EV Range & Battery Degradation Guide

A beginner's guide to owning your first EV

RECURRENT

INTRODUCTION

Let’s Talk About Range, Baby

Part of **The Complete Used EV Guide**

Range is often a top consideration when buying an electric car. How far can the vehicle drive on a single charge?

This distance can vary a lot. An older Nissan LEAF may be rated for 70 miles while a newer Tesla Model S may be rated for over 400 miles.

IMPORTANT:

The EPA *rated range* is not the same as *actual range*.

Lots of factors — both short term and long term — can impact how the achievable range varies from the original rated range. This is similar to how a gas-powered car does not always get the exact same miles per gallon that it is rated. External factors can affect the efficiency of all vehicles.

This guide explores many of the things that impact your vehicle’s range so you can find the right electric car for you!

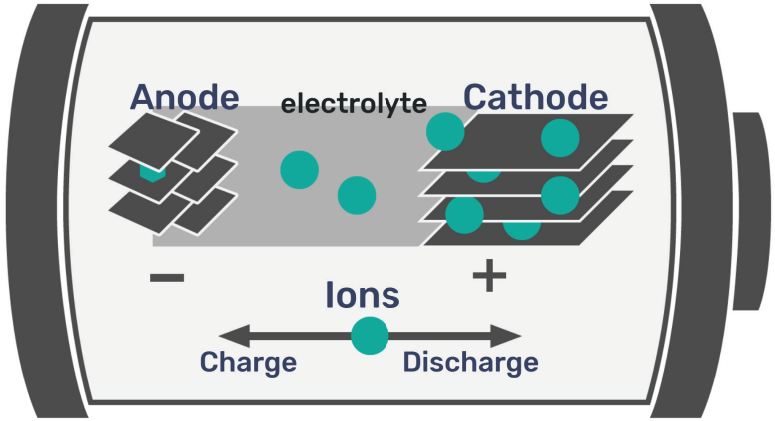
INTRODUCTION

What is an EV battery?

Most EVs are powered by lithium ion batteries. The detailed battery chemistries can differ by brand, model and year, but all have the same general considerations.

Lithium is a staple because it is a light metal with a high electrochemical potential. That means it can produce more electricity using less material and space. Lithium ion batteries produce energy when lithium ions move from the negative electrode (or anode) to the positive electrode (or cathode), and are charged when the lithium ions move in the opposite direction.

That movement, from side to side, is the critical piece of charging and discharging a battery and the thing that generates electricity.

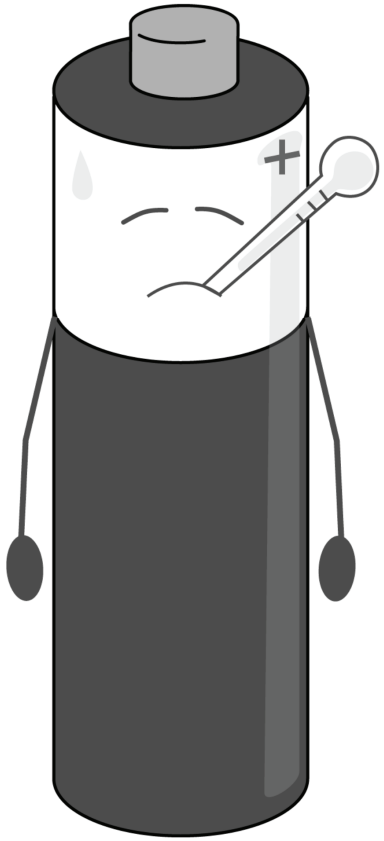


Range & Range Loss

There are two types of range loss.

Long term range loss is permanent

Short term range loss is temporary



Think of it like a person. We have all felt a bit sluggish after a long day or short night. That is a short term energy loss that disappears with rest. We also tend to get a little slower with age, a natural part of the aging process. That is a long term and permanent shift in energy.

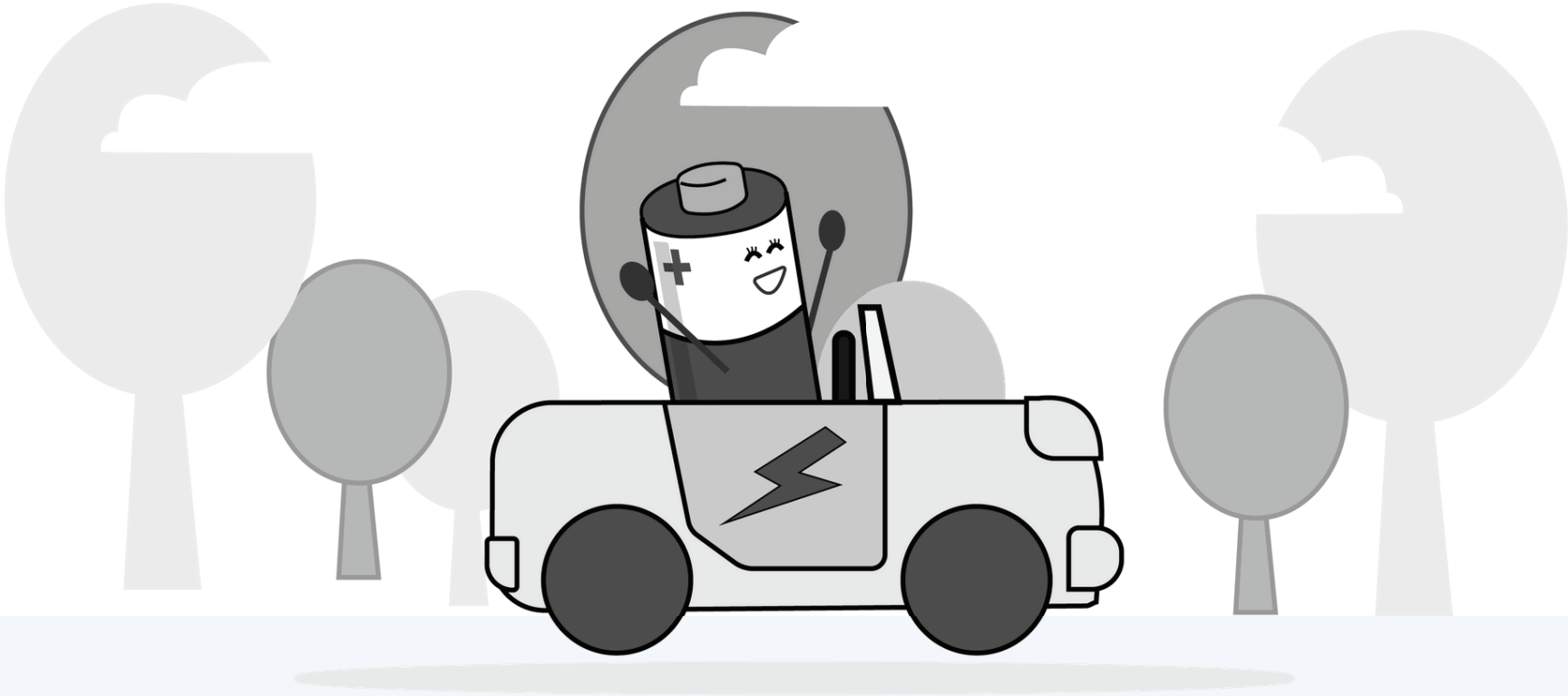
Drivers should understand each of the short term factors and how to avoid the long term factors.

Short Term Range Loss

Short term means that any loss in range is limited to that day or charging cycle.

Rapid acceleration and high-speed driving

Extreme outdoor temperatures



SHORT TERM RANGE LOSS

Acceleration and High-speed Driving

Whereas a vehicle with an internal combustion engine will use fuel most efficiently on the highway, EVs see the best battery range when they are driven slower and on city streets. This does not mean that EVs aren't great for road trips, as many drivers can attest, but highway driving will not capitalize on **regenerative braking** in the same way that city driving will.

When a car brakes, it is slowing down and losing kinetic energy. Regenerative braking is simply taking the velocity lost while slowing down and using it to charge the battery.

Also, driving fast or uphill will cause you to use energy more quickly than usual so you may notice a decrease in available range if you're racing uphill. Coasting downhill or driving slowly will use your battery's energy most efficiently.

SHORT TERM RANGE LOSS

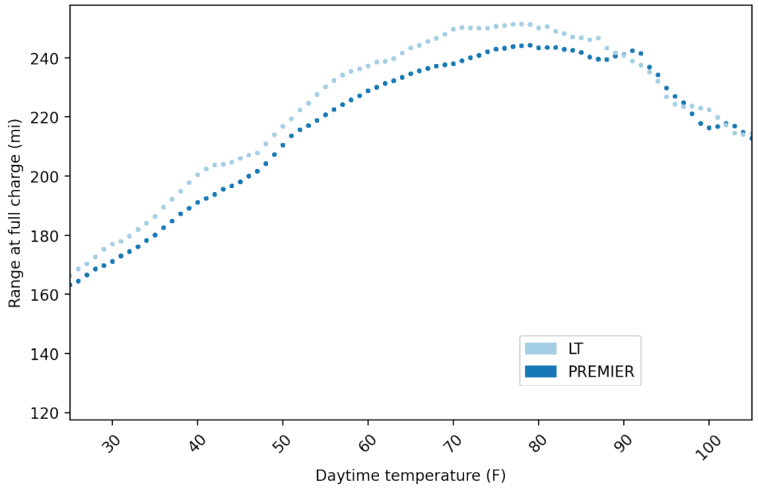
Outdoor Temperatures

“Why does my range drop when it’s cold?” is one of the most common questions we hear so we wrote an **article** about it. Summary: cold weather tends to slow the chemical and physical reactions that make batteries work, and that temporarily decreases short term range.

Hot and cold outdoor temperatures also make drivers rely more on heating and air conditioning, which can use a lot of energy. Some vehicles have auxiliary batteries to support climate control systems that would otherwise pull energy away from the primary battery.

Consider an EV with an auxiliary battery if you live in an area with extreme temperatures.

This chart plots the ranges of 1,000 Chevy Bolt models (LT and Premier trims) at different temperatures. You can see that some range is lost at both low and high temperatures.



Long Term Range Loss

Some aspects of long term range loss are unavoidable as batteries naturally degrade over time. As EV owners, we can both add and avoid certain steps to maximize the battery lifespan so our cars can drive farther, longer.

The main way that a lithium ion battery degrades is called capacity fade, due to loss of active material in the battery. Loss of active material is just a fancy way of saying there is less surface area available inside the battery for lithium reactions on the electrodes.What types of things cause long term range loss?

Depth of discharge

High heat

Frequent fast charging

LONG TERM RANGE LOSS

Depth of Discharge

Lithium ion batteries are sensitive to something called depth of discharge, or how much battery you use in between charging. In other words, the difference between your starting and ending state of charge when you use your EV. Using smaller depths of discharge can help preserve battery health, including lifetime, capacity and power

The takeaway here is that rather than using 50% of your battery before recharging, you might use 20% of the battery, charge, and then use another 30%. Of course, only do this if and when it works for your lifestyle!

LONG TERM RANGE LOSS

High Heat

Heat affects EVs in two key ways:

Storing an EV in high heat. A process known as calendar aging refers to battery degradation that happens regardless of use. It is largely due to growth in the protective layer around the anode. At high temperatures, reactions happen faster and its protective structure can degrade.

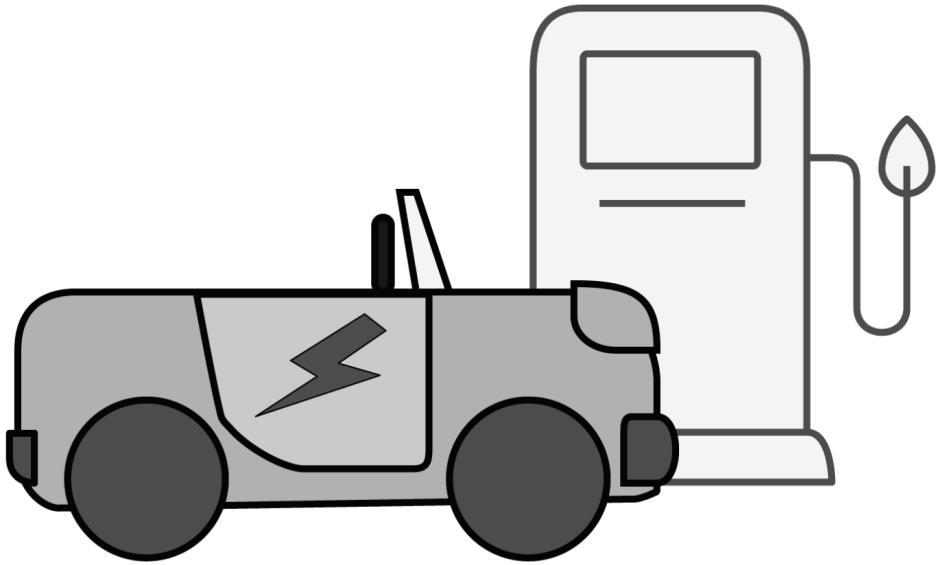
Charging an EV in high heat. High temperatures increase the effective force of the electric current that drives lithium ions from one node of the battery to the other, causing physical stress and damage on the receiving end. The higher the temperature, the more stress fractures and damage the battery node experiences.

One particular consideration in terms of temperature and range is how your battery temperature is regulated. Many EVs, such as those from Tesla and Chevrolet, use liquid for thermal control and are generally able to regulate hot battery temperature better than vehicles that use passive air to cool batteries. Depending on the temperature variation in your region, you may want to consider the battery thermal management system for the longevity of your car.

LONG TERM RANGE LOSS

Frequent Fast Charging

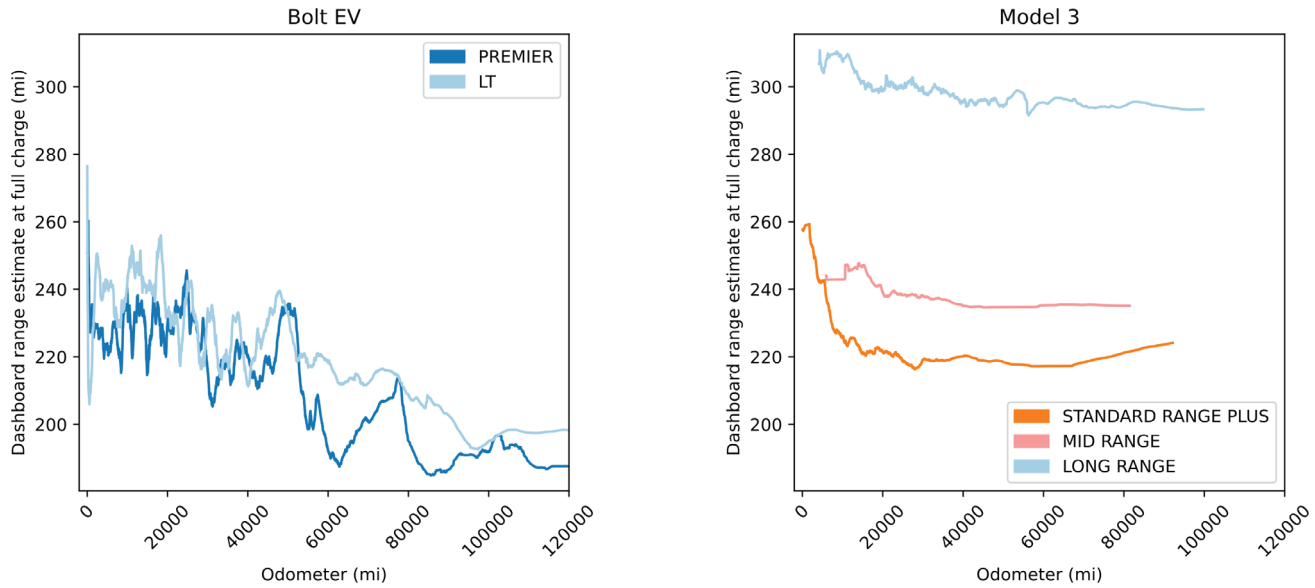
Similar to high heat, higher voltages generally lead to faster reactions. This often means that the “unwanted” chemical reactions that make batteries degrade happen faster, although studies are not conclusive on the magnitude of fast charging effects. Using laboratory experiments on single battery cells as a guide, many experts suggest using fast chargers only occasionally or when necessary for road trips.



Range Loss Over Time

It depends. Our initial studies have found that an EV like the Chevy Bolt or Tesla Model 3 lost 20-40 miles of range in the first 20,000 miles before degradation leveled off. After this, the battery degrades much more slowly. Battery degradation tends to follow an S-curve, where more range is lost in the earliest and latest stages of battery life.

This chart compares rated range at 100% charge against odometer mileage for the Chevy Bolt (left) and Tesla Model 3 (right).The initial drop-off in range is typical for all electric vehicles and indicates that the battery is settling into its steady state.



CONCLUSION

Used EV Battery Health

An EV battery is the most expensive part in a car but it is both literally and figuratively a black box. It can be difficult for used car shoppers to check the battery before buying a car.

The best possible way to assess battery health would be to remove it from the car, ship it to a lab, and perform chemical testing. If that sounds costly, it would be!

The next best option is through machine learning: comparing one vehicle to many others. Recurrent has thousands of EV drivers who anonymously share a few data points each day and we aggregate that information to help all drivers understand their cars.

That includes EV shoppers. If you are shopping for an electric car check out our **shopping tool** to learn more.