THE Detroit News

The minerals in the batteries are too valuable. There will be enough quantity for industry to scale up for it.

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Recyclers gearing up rapidly for bonanza in auto batteries



A boxful of small batteries waits to go into the recycling process May 11 at Cirba Solutions' EV battery recycling plant in Wixom, Michigan. CLARENCE TABB JR./THE Detroit News

Also in the IRA (Inflation Reduction Act) Recycled minerals begin their second life designated as being sourced in North America.

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Battery recycling is key to a clean future



Recycling is part of the IRA because it is important.

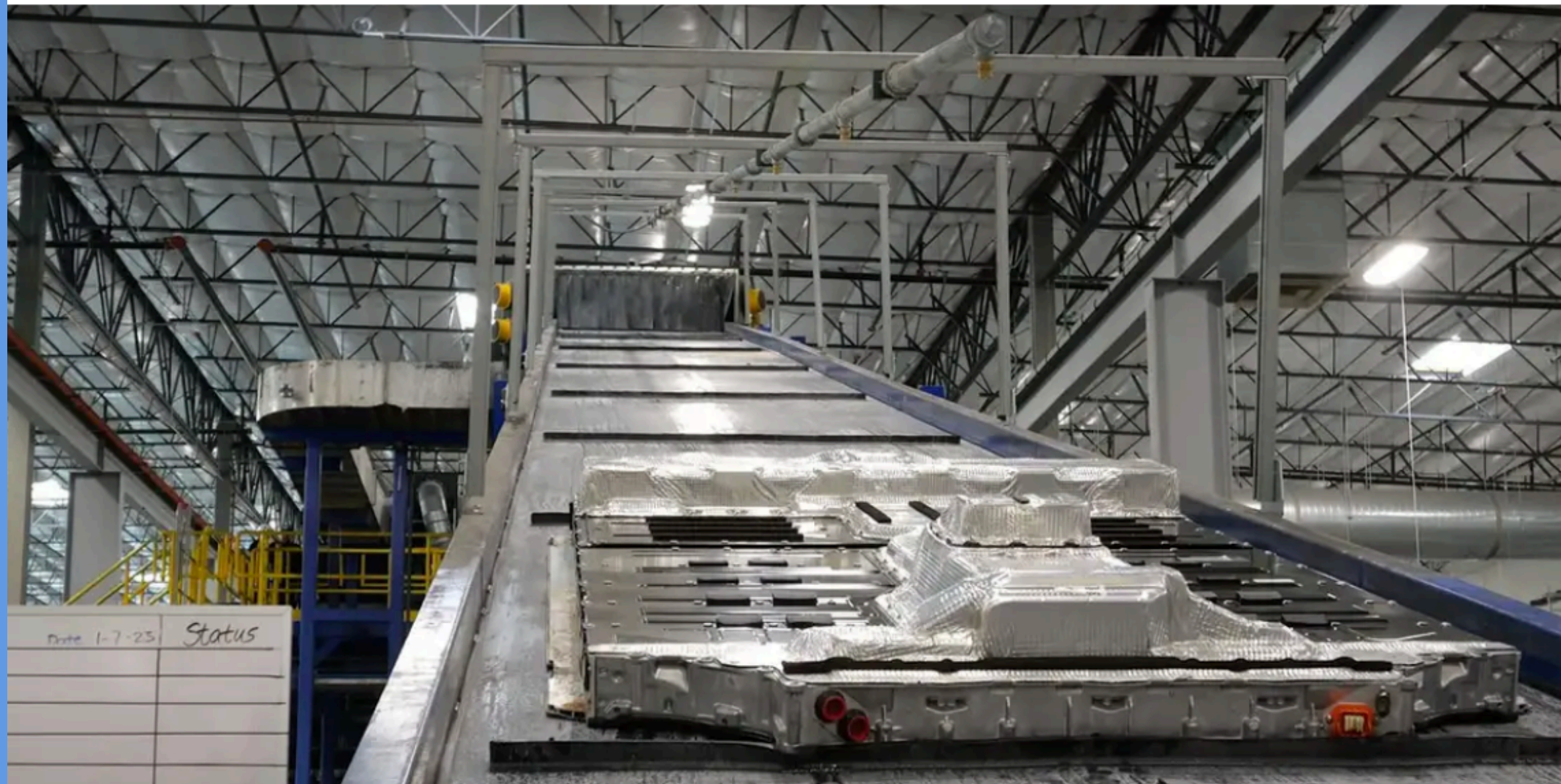
A parking spot reserved for electric vehicles is seen in the parking lot of a metro station in Norwalk, Calif., Monday, Aug. 29, 2022. Discounted prices, car-share programs, and a robust network of public charging stations are among the ways California will try to make electric vehicles affordable and convenient for people of all income levels as it phases out the sale of new gas cars by 2035. Advocates for the policy say the switch from gas- to battery-powered cars is a necessary step to reducing pollution in disadvantaged neighborhoods, but that the state make sure those residents can access the cars, too. (AP Photo/Jae C. Hong)

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Step Inside The Factory That Recycles 95 Percent Of EV Batteries

As the electric vehicles arms race amps up, this American factory is working to recycle outdated and abandoned EV batteries



Recycling is part of the IRA because it is important.

<https://jalopnik.com/step-inside-the-factory-that-recycles-95-percent-of-ev-1850793666>

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60% rule is easiest to
long life.

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The more you charge, the longer it takes

“For a gasoline car, you would fill it up,” Musk said during a recent episode of “The Joe Rogan Experience” podcast. “For a battery, the charge state tapers off as you get above 80%.”

“I think the right analogy here is cars in a parking lot,” he continued. “The lithium ions are trying to find a parking space as they move across from one side of the battery to the other side.”

A battery at low charge is akin to an empty parking lot, Musk said — the ions can “zip right in there and find a spot.” But as the battery gets closer to full, it becomes more like a busy mall’s parking lot, where the available spots are scarce. In that situation, the ions “have to bounce around more” to find their places.

“Getting from 80 to 100 (percent) takes about as much time as getting from 0 to 80,” Musk told Rogan.

In other words, you could cut charging time by 50% and still get 80% of your EV’s range. That tradeoff could help keep your long road trips from becoming interminable.

This is good for two reasons. 1- lots of batteries. 2- North American sourcing means tax credit eligibility.

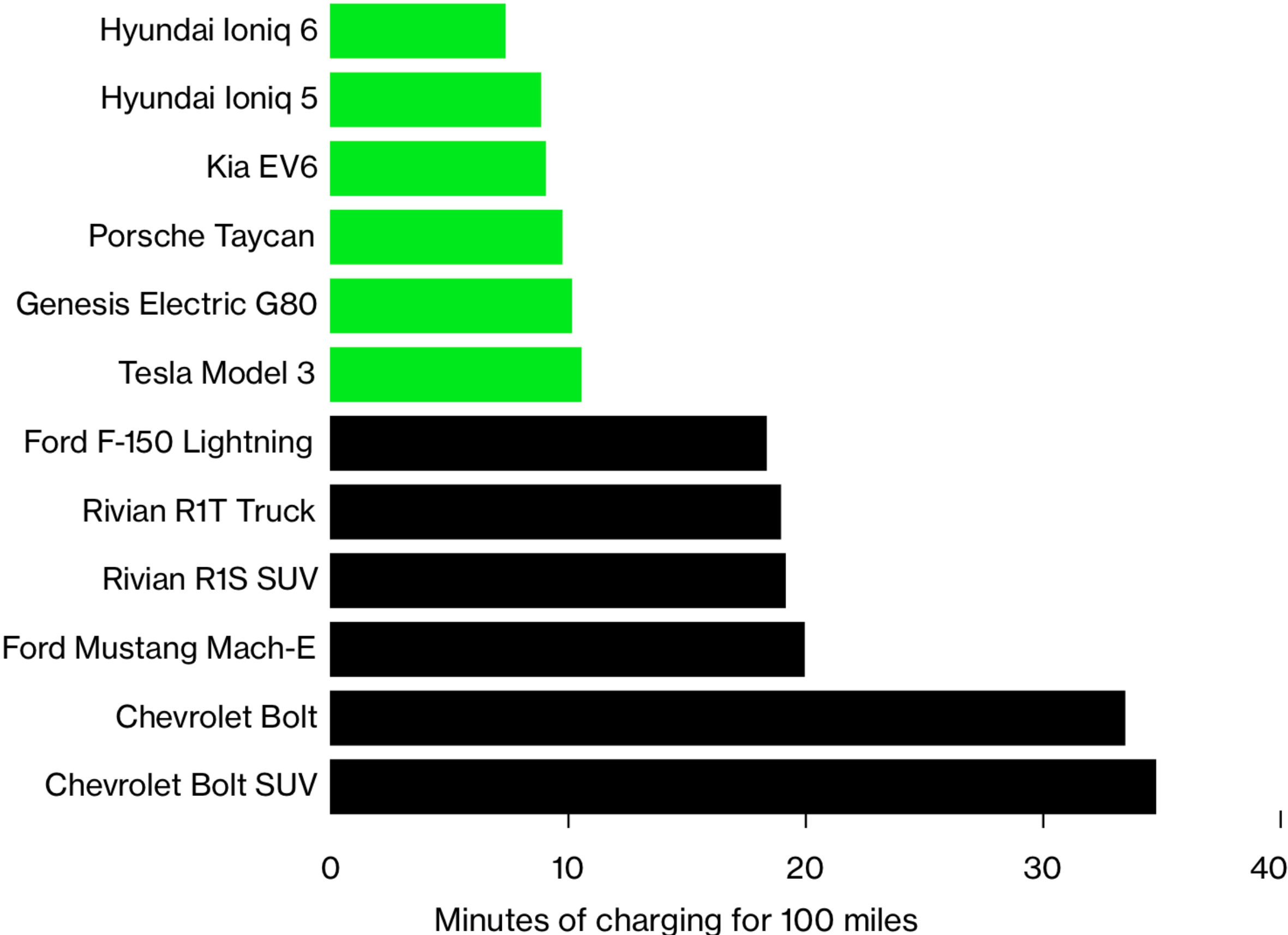
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Some EVs Take Four Times Longer to Charge

Average charging time needed to drive 100 miles

■ Best Performers ■ Worst Performers

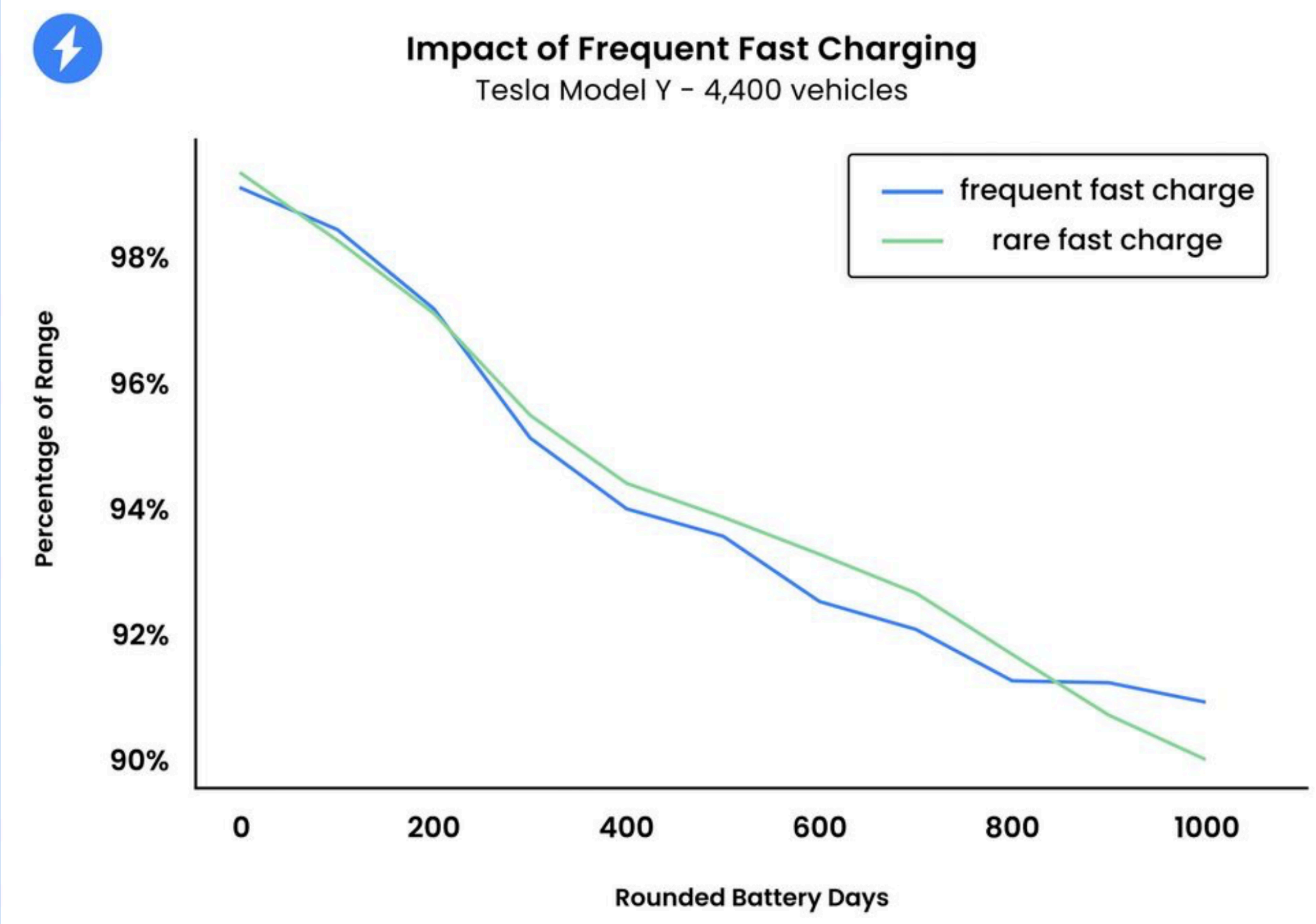


Source: Edmunds

Note: High-speed chargers are required to achieve max charging rates.

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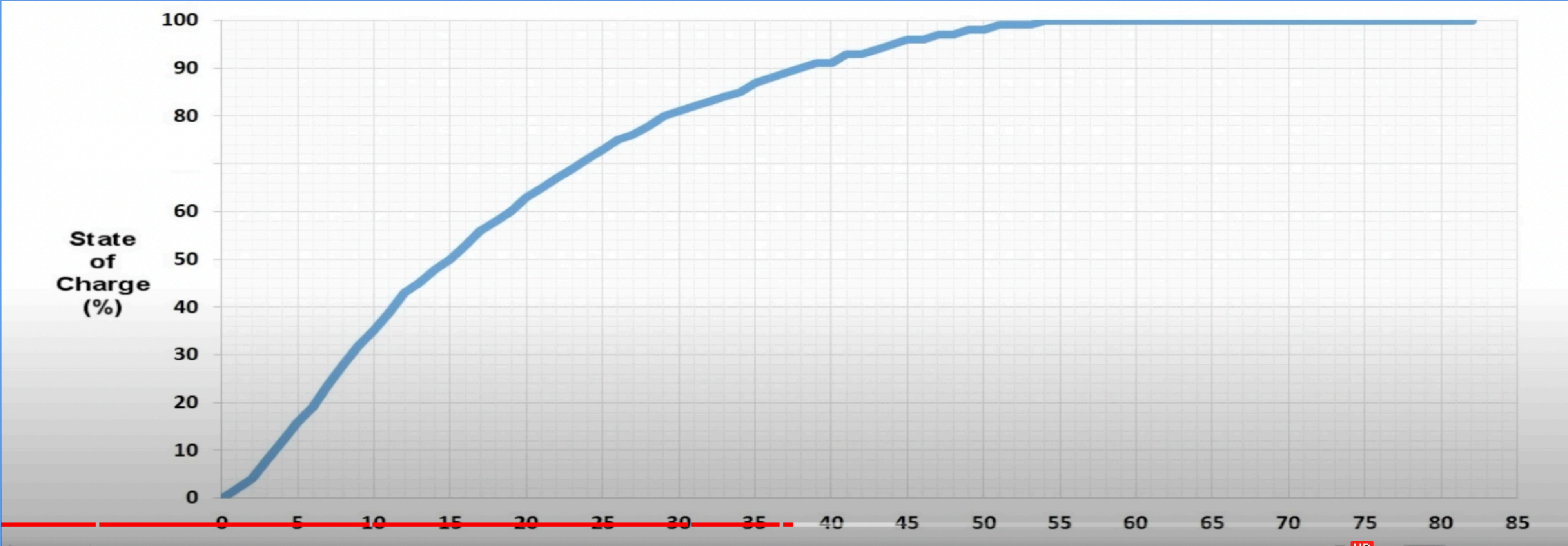
The 60% rule works
because of the
changing
curves

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The Curves

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This graph shows how the percentage of charge as it changes during the time of the charge. The battery reaches 80% in less than 20 minutes. After that the battery is filling slower & slower & slower.



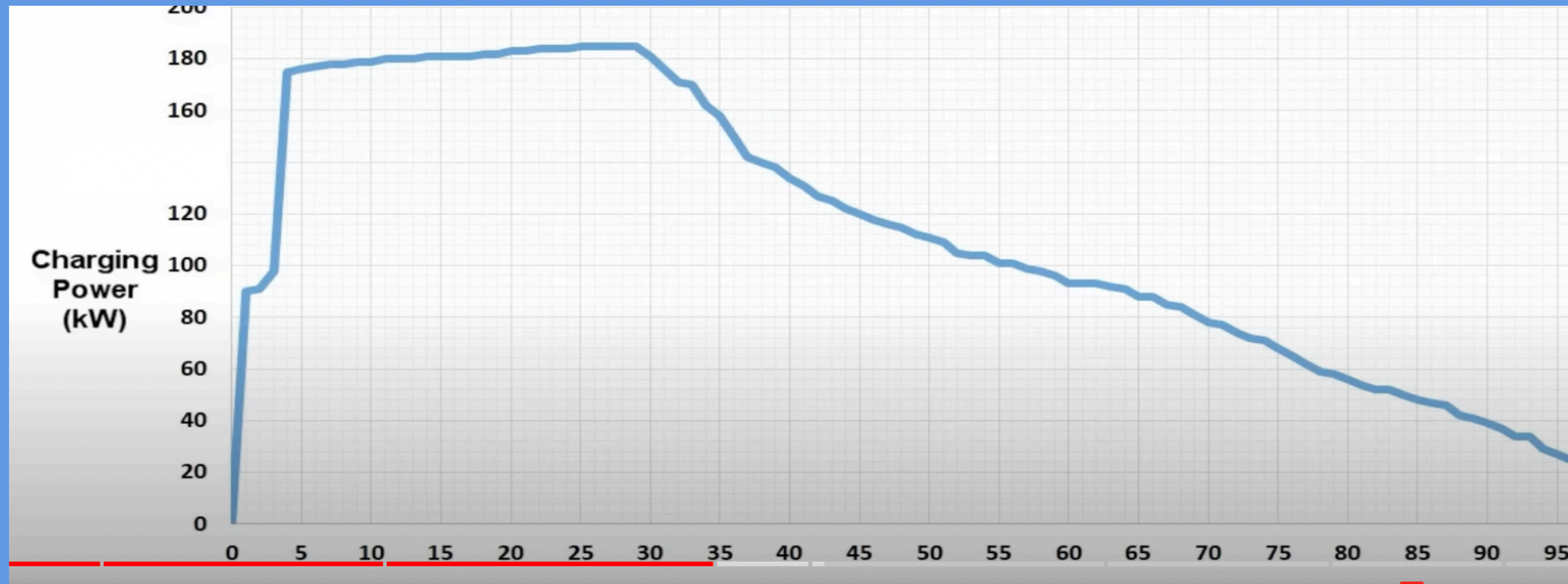
Direct Current Fast Charging Tesla model 3

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The Curves

This shows us how the speed of the charge is higher early and lowers as the battery approaches 100%. This helps protect battery life.



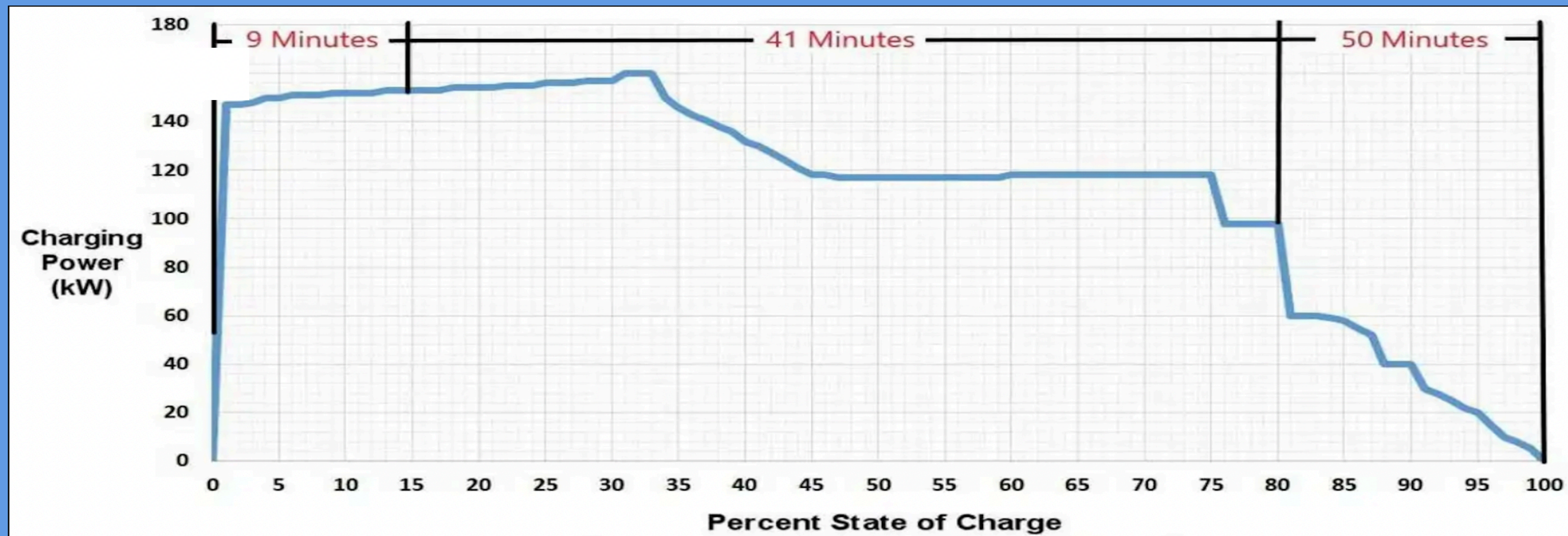
Direct Current Fast Charging Tesla model 3

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The Curves

The Ford F-150 Lightning w/ 135kWh battery pack. Going below 15% is to be avoided (if at all possible). That “sweet spot” of 15 to 80%, which takes 41 minutes to charge. The remaining 20% (from 80 to 100%) takes an additional 50 minutes ! If you are waiting, that 50 minutes is painfully long. That would not be convenient charging.



**65% charge in
41 minutes.**

**20% charge in
50 minutes.**

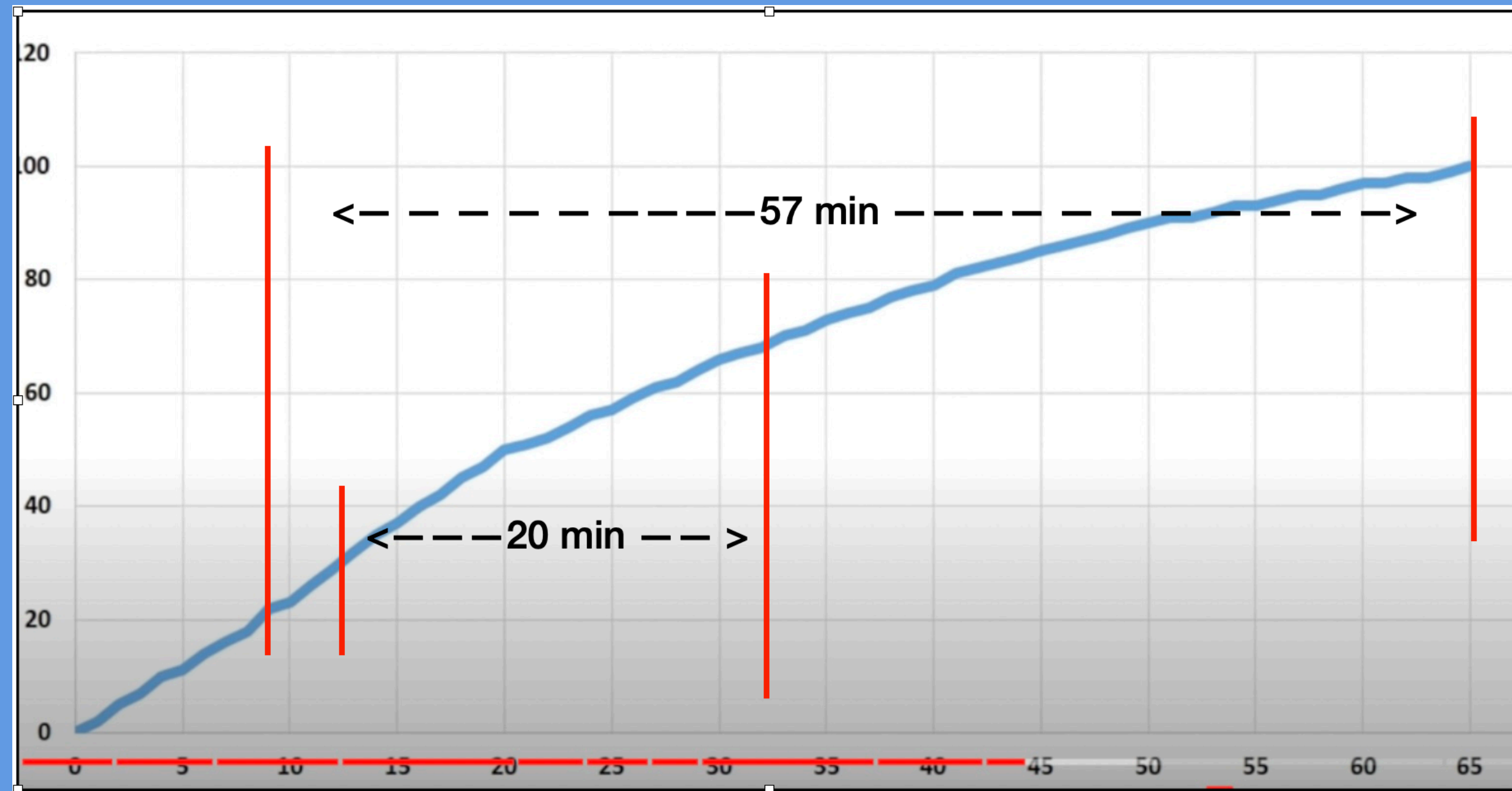
Direct Current Fast Charging Ford Lightning

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The Curves

Charging from 20%-100% takes 57 minutes and get 180 miles of driving. But if you charge from 30% - 70% twice (make 2 stops). You get 180 miles of driving with only 40 minutes of charge time.

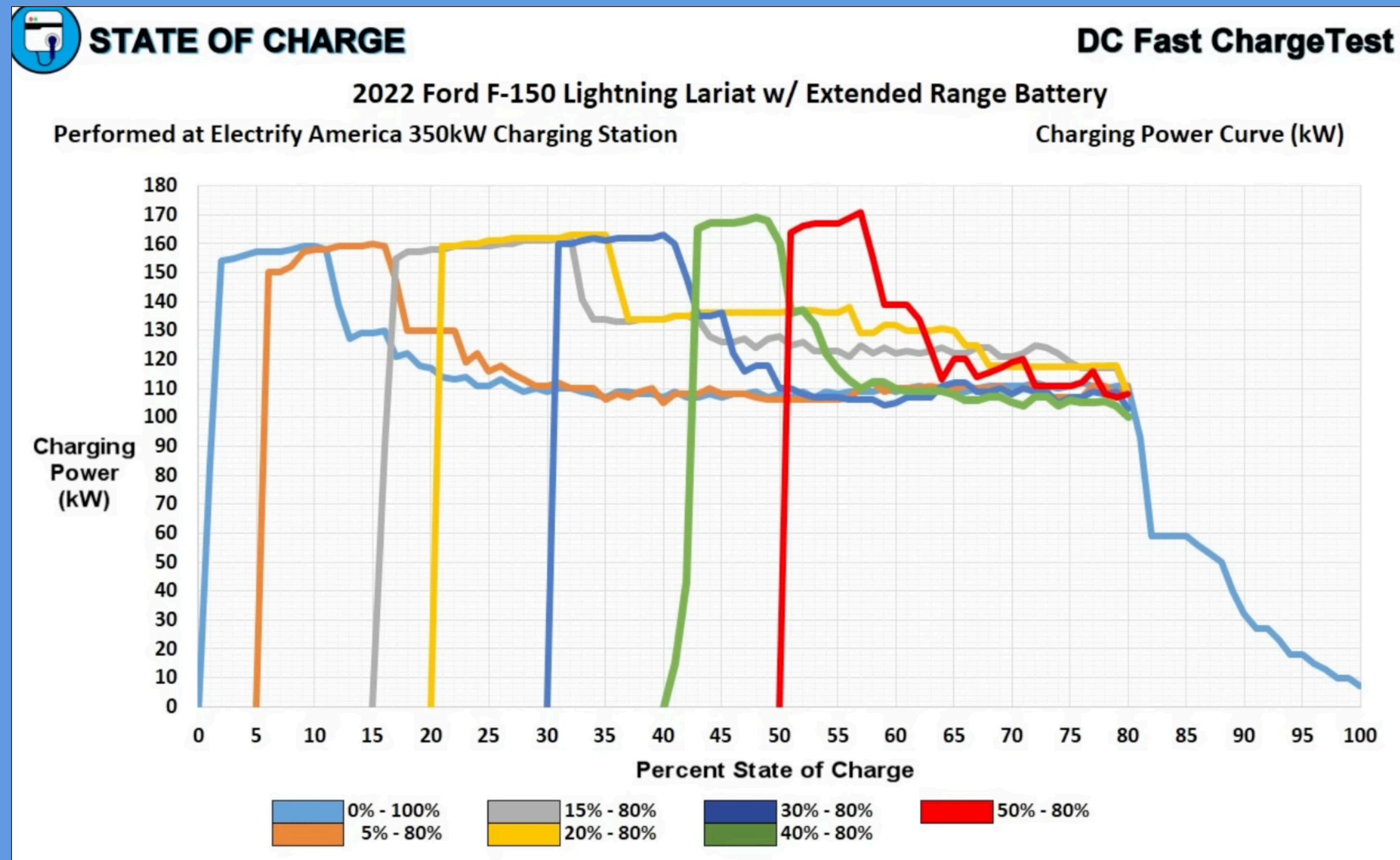


Get out the car and stretch your legs. For a lot of people that second stop at 90 miles is going to happen whether or not you charge.

Direct Current Fast Charging VW ID4

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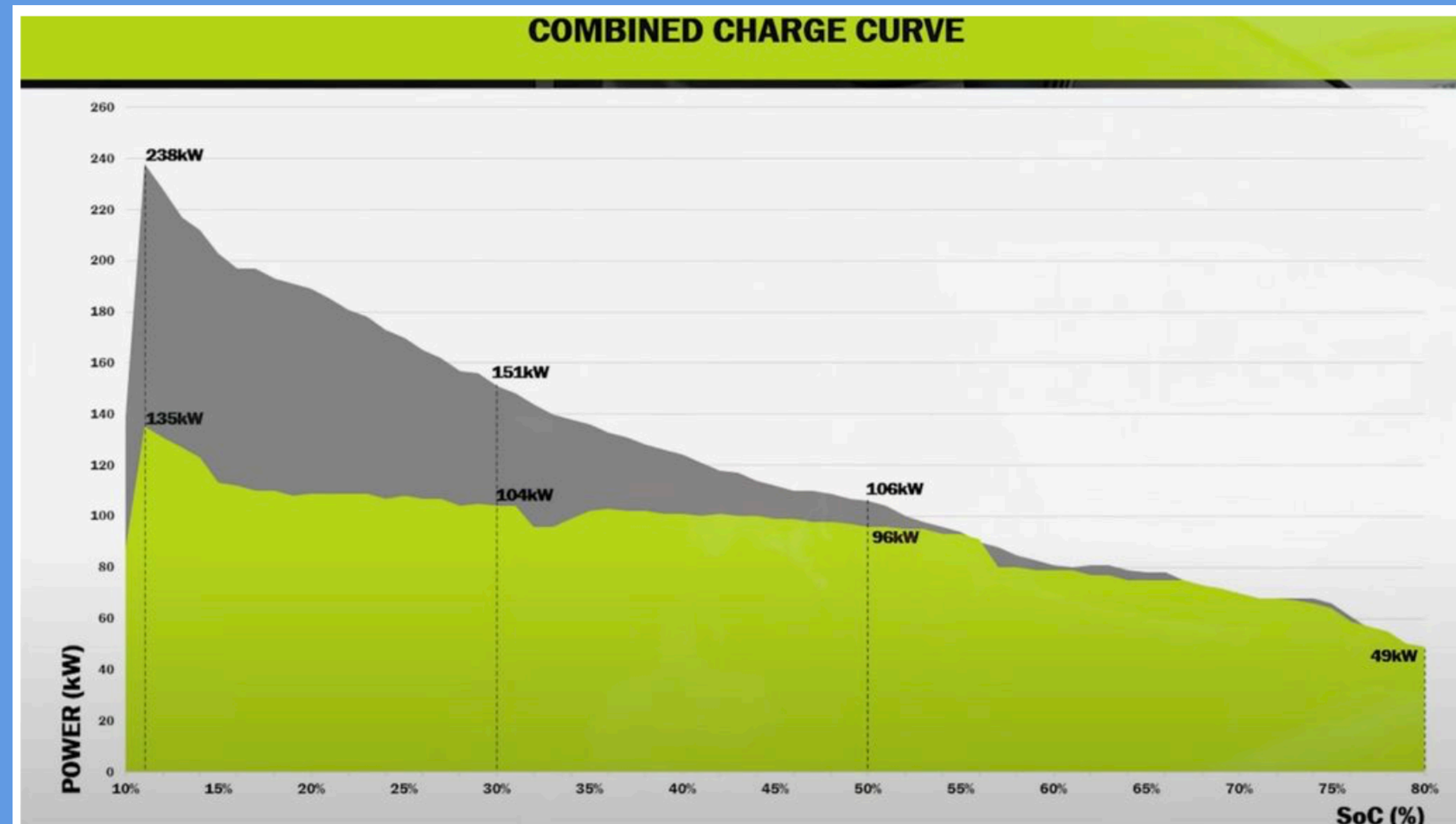
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Ford Lightning pickup trucks are the only ones (for now) with this charging scheme. Up to a 50% SOC it always starts at about 150kw then tapers off. All other cars the highest speed is determined by the SOC. Battery temp has not yet been affected by heat, so why not start the charge at a higher rate ?

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Charging curve with battery preconditioning (grey) vs. charging curve with cold battery (green)

The effects of Battery heating (when cold out). This is also an excellent way to charge fast and not effect battery health. If you target your charging levels, it can greatly reduce charging times on a long trip.

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The end

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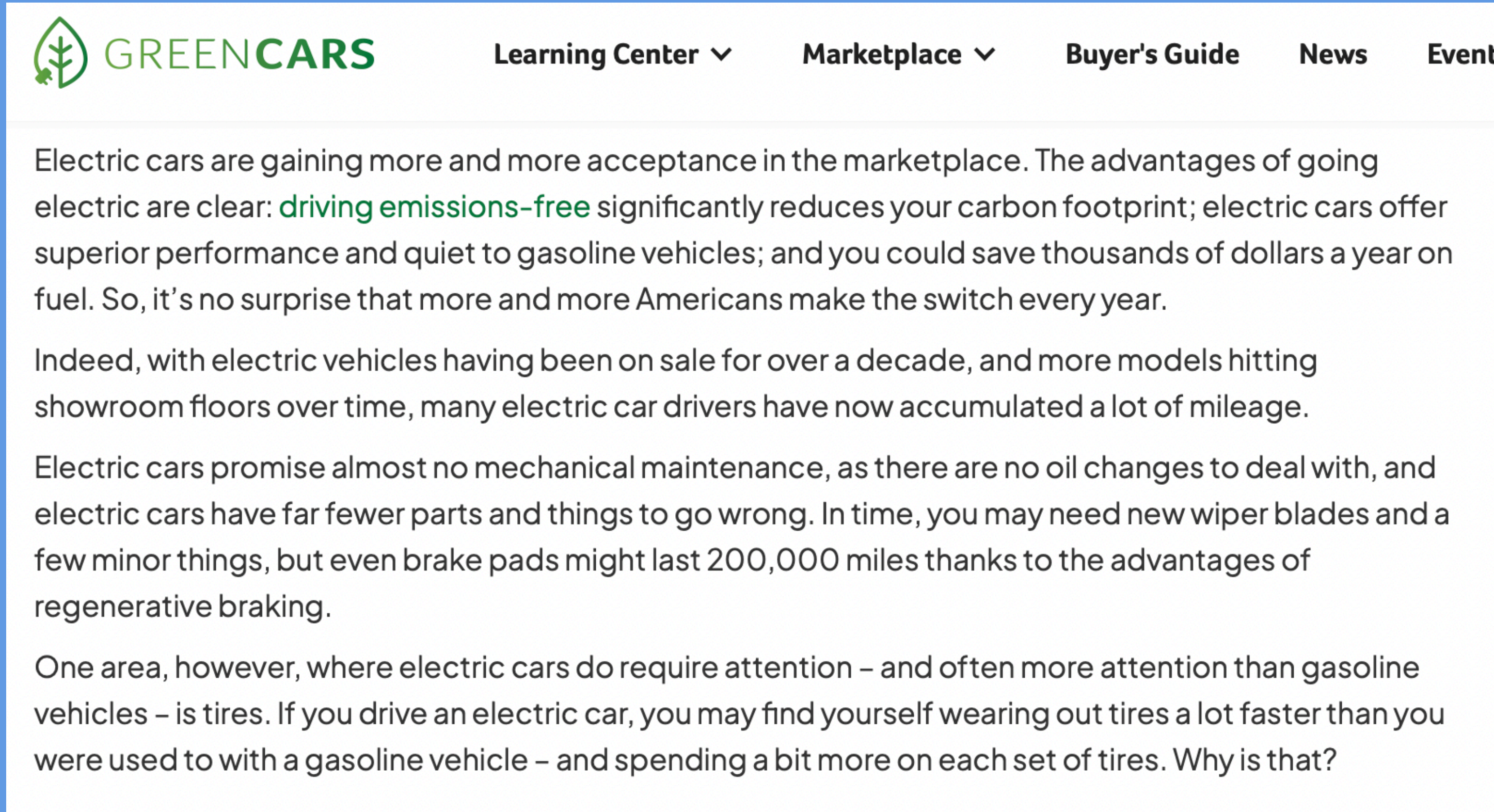
Maintenance

Total Cost of Ownership
Or
Maintenance

Looking Into Electric Cars

Maintenance

Maintenance



The screenshot shows the GREENCARS website header with navigation links: Learning Center, Marketplace, Buyer's Guide, News, and Events. The main content area contains an article titled "Electric cars are gaining more and more acceptance in the marketplace. The advantages of going electric are clear: driving emissions-free significantly reduces your carbon footprint; electric cars offer superior performance and quiet to gasoline vehicles; and you could save thousands of dollars a year on fuel. So, it's no surprise that more and more Americans make the switch every year. Indeed, with electric vehicles having been on sale for over a decade, and more models hitting showroom floors over time, many electric car drivers have now accumulated a lot of mileage. Electric cars promise almost no mechanical maintenance, as there are no oil changes to deal with, and electric cars have far fewer parts and things to go wrong. In time, you may need new wiper blades and a few minor things, but even brake pads might last 200,000 miles thanks to the advantages of regenerative braking. One area, however, where electric cars do require attention – and often more attention than gasoline vehicles – is tires. If you drive an electric car, you may find yourself wearing out tires a lot faster than you were used to with a gasoline vehicle – and spending a bit more on each set of tires. Why is that?"

Few people want to go out on a limb and say no maintenance.

But I have never taken my 30 year old electric drill in for maintenance. There will be some things that need it.

First up will be fluid changes in the mechanical brakes every 3 years. After that I can't remember anything I needed for the Subaru that the EV will need.

(OOOPS I tried to get brake fluid service and honest mechanic said wait until 10 years)

Looking Into Electric Cars

Maintenance

- Brakes
- Tires
- Cabin air filter
- High voltage battery
- 12V battery checks
- Lubricants
- AC

This is the maintenance list for an EV. I went to my favorite Gas vehicle mechanic to see if he wanted to do my brake fluid change. Said no, brake fluid is good for 200,000 miles. Don't get brake work done unless there is a symptom.

I will forever buy my tires at Beaumont Tire
812 Dennison, just east of the Dunkin' Donut on Prospect.

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Maintenance

Energy



Hard to give a dollar amount on this. Each post office vehicle will save more than a vehicle for personal use. Maybe if someone drives very far everyday for work.

I will guess a good ballpark estimate is that every mile driven will save 10 cents. To get a total for the year, a number for yearly mileage is needed. For the last year of my gasoline Subaru - 6000 miles or \$600. But I've driven my VW ID4 twice that far this year.

Looking Into Electric Cars

Maintenance

Tires

OUCH!!!

HANKOOK
KINERGY AS X EV
Crossover/SUV Touring All-Season

Front: **235/55R19 105T XL** Qty: 2 Per Tire: **\$361.99**
Style: **Blackwall**
Eco Focus: **Kontrol Technology**
Electric Vehicle Tuned
Load Range: **XL**
Serv. Desc: **105T**
UTQG: **500 A A**
Mile. War.: **None**

In Stock
Delivery by **Monday, 11/28** to 61820
Free Shipping

Compare
Not Yet Rated
 Original Equipment

Rear: **255/50R19 107T XL** Qty: 2 Per Tire: **\$398.99**
Style: **Blackwall**
Eco Focus: **Kontrol Technology**
Electric Vehicle Tuned
Load Range: **XL**
Serv. Desc: **107T**
UTQG: **None**
Mile. War.: **None**

In Stock
Delivery by **Monday, 11/28** to 61820
Free Shipping

Set of 4: **\$1,521.96**

Tires are the big one. I haven't purchased tires in a while, but it looks like twice as much. Remember - These are TRUCK tires. With the EV battery the gross vehicle weight of the cars are high and need almost truck sturdy tires. Also non-EV tires are available cost less upfront. EV tires will get better range and cost less over time.

TireRack website - (I buy all my tires there)

Its possible that a lot of EVs will be like mine and not have tire rotation.

The illustration is for my tires and note different sizes, front and back.

Looking Into Electric Cars

Maintenance

Tires




MICHELIN
ENERGY SAVER A/S
Passenger All-Season

Size: **215/50R17 91H**
Selfseal, TPC Spec, Chevy Bolt
Style: **Blackwall**
Eco Focus: **Green X**
Electric Vehicle Tuned
Serv. Desc: **91H**
UTQG: **480 B B**
Mile. War.: **65,000 Miles**

Qty: 4
Per Tire: **\$244.77**

Out of Stock
Additional inventory due 12/01/22
Delivery by **Wednesday, 01/18** to 61820

 **Free Shipping**




TOYO
PROXES A40
Passenger All-Season

Size: **215/45R18 89V**
Serv. Desc: **89V**
UTQG: **300 B A**
Mile. War.: **None**

Qty: 4
Per Tire: **\$174.20**

Out of Stock - On Backorder
The manufacturer does not have an expected due date at this time

 **Free Shipping**
Set of 4: **\$696.80**

Less OUCH!!!

The top tire is OEM for Chevy Bolt. The other is for a Mazda 3 considered a very similar car. The Bolt tires are designed for better range and are for a heavier vehicle. Note the Chevy tires carry a fairly high mileage warranty. The Mazda tires has none.

Looking Into Electric Cars

Maintenance



Affirmation for Electric Vehicle

Definition (625 ILCS 5/12-805): Beginning on January 1, 2020, the registration fee for Electric vehicles shall be equal to the fee set forth in Section 3-806 for motor vehicles of the first division, other than Autocycles, Motorcycles, Motor Driven Cycles, and Pedacycles. In addition to the registration fees, the Secretary shall assess an additional \$100 per year in lieu of the payment of motor fuel taxes. \$1 of the additional fees shall be deposited into the Secretary of State Special Services Fund and the remainder of the additional fees shall be deposited into the Road Fund. (Source: P.A. 101-32, eff. 6-28-19.)

Fees

Random-Number Electric Vehicle License Plates

- Newly acquired vehicle/first-time issuance - \$406 (\$155 title fee + \$251 registration fee)
- Currently titled vehicle/first-time issuance - \$251 (\$251 registration fee)
- Current plates expire within 90 days - \$280 (\$251 registration fee + \$29 replacement fee)
- Current plates do not expire within 90 days - \$280 (\$251 registration fee + \$29 replacement fee)
- Annual renewal - \$251

Registration

Passenger vehicle plates in Illinois cost \$100 more to offset the motor vehicle fuel tax that they do not pay.

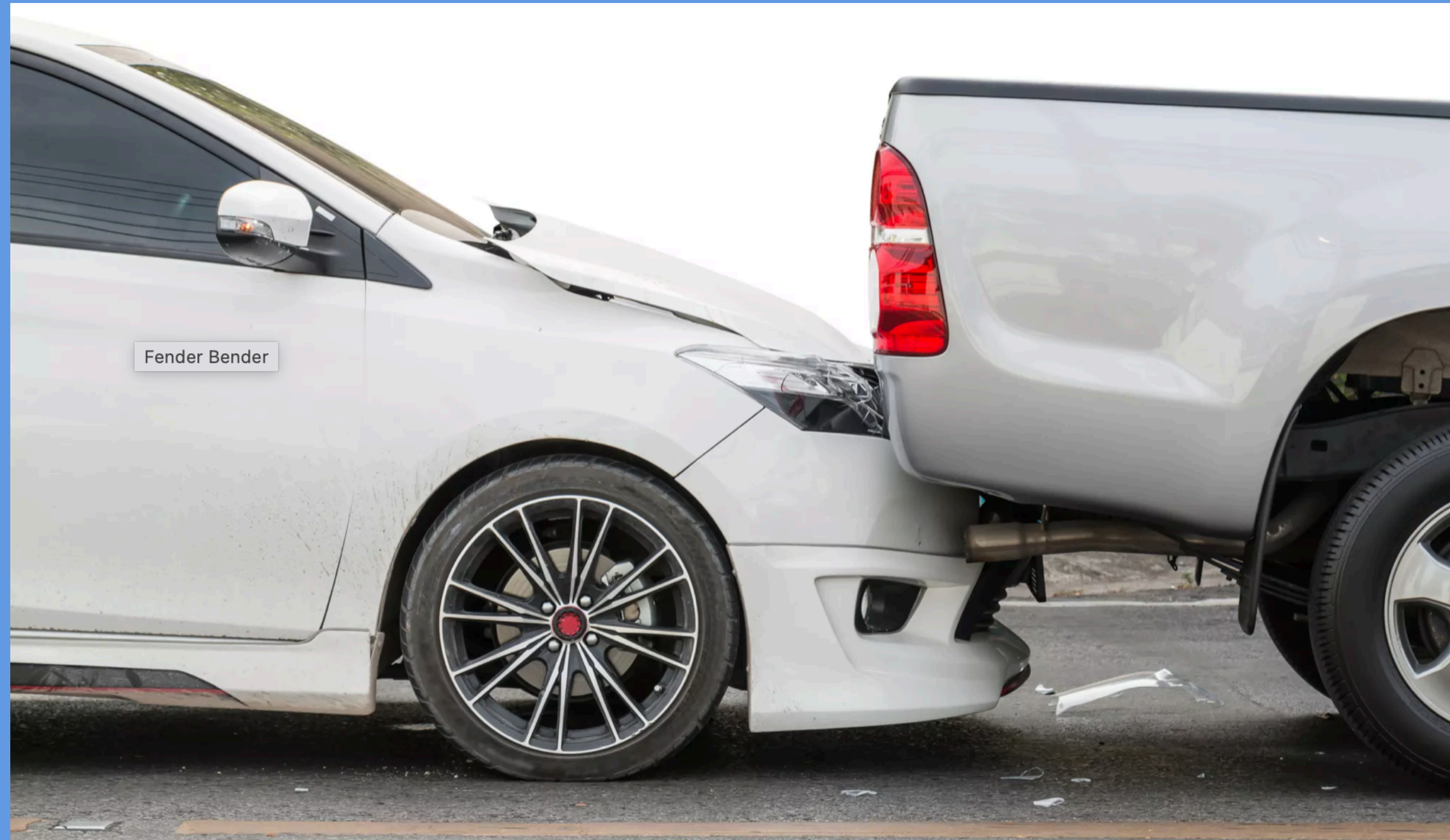
Passenger	\$151
Passenger Personalized	\$158
Passenger Vanity	\$164
Persons with Disabilities	\$151
Persons with Disabilities Personalized	\$158

Illinois Sec. Of State website

Looking Into Electric Cars

Maintenance

Insurance



Expect car insurance to start a little higher. For a lot of insurance companies, the actual payouts for losses is an unknown, I expect that to go down as more EV drivers are cautious and the percentage of Tesla (Plaid version) street racers diminishes.