TVA EnergyRight®

Know EVerything:

Your guide to electric vehicles.

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Hello, friends and neighbors!

If you're reading this guide, you're probably considering purchasing an electric vehicle. And if you're anything like the EV owners we've talked to, you probably have plenty of questions! We get it: The EV world changes quickly and it can feel a little overwhelming. That's why TVA EnergyRight decided to launch the Driving EVolution blog series featuring research-driven, informative articles about electric vehicles.

And guess what? Our initial posts were so well received that we decided to create an EV buyer's guide.

Welcome to the EV world.

In 2020, TVA began working with a broad coalition of partners to increase the use of EVs in the region and to pave the way for more than 200,000 EVs on the region's roads by 2028.

Why is TVA paving the way for EV adoption? We're doing this because making the switch to EVs could save the region's drivers millions in gasoline and scheduled maintenance costs, and dramatically reduce carbon emissions across the region. Electric cars can also fuel investment in local jobs and keep refueling dollars—from locally produced electricity—in our communities. On top of all that, the Tennessee Valley region is already one of the top EV manufacturing hubs in the country, with plenty of room to grow.

We also know that big changes—like purchasing a vehicle that runs on electricity instead of gasoline—can lead to big questions. And that's why we're doing our best to provide unbiased answers to your pressing EV questions.

Enjoy the ride with us!
– The TVA EnergyRight® EV Team

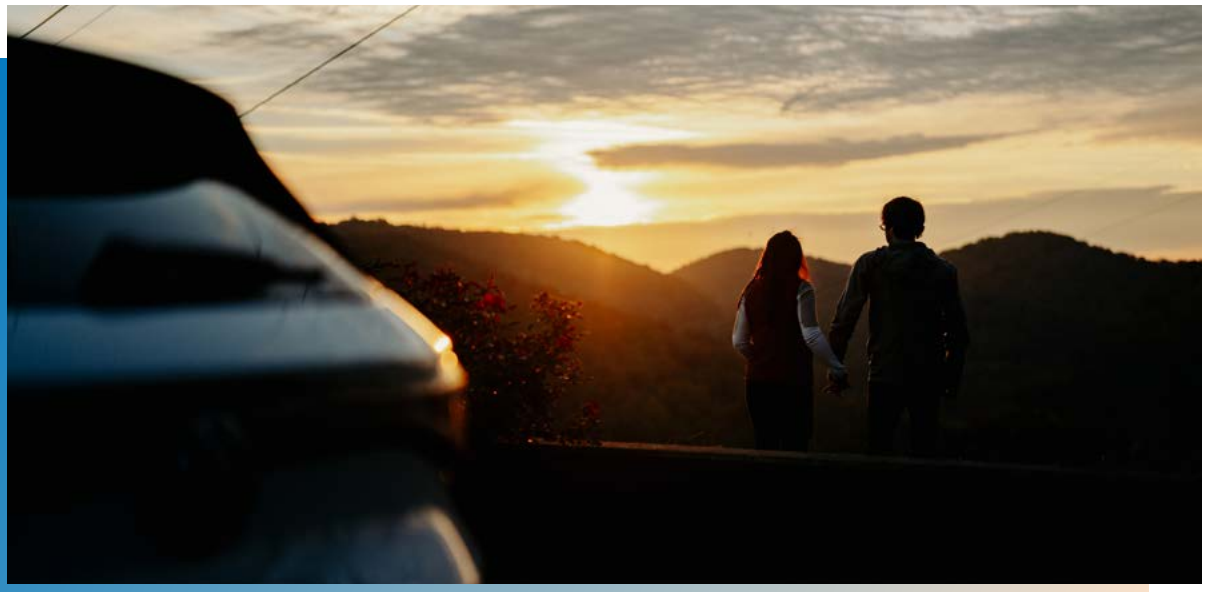
About the author: The TVA EnergyRight EV Team works diligently to make sure the people of the Tennessee Valley region have fact-based information about electric vehicles so they can decide how EVs fit into their lives. TVA is collaborating with state agencies, local power companies and other partners to pave the way for EV adoption in the region. This includes developing the Fast Charge Network, which will place public fast chargers at least every 50 miles along the interstates and major highways across TVA's seven-state service area by 2026.

DRIVING EVOLUTION DRIVING EVOLUTION

CHAPTER 1

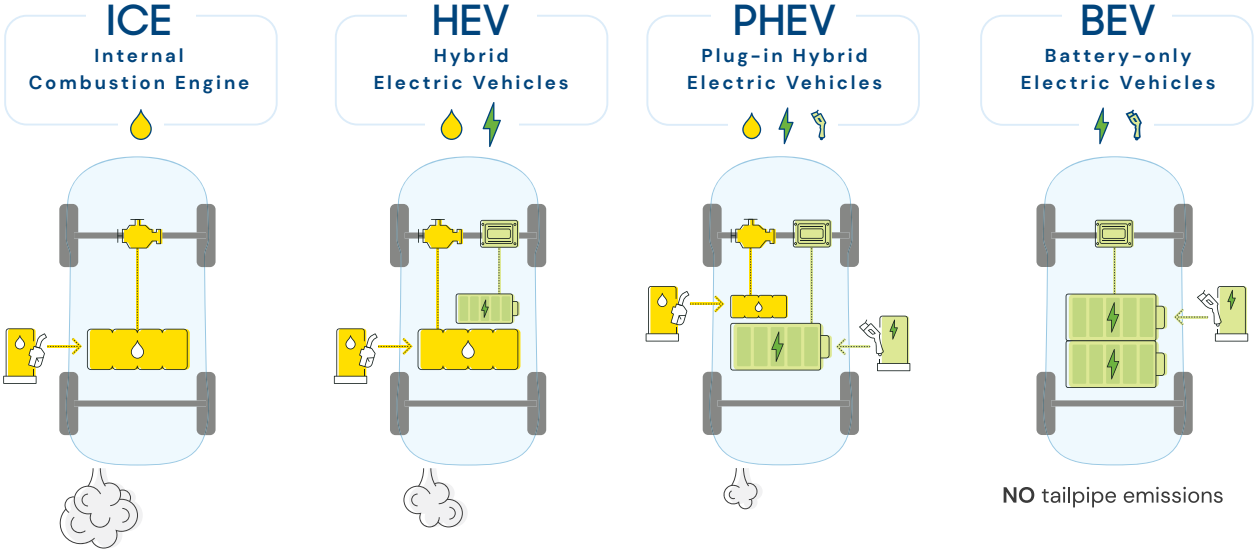
EV 101

Your guide to the different types of electric vehicles.



For the purposes of this guide, we're focusing on on-road cars, trucks and SUVs. However, be sure to visit EnergyRight.com/ev/evblog for posts about electric bikes, agricultural equipment, recreational vehicles and more!

TYPES OF DRIVETRAINS



Battery-only electric vehicles: BEVs (aka EVs)

Also known as "pure," "full" or "all-electric" cars—or, more commonly, if not a little confusingly, EVs. A battery-only EV uses only electric power for propulsion. This means zero tailpipe emissions and lower scheduled maintenance costs. Plus, BEVs have the potential to be insanely quick off the line.

Pros:

- Zero tailpipe emissions.
- Less maintenance.
- Better performance and power delivery.
- Quicker "off-the-line" 0-60 speeds.
- More efficient than gas-powered cars.
- Uses locally produced electricity.
- At-home charging convenience.
- Select models can power your home during outages.
- Long-lasting, reliable batteries.
- Federal tax credits may be available.

Cons:

- People are generally less familiar with owning and driving an EV.
- Longer trips require planning for refueling stops at public charging stations.
- Heavier vehicle weight (and faster acceleration) may lead to faster tire wear.
- New EVs may still cost more than a similar internal combustion engine (ICE) vehicle.

Plug-in hybrid electric vehicles: PHEVs

Think of a PHEV as the middle ground between an all-electric and a conventional hybrid. Like all EVs, PHEVs use a rechargeable battery, electric propulsion and regenerative braking to improve fuel efficiency, reduce total tailpipe emissions and minimize wear and tear on brakes.

Unlike battery-only EVs, however, PHEVs can also rely on a gas-powered internal combustion engine (ICE) for propulsion.

Pros:

- Capable of covering the average commute on battery power alone.
- Generally more fuel efficient than a regular hybrid.
- Capable of long-distance gas-powered driving.
- At-home charging convenience.
- Federal tax credits may be available.

Cons:

- Maintenance is the same as a gas-powered car.
- Smaller batteries mean shorter all-electric driving ranges.
- Burns fossil fuels.
- Produces tailpipe emissions.

Hybrid electric vehicles: HEVs

Also known as “conventional,” “self-charging” or “mild” hybrids, these EVs use gas-fueled engines and electricity-fueled motors. Hybrid vehicles—like the Toyota Prius—are very similar to PHEVs, with one critical difference: You don’t plug it in to refuel with a charge.

Pros:

- Better fuel economy than most gasoline-powered vehicles.
- No changes to your driving habits or lifestyle.
- Regenerative braking may increase the lifespan of your brakes.

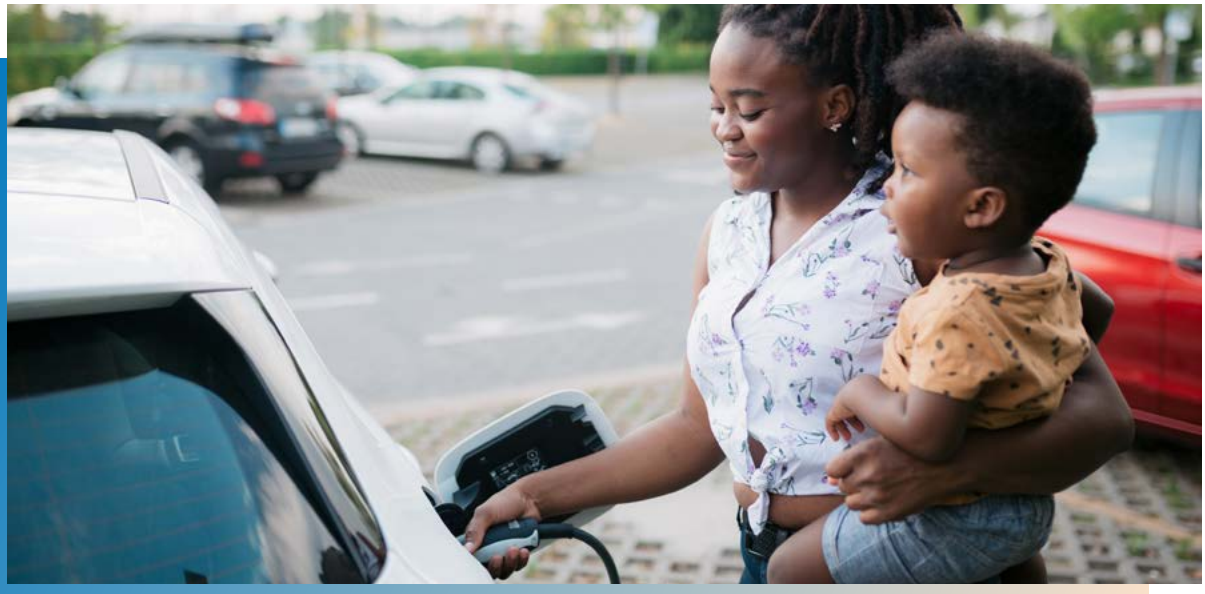
Cons:

- Maintenance is the same as a gas-powered car.
- Burns fossil fuels.
- Smaller batteries limit the electric-only range.
- Lacks at-home refueling/charging convenience.
- Less efficient than electric vehicles.

EV FAST FACT

Regenerative braking lets EVs and hybrids store energy in the battery so you can use it later when you hit the accelerator.

SOURCE: How-To Geek



Busting EV myths: fiction vs. fact

Fiction	Fact
EVs are boring and lack performance.	EVs are quicker 0-60 mph than many of their gas-powered counterparts.
EVs are worse for the environment than gas-powered cars.	EVs produce zero tailpipe emissions and fewer overall greenhouse gas emissions.
EVs lack range.	Most modern EVs have 200+ miles of range.
EVs are too expensive.	On average, EVs cost just 4% more than gas-powered cars, but incentives, lower fueling costs and lower scheduled maintenance costs more than offset the additional up-front expense.
EV charging is inconvenient and costs too much.	More than 80% of EV owners charge their vehicles at home. In all 50 states, it's cheaper to charge an EV than fill up with gasoline.

How do I choose an electric vehicle that's right for me?

For some, buying a new (or new-to-you) car is tons of fun: Test drives! New car smell! Fun features! Other drivers simply see the whole car-buying process as a fearsome chore.

We can't change how you feel about buying a car, but we *can* shed some light on how to choose an EV that's right for you and make your decision-making a little easier.

In many ways, a car's a car and buying an EV isn't all that different. However, if you're in the market for your first EV, there are a few fundamental differences between buying a gas-powered car and an electric-powered one. We'll help you wrap your head around those differences so you can hit the sales lot with confidence.

Identify your must-haves.

As more and more electric makes and models hit the market, it's becoming easier to find a car that fits your lifestyle. Ask yourself: Where do I drive? What do I like about my car? What do I dislike? How do I drive? What do I need to carry?

If you're using the car primarily for local commuting, your options range from affordable compact sedans to luxury trucks and SUVs. If performance is your priority, premium EVs can offer instant gratification and some of the quickest 0-60 times on the road. If you often travel long distances, look for a longer-range battery-only EV. You may also want to consider the additional range flexibility that a plug-in hybrid or hybrid affords.

Tune in to your driving experience.

EVs function just like any other car you've ever driven: You buckle in, start it up and drive to your destination. But they *perform* very differently.

Gas-powered cars take some time to build up maximum power and torque. EVs, on the other hand, hit peak power the moment you put the pedal to the metal. This instant torque makes EVs feel lively and quick. Some can even accelerate from zero to 60 in less than three seconds. If "fun to drive" is what moves you, be sure to check out acceleration times.

If acceleration isn't your driving motivation, you'll find that even the most modest and affordable EVs have plenty of pep for daily driving.

Know your EV lingo.

Be sure to skim through the glossary on page 52 before you hit the sales lot. Better yet, take this guide with you as a handy reference!

Determine your range requirements.

How much range you need may dictate your EV search. To get a solid sense of your range requirements, keep track of how much you drive each week. Most EVs can travel over 200 miles on a single charge, while some of the premium models top out at around 400 miles.

Several EV owners we've chatted with encourage potential buyers to figure out how much range they need to get through the week on a single charge, and then add about 20% as wiggle room. So if you regularly drive 175 miles each week, look for an EV with a range of at least 210 miles.

Make a list.

You don't strictly *have* to make a list, but we're big fans of them. You can use the worksheets on page 62 to jot some notes, or you could go crazy with a spreadsheet. The choice is yours!

Find a dealer you trust.

If you're shopping for your first EV, you'll probably have lots of questions. Look for a dealership that advertises its electric vehicle offerings and for salespeople who understand EVs and can guide you through the car's features with confidence. Be sure to ask them whether or not the car is eligible for the federal tax credit, which changed in 2023.

Remember, you're the customer! If you're not clicking with the dealership or salesperson, visit another showroom or ask for a different representative. For those in the market for a pre-owned EV, consider finding a reputable online retailer like MYEV.com or Carvana.

Head out for a test drive.

The best way to find an EV that sparks some joy is to get behind the wheel. Make a list of your top contenders and have some fun figuring out which EV is right for you. (Interested in a long-term test drive? Be sure to check out Chapter 5.)

Visit **EnergyRight.com/ev/find-an-ev** and use our Find an EV or Compare Vehicles tools to get your list started.

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CHAPTER 2

Get charged up

Get plugged in to the different EV connectors and charging levels, installation and equipment.

What's the deal with all the plugs?

The charging plug—or connector—is the part of the charger you hold in your hand and plug into the car. Once it's securely plugged in, current flows into the EV's battery and begins charging it up. It's like plugging in your TV, but on a much bigger, differently shaped scale.

COMMON EV CONNECTORS

J1772

Combined Charging System (CCS)

North American Charging Standard (NACS)

In the pioneer days of electric vehicles, *every* manufacturer had a proprietary plug. Needless to say, things were a little plugged up. Fortunately, the frontier has been (largely) settled. Here in the United States, manufacturers are circling the wagons around a couple of different types of plugs.

As of publication, most EVs on the road have a combination of the SAE J1772 and a combined charging system (CCS) connector in the same location. These charging systems are approved by the Society of Automotive Engineers (SAE). The top half enables Level 1 and Level 2 charging (see page 14 for more on charging levels) and the bottom half adds DC fast charging capabilities.

However, the SAE J3400 North American Charging Standard (NACS)—what was formerly Tesla's proprietary plug—is gaining traction in the U.S. The NACS plug also supports both AC and DC charging.

From June 2023 through February 2024, major automakers including BMW Group, Fisker, Ford, General Motors, Honda, Hyundai Motor Group, Jaguar Land Rover, Lucid Motors, Mercedes-Benz, Nissan, Polestar, Porsche, Rivian, Subaru, Stellantis, Toyota, Volkswagen and Volvo Cars all announced that they would equip their North American EVs with NACS charge ports from the factory starting in 2025. They will also offer adapters for existing vehicles with CCS ports.

Many charging station companies, like Blink Charging, ChargePoint, EVgo and Tritium, have already announced support for NACS as well. They will soon offer NACS connectors on their DC fast chargers.

If you're buying a used Nissan or Mitsubishi electric car, it *may* have a CHAdeMO connector. Most automotive manufacturers are phasing this connector out. As a result, it may be harder to find public fast charging options for CHAdeMO-equipped cars in the future. At this time, TVA's Fast Charge Network sites will continue to support CHAdeMO connectors and CCS, and will work to accommodate additional charging plugs as automakers adopt the various standards in the future.

Check your charge.

Charging Basics: Get to know the three levels of EV charging.

- **Level 1:** Chargers that plug into a regular 120-volt home outlet. Charge time: 10-20+ hours.
- **Level 2:** 240-volt chargers (like a dryer outlet) can fully charge an empty battery-only EV (BEV) in 4-10 hours.*
- **DC Fast Charging:** Typically found at public locations like malls or retail centers and off interstate highway exits. They're intended for short stops on long road trips and can fill up a low battery in 15-45 minutes.

*Assuming a 60 kWh battery

CHARGE ANYWHERE

Home charging
Level 1 Charging

CHARGING TIME
10-20+ hours

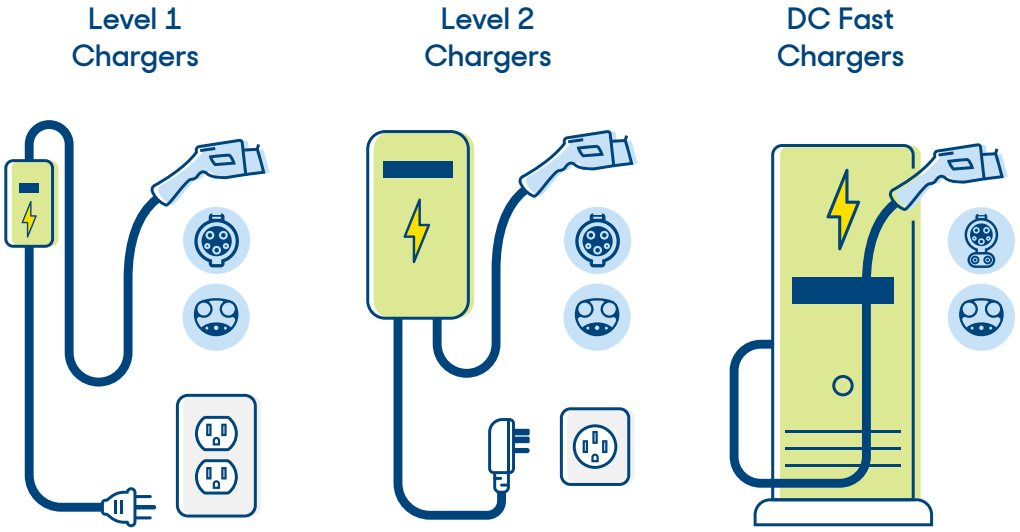
Home, restaurants and hotels
Level 2 Charging

CHARGING TIME
4-10 hours

Interstates, public and retail charging
DC Fast Charging

CHARGING TIME
15-45 minutes

EV CHARGING LEVELS



EV CONNECTORS

Every mass-market electric vehicle or plug-in hybrid can be charged with a **Level 1** charger by plugging the charging equipment into a regular wall outlet—just like your television or hair dryer! It will get the job done and it's the most economical charging solution, but it's also the slowest way to charge an EV. However, if you routinely drive less than 30 miles a day and can consistently plug in every night or two, this may be the lowest-cost charging option for you. It adds between three and five miles of range per hour of charging.

Most EV drivers recommend having a **Level 2** charger professionally installed at your home. A Level 2 charger can plug into the same kind of outlet as your clothes dryer. Or, even better, you can skip the plug and have your charger hardwired directly to your electrical panel. Level 2 chargers can easily charge your car overnight, adding 100–200 miles of range while you sleep.

WAKE UP CHARGED UP.

With a **Level 2 charger**, you can plug in your nearly depleted EV when you get home from work and take your first sip of morning coffee with the satisfaction of knowing that your battery is topped up and ready to whisk you away.

Public **DC fast charging** stations are available for longer road trips and can add 100-200 miles to your battery in 30 minutes or less.

Charging your EV at home: Fueling where you live.

EV drivers in the Tennessee Valley region have plenty of good things to say about their vehicles and aren't shy about sharing their enthusiasm. Those who like to get from point A to point B quickly are thrilled by instant torque. Others are delighted by the fact that their cars produce zero tailpipe emissions. Everyone appreciates the lower overall cost of ownership and eliminating costly trips to the gas station.

Our region's low electricity rates mean that home charging is a great way to save on fuel costs.

Nearly everyone we spoke to had good things to say about the convenience of charging their EVs at home. Plus, the cost of our region's clean, reliable electricity remains lower than 70% of the nation's top 100 utilities. When you use TVA's nearly 60% carbon-free and locally produced electricity to fuel your car, truck, motorcycle or bicycle, filling up at home makes good financial sense—and it's good for the local economy.

How much does it cost to charge an EV at home?

Residential electricity rates in our region are among the lowest in the country, which means that EV owners in the Valley save more than $20 per refueling!

Use this formula to estimate how much fueling up with electricity will cost you:

# miles per day	x	30 days per month	x	# kWh kWh per mile*	x	0.068331** base rate	=	$$ per month electricity use

* Find miles per kWh for common EV makes and models on pages 63-64. Note: mi/kWh = 1 ÷ (kWh/mi)

** Example: Middle Tennessee Electric residential (discounted, off-peak consumption plus fuel cost adjustment) rate as of 4/30/24.

Can my home handle an EV charger?

This is a question we hear *a lot*.

Consult with a certified electrician who can take a look at your electrical panel and service. In some instances, they'll easily identify spare electrical capacity (amperage) and breaker space. If that's not the case, they'll likely have a few recommendations that'll work for you.

Possibilities may include:

- Exploring smart energy devices that can share power between existing appliances, like your clothing dryer and your EV. (Encourage your electrician to check with local code officials when they pull a permit for your EV charger installation.)
- Choosing a lower-power (lower-amperage) charger.
- Upgrading your wiring and electrical panel to accommodate a higher-power (higher-amperage) charger.

Home EV charger installation.

Technically speaking, a charger isn't a charger.

Did we just blow a fuse?

That Level 1 or Level 2 charger in your neighbor's garage and that fast charger around the corner from your office is *actually* a device known as electric vehicle service equipment (EVSE). Just rolls right off the tongue, doesn't it?

The National Electronics Manufacturers Association (NEMA) tells us that although an EVSE is a more accurate name, most people are going to refer to that device as a "charging station" or "EV charger."

And once you get past this explanation, so will we. Still, curious minds may want to know why an EV charger is also known as an EVSE.

For starters, the *charger* is actually built into the vehicle itself. The EVSE—that thing you plug into the wall outlet and will likely continue to call a charger or charging station—is essentially a very sophisticated extension cord with built-in safety features.* Among other things, the EVSE tells the vehicle's internal charger how much power is available and then sends the current to the car.

*WARNING: NEVER use a conventional extension cord to charge your EV. Use only certified EV charging equipment.

For peace of mind, you'll want to find a certified electrician you can count on. Some electricians are certified by the Electric Vehicle Infrastructure Training Program (EVITP). You can search the organization's website to find a technician.

You may also be able to find trained installers through Qmerit, a company that connects automakers, technology leaders and service providers to EV owners. Automakers, dealers and EVSE companies like EvoCharge or ChargePoint may also be able to point you in the right direction. If the electrician is not certified by EVITP or a charger manufacturer, consider asking potential contractors how many EV chargers they've installed. This may give you a better sense of their level of expertise. And don't forget to ask for references!

If you're ready to pull the plug and purchase an EV, consider starting the charger installation process before you bring your new baby home. The installation process may take up to eight weeks, depending on the contractor, installation complexity and equipment availability.

How much does it cost to install a home EV charger?

Charger costs can vary widely. At the time of this guide's publication in 2024, Level 2 chargers listed on the EnergyRight Efficient Choice Marketplace ranged from $299 to $699, with an average price of $518.

According to Qmerit, an EV charging installer recommended by dozens of EV manufacturers, a typical home installation can cost anywhere from $800 to $2,000, depending on job complexity, charger power and the distance between the electrical panel and the charging station.

Charger Amperage	Required Circuit Breaker Size	Charger Power Output	Estimated Driving Range Added per hour of charging
16A	20A	3.8 kW	12 mi
24A	30A	5.7 kW	18 mi
32A	40A	7.6 kW	25 mi
40A	50A	9.6 kW	30 mi
48A	60A	11.5 kW	36 mi
80A	100A	19.2 kW	60 mi

SOURCE: InsideEVs.com

How many kilowatts do I need?

MotorTrend recommends 9.6 kilowatts (40 amps), noting that it will add about 29 miles per hour of charging for midsize crossover SUVs. The more kilowatts (or amps) your charger can deliver, the faster your EV battery can charge.

However, the car itself will determine the final charging speed, no matter which charger you buy. In some instances, higher-power chargers won't necessarily charge your EV more quickly. Check out the table above to get a sense of how quickly charger amperage and power output impact charging times. But remember: There's no benefit to buying a charger that exceeds your car's charging capabilities.

Hardwiring vs. plug-in installation

Although using a NEMA 14-50 outlet (like your dryer outlet) allows you to unplug and take your charger with you if you move, most installation pros recommend hardwiring your home charger. However, if you take the plug-in installation path, use a commercial-grade plug designed for charging. Inexpensive residential outlets are not intended for 8-12 hours of EV charging and may overheat.

Choosing a Level 2 charging station.

A Level 1 charger is typically included when purchasing an EV. Some manufactures offer Level 2 chargers as well. However, if your car doesn't come with one, and you find yourself in the market for a Level 2 charger, you can visit the EnergyRight Efficient Choice Marketplace and search for EV chargers by Enervee Score®, brand, cost, customer reviews, features and more. Don't worry! We'll break it down for you so you can shop with confidence.

Enervee Score®

This score shows you how energy efficient a product is compared to all the other products in the category. The closer to 100, the more efficient the charger. (That is, chargers with a rating close to 100 use less energy to fill up your battery.) For EV chargers, the score is based on a combination of smart charging features and savings from electrical losses.

Home EV charging station make and model

With so many options available, it can be tough to figure out which home charger is the best. And what's best for you and your EV may not be the best option for your neighbor. To find the right home EV charging station, we recommend reading customer reviews on the Marketplace and checking out independent reviews from trusted sources like MotorTrend, Wirecutter, EVChargingStations.com or Consumer Reports.

Whatever model you choose, just make sure it has a certification sticker identifying the Nationally Recognized Test Laboratory that completed UL Solutions' safety standards testing. This certification ensures that the equipment has been tested rigorously for safety. You can also look for an ENERGY STAR certified charging station, as they're required to be listed to UL Solutions' standards.

SAFETY CERTIFICATION MARKS

Cost

Although you can sort chargers by price, we don't recommend this method—as tempting as it is! Purchasing a new car is a long-term investment and your choice of charging equipment should be, too. You should be able to choose a high-quality charger within a $500-700 range. To maximize your enjoyment, select a charger that's efficient and well reviewed, has the features you need and is built to fit your charging location.

NEMA electrical enclosure rating and ingress protection

The National Electrical Manufacturers Association (NEMA) defines the standards used for electrical enclosures. NEMA-rated enclosures help protect against accidental access to dangerous components and environmental hazards like water or dust. The ratings help define the types of environments (indoors or outdoors) in which an enclosure can be used.

Ingress protection (IP) ratings are defined by the International Electrotechnical Commission (IEC) and certify that an object is able to withstand a certain and specific amount of exposure to solids (like dust) and liquids (like rain). The higher the IP rating, the better protection it offers against the elements. In other words, look for an IP rating of 5 or 6 if you're installing your charger outside.

When professionally installed and used according to the manufacturer's directions, yes, EVs are designed to charge safely in rain, snow or ice. Just be careful out there on those slippery roads!

Popular EV charging features

Not only is a Level 2 charger the fastest way to charge your EV at home, but these chargers usually come with more handy features than your standard Level 1 charger. Keep these charger features in mind as you shop:

Wi-Fi connectivity: This gives you the ability to monitor charging remotely and receive alerts delivered to an app on your phone.

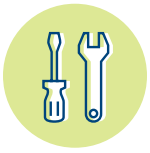
Amp output (max power) capability: Depending on your vehicle, you may benefit from higher (or lower) output capabilities.

Managed charging: Programming your charge times ensures that your vehicle is charged up when you need it. Plus, when you program your charging to occur during off-peak times—when energy is cheaper and readily available—you can help support a more reliable and resilient power grid.

Cord length: Do you need a charging cord that's long enough to span a two-car garage?

Cord management: This one's for you, neat freaks. Some folks don't mind messy cords. Others can't stand an undressed cable. If you don't know what "cable dressing" is, don't worry too much about cord management. If you're nodding your head in reverent appreciation here, look for a charger with a built-in cord management system.

Smart assistant integration: Some chargers connect with digital assistants like Alexa or Google Assistant.



Installation: Level 2 chargers may have multiple installation options, like 14-50 plugs (like your dryer outlet plugs) or 6-50 plugs. However, they're only good up to 50 amps. If you want a higher-power charger, you must have it hardwired to your electrical panel.

Visit the EnergyRight Marketplace to find a Level 2 home charger that works for you: EnergyRight.efficientchoice.com/ev-chargers

Destination charging: Fueling up on the go.

When it comes to EV chatter, there's usually a lot of talk about the public charging infrastructure. While it's a very valid discussion, it detracts from the fact that most charging—and the most cost-effective charging—happens at home. A recent J.D. Power report, "Level Up: Electric Vehicle Owners with Permanently Installed Level 2 Chargers Reap Benefits from Their Investment," noted that 88% of EV owners say they charge their vehicle at home "often" or "always."

EV PRO TIP

Going on a long EV road trip? Use mobile apps to find charging stations along the way.

Still, when there's a road trip on your calendar, it's good to have a map of Level 2 and DC fast chargers in your pocket!

Meet the Fast Charge Network

TVA is collaborating with state agencies, local power companies and other partners to pave the way for EV adoption in the region. This includes developing the Fast Charge Network, which will place public fast chargers at least every 50 miles along the interstates and major highways across TVA's seven-state service area by 2026.

Joining a charging network is another great option. Charging apps offered by manufacturers or third-party charging networks like ChargePoint, Chargeway, EVgo or PlugShare can help you make sure the charger you're heading to has the connector you need and if they're available to start charging.

You can find charging stations in our region on our website at **EnergyRight.com/ev/charging**.

Charging etiquette

It all boils down to this: Treat others as you want to be treated.

Charge at charging stations, don't park at them.

Parking at a charging station is a lot like parking at the gas pump and then sitting down with a Big Mac for half an hour. You've seen people do it, but don't be those people!

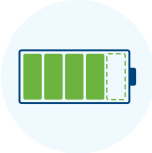
We know that parking is a bear, but unplug and move your car away from the charger as soon as your app tells you that you're charged up or that you've hit your charging target.

Charge in the *right* spot.

Park it in the spot that's closest to the charger rather than looping the charge cord into an adjoining space. You may have to back in, but that's what backup cameras are for!

Charge at the right station for your car.

If you're driving a car that can accept a charge up to 50 kW, don't charge at a station that puts out 350 kW. Most charging stations clearly display their maximum capability, just like octane levels are displayed at the gas pump.



80% is A-OK!

Most EV charging slows down significantly when the battery hits an 80% charge. This protects the battery from the heat that's generated by fast charging. If there's someone waiting, call it a day. If there's no one in line, feel free to hang out until you hit 95%.

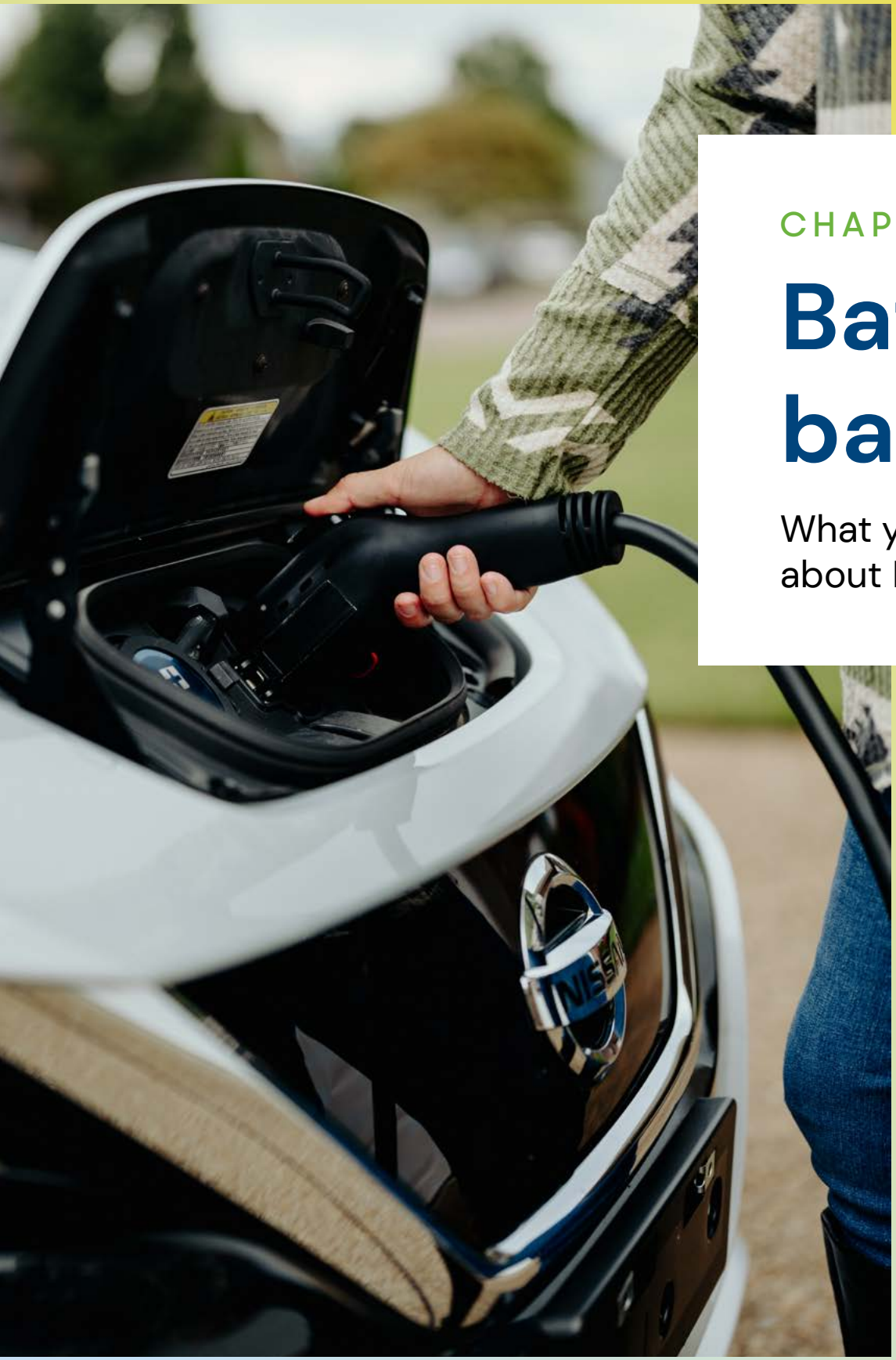
Don't cut the line.

Take note of the cars around you and make sure there aren't any other EV drivers waiting around for a charge.

Don't unplug someone else's car.

It's not your car. It's not your charger. Be patient and give people a few minutes of grace.

WARNING: Do NOT remove a plug that's locked into a charging port. You could damage the car and the cable—leaving you with an irate owner and a thirsty battery.



DRIVING EVOLUTION DRIVING EVOLUTION

CHAPTER 3

Battery basics

What you need to know about EV batteries.

What's the standard EV battery warranty?

Federal law mandates that manufacturers offer at *least* eight years or 100,000 miles of EV battery warranty coverage; however, some manufacturers offer a 10-year warranty.

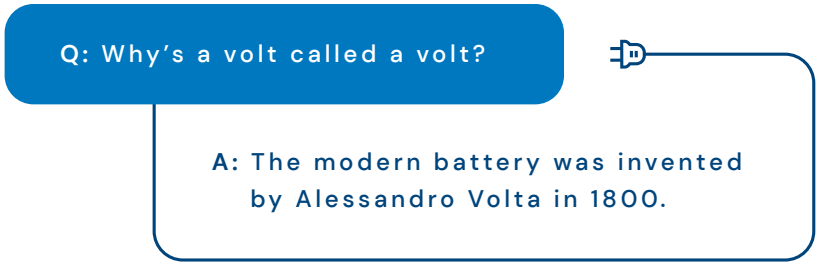
How does an EV battery actually work?

Have you ever wondered how EV batteries get the job done? You're not alone! Fortunately, you don't need to know exactly how an internal combustion engine works in order to drive your car or motorcycle. If that were the case, there would be plenty of us looking for alternative modes of transportation.

Although we don't necessarily *need* to know how EV batteries work, many of us not-so-secretly *want* to know.

An electric vehicle—whether you're talking about a truck, personal watercraft or bicycle—uses battery packs to store electrical energy to power the motor (or motors) connected to the wheels.

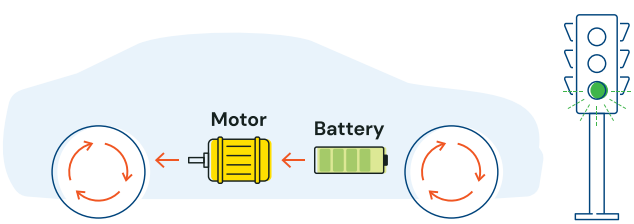
For your daily dose of trivia: The modern battery was invented by the Italian physicist Alessandro Volta in 1800.



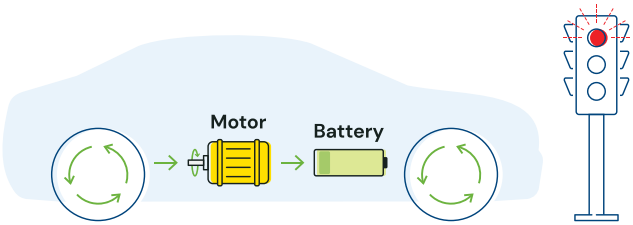
What does regenerative braking have to do with an EV's battery?

EV batteries are charged by plugging the EV charger's cord into the vehicle's charging port. They can also gain charge from regenerative braking systems. "Regen" braking systems are unique to EVs. They turn a vehicle's kinetic energy (energy that relates to motion) back into electric energy. This transformation occurs during braking, decelerating or coasting downhill. Plus, these systems also dramatically reduce wear and tear on a vehicle's braking system.

HOW REGENERATIVE BRAKING WORKS.



Energy is **consumed** during acceleration.



Energy is **reclaimed and stored** during braking, deceleration or coasting downhill.

What's the AC/DC deal?

Before we go too far down the charging path, let's hit the basics: AC stands for alternating current. DC is short for direct current.

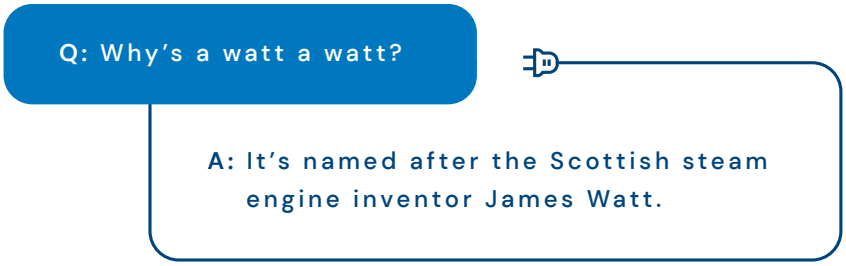
Alternating current describes the flow of electricity. Simply put: With AC, the current changes (alternates) direction every 60 seconds in the U.S. The alternating current makes sending electricity over long distances (like from the power plant to your home) more efficient. AC is used in your home and at most commercial locations. AC powers Level 1 and Level 2 EV chargers.

Q: Who was involved in the "War of the Currents"?

A: Thomas Edison (team DC) and Nikola Tesla (team AC).

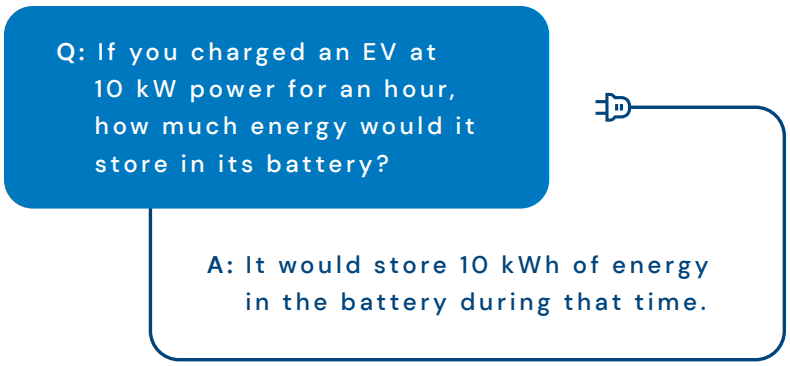
Direct current provides constant voltage and the current flows in one direction. It doesn't change or vary over time. DC powers EV fast chargers because the direct flow of current—delivered directly to the battery—can charge more quickly.

Kilowatts and kiloWHYs.



So what's a kilowatt (kW) and why do kilowatt hours (kWh) matter?

A kW is 1,000 watts, a unit of measure for power. Power tells us how fast energy is moving at any moment in time. A kWh tells you how many of those units are consumed in an hour.



Why do we care about kilowatts and kilowatt hours? Because they can help tell us how much it will cost to charge an EV.

miles per day **x** **30** days per month **x** **#** kWh kWh per mile* **x** **0.09621**** base rate **=** **$$** per month electricity use

They also determine how quickly it can recharge. The higher the kW your car can accept, the faster it will charge.

* Find miles per kWh for common EV makes and models on pages 63-64. Note: mi/kWh = 1 ÷ (kWh/mi)

** Example CDE Lightband residential electricity rate as of 12/30/23.

Understanding battery capacity.

Craving another answer to kiloWHY? Look no further than battery capacity, or the amount of energy that an electric vehicle's battery pack can contain. This capacity is measured in kWh.

Battery capacity and EV range—how far a vehicle can go on a single charge—go hand in hand. Generally speaking, the greater the battery capacity (or the bigger the battery), the greater the range.

This is why some manufacturers offer different battery sizes. The Nissan LEAF, for example, offers two battery options. Its standard 40 kWh battery is EPA rated for up to 149 miles and the 60 kWh battery is EPA rated for up to 212 miles. The Ford Mach-E offers a 70 kWh standard battery and an optional 91 kWh extended-range battery.

Just as gas-powered cars and trucks have varying gas tank capacities, EV battery charging times may also vary depending on battery capacity and how much power is being delivered to the battery. Battery management systems in today's EVs automatically manage charging variables to maximize charging speed, ensure safety and minimize battery degradation.

For more on charging, be sure to check out our blogs "Blow your mind (not fuses) with these top EV charging tips" and "How do I choose an electric vehicle that's right for me?"

What are the different types of batteries used in EVs?

Nickel metal hydride

Early EVs and some hybrids use durable nickel metal hydride batteries. However, these batteries are expensive, lose their charge more quickly than modern EV batteries and are inefficient at high temperatures.

Lithium-ion

This is what many EVs on the market today use. When compared to lead or nickel metal hydride batteries, they're lighter and highly efficient.

Lead acid

Lead acid batteries, like those used to supply the electricity a gas-powered car needs to start, are *not* used to propel EVs because they're heavy and more susceptible to extreme temperatures.

Solid-state

We'll call these near future-state quick-charging batteries. They're in development right now, but some manufacturers are planning to roll them out as early as 2027. Solid-state batteries offer higher energy density, greatly extended range and faster charging times.

Can I recycle EV batteries?

Yes! Well, your car's manufacturer can. Although most EV car batteries on the road today aren't ready for retirement, automotive manufacturers are already making plans for recycling and repurposing used EV batteries.

EV batteries contain valuable minerals like lithium, cobalt and nickel—all of which can be recycled, repurposed and reused.

According to U.S. News & World Report, Tesla recycles batteries on its own and Ford, Volkswagen, Toyota, Audi and Volvo have all partnered with Redwood Materials for battery recycling. Hyundai is working with UL Solutions to create battery energy storage systems from used EV batteries.

Are EV batteries safe?

EV batteries are designed with safety features to prevent overheating, fires and explosions. However, manufacturing defects, damage and improper charging can lead to battery fires. As with any vehicle defect, manufacturers may have to issue a recall to address safety concerns.

EV PRO TIP

You can check for vehicle recalls at nhtsa.gov/recalls.

Poorly installed Level 2 chargers can also lead to safety concerns. The solution? Never use an extension cord to charge an EV. Also, hire a licensed electrician who has EV experience or is certified through a program like the Electric Vehicle Infrastructure Training Program (EVITP) to install a safety-certified Level 2 EV charger.

CHAPTER 4

Conquering range anxiety

Alleviating range anxiety.

Concerns about the charging infrastructure and range anxiety hover around the top of the list of considerations for people considering an EV. There's no way around it: For now, driving an EV on a long-distance trip requires more planning than driving an ICE-powered car.

The good news? The charging infrastructure is actively being developed, and TVA is collaborating with state agencies, local power companies and third-party charging experts to help alleviate range anxiety by creating a network of public fast charging stations at least every 50 miles along major travel routes in our seven-state region.

We're also happy to share a few tips to help alleviate range anxiety.

Locate chargers before you hit the road.

Drivers we spoke to recommend joining a charging network and taking advantage of their apps to find stations and keep a record of all your charging transactions in one place.

If you'd rather not join a network, there are plenty of other ways to make sure you stay charged up on the go. If your vehicle has connected services, its embedded navigation system can direct you to nearby charging stations. Apple Maps and Google Maps use different databases, so you may want to check a few different sources if you're planning a long-distance trip in your EV. You can also locate chargers on TVA EnergyRight's website at EnergyRight.com/ev/charging.

Although more and more public fast charging stations are coming, most people enjoy the affordable convenience of charging their EVs at home. At least 80% of EV charging happens at home, overnight. Since most EVs can handle a weekly commute with ease, owners typically charge up once or twice a week at home.

10 range-saving tips for long-distance driving.

Slow down!

Not only is it safer, but if you're in it for the long haul, it's also much easier on the battery. The faster you go, the more power you need to pull from the battery to maintain that speed.

Use eco mode.

Many EVs have a specialized setting that restricts power to power-greedy features. You won't break any land speed records this way, but you just might become a hypermiler.

Easy does it.

One of the best ways to maximize your range is to keep your driving nice and smooth. Your passengers will thank you, too. EVs are wicked quick, but rocketing to 60 in a blink uses more power than a slow and steady acceleration.

Go cruising.

Even if you're on a two-lane country road, using cruise control helps you maintain a steady speed and avoid stealthy acceleration.

Regen is next-gen.

Regenerative braking offers gentle deceleration and helps your battery grab a bite of energy. The stronger your car's regen brakes are set (see one-pedal driving, below), the more power you'll get back and the faster you'll slow down before you have to hit the actual brake pedal.

One-pedal driving.

Many EVs and PHEVs offer one-pedal driving. As you ease off the accelerator, the vehicle decelerates and coasts to a stop. Don't worry, your brake lights come on when you take your foot off the accelerator! One-pedal driving can add 13 miles to the estimated range, depending on terrain, temperature and more. Once you get used to it, you can stop and go using only the accelerator. This not only extends your EV's maximum driving range, but it also extends the life of your brake system.

NOTE: Use the standard hydraulic brakes for any emergency stops!

Eco-mapping.

Select the most environmentally friendly route option—generally speaking, the route with the fewest stops is best. Google Maps even has a fuel-efficient route option that's worth exploring.

Aero is aces.

EVs are aerodynamic marvels. For long road trips, remove anything that can cause drag, like flags, luggage racks, kayak J-hooks and bike racks. Closing your window and sealing up the sunroof also helps minimize drag and maximize your range.

Check your tires.

Tire pressure can make a huge difference in range. If they're too low, it increases friction between the tires and the road, which increases tire wear and nibbles into your range. Check the inside of the driver's door for the recommended tire pressure.

Cool it on the heating and air conditioning.

Setting the AC to arctic on a steamy day can reduce an EV's range by as much as 17% in the summer, and warming an EV's cabin can also reduce winter range significantly. Some automakers offer an eco-climate setting that you may want to turn on before you hit the road.

Tow with care.

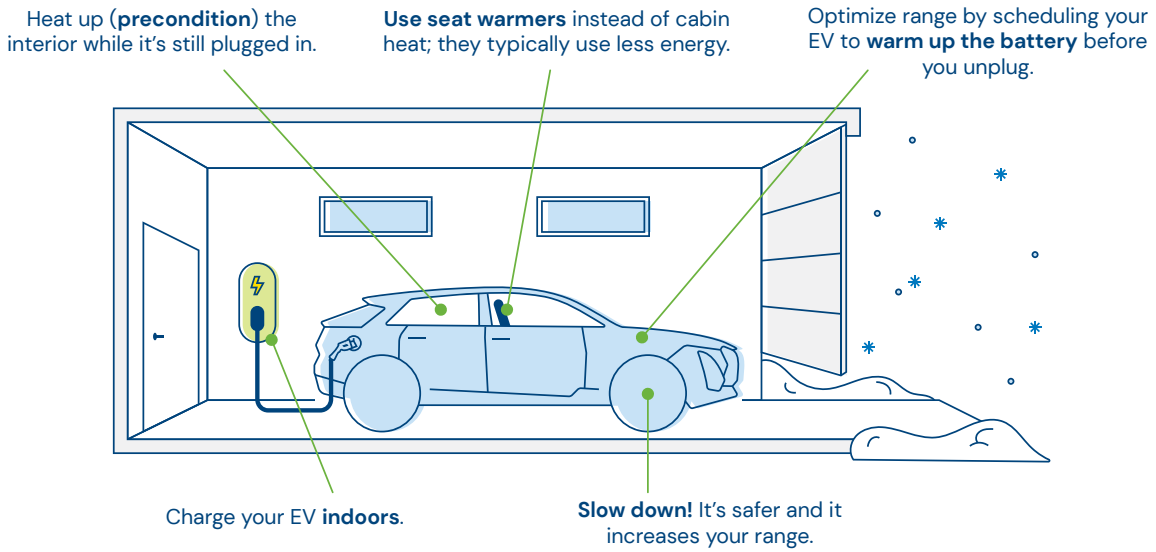
Many EVs, like the Rivian, Ford Lightning and Audi e-tron, are powerful enough to easily accommodate towing. However, honesty is one of our guiding principles, so we're going to give it to you straight: You can tow with many EVs, but towing to maximum capacity can more than halve an EV truck's driving range. So plan your power-ups accordingly.

(Of course, towing also takes a significant toll on gas mileage!)

How to maximize EV range in cold weather.

After the record-snapping cold spells of 2022 and 2024, the cold weather question is fresh on the mind. Here's the thing: All cars, gas *and* electric, use more energy in cold weather. That means lower gas mileage for ICE drivers and a shorter range (how far an EV can go on a single charge) for EV drivers.

According to Consumer Reports, extreme temperatures can reduce an unplugged EV's range by about 20%, and recharging takes longer.



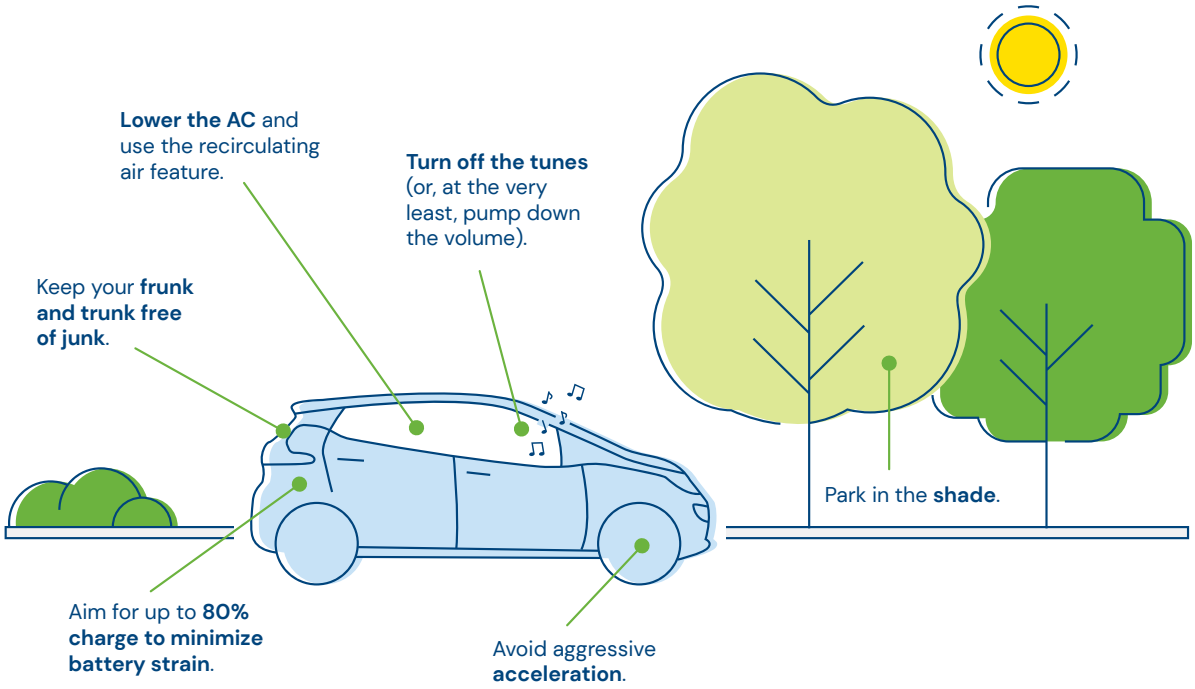
Here are a few tips for getting the most out of your EV range during extreme cold (20° F and below) temperatures:

- Charge your EV indoors.
- Precondition your cabin while the EV is still plugged in. Many EVs allow you to schedule preconditioning—EV lingo for heating or cooling the cabin—so you can climb into a toasty-warm car on a cold day without using energy from the battery.
- Allow your battery to warm up to optimal operating temperature before leaving your garage.*
- Use seat warmers instead of cabin heat; they typically use less energy, and they offer instant gratification.
- Slow down! Not only is it safer, but it increases your range. The faster you go, the more energy your EV uses, so set that cruise control and let it ride!

*Preconditioning time may vary depending on the temperature and type of EV you drive. Most EVs have a preconditioning function that you can schedule to automatically warm up the battery and cabin from the power grid instead of your vehicle's battery.

How to maximize EV range in hot weather.

Extreme heat (95° F and above) can cause a temporary drop in an EV's range. Most cars are built with heating and cooling systems to regulate their temperature to prevent long-term detrimental effects on your battery.



Here are a few tips for getting the most out of your EV range during extreme heat (95° F and above):

- Park in the shade.
- Lower the AC and use the recirculating air feature to maximize cool air and minimize energy consumption.
- Avoid aggressive acceleration.
- Keep your trunk and frunk free of junk (lighten your payload).
- Aim for up to 80% charge to minimize battery strain.
- Turn off the tunes (or, at the very least, pump down the volume).

CHAPTER 5

Test-driving and buying an EV

Five fantastic ways you can get behind the wheel and test drive an electric car.

Five fantastic ways you can get behind the wheel and test drive an electric car.

Are you wondering: "Where can I test drive an electric car and *really* get a feel for what it's like to own an EV?"

You're not alone. There are plenty of EV-interested car buyers just like you. That's why we came up with a few creative suggestions for ways that you can go for great EV test drives.

1: Schedule an EV test drive with a dealer.

Test drive an electric car with a salesperson in the passenger seat—it's a great way to get a rundown of a car's features, capabilities and technology. Whether you need a quick first impression or a final thumbs-up decision, a dealer test drive is a good way to go.

EV PRO TIP **Call a dealership and ask for their go-to EV salesperson. If they don't have one, call another dealership.**

You'll want to test drive several different EV makes and models, so start by comparing vehicles online. Visit EnergyRight.com/EV and try the Compare Vehicles or Find an EV tools to get started.

Once you've created your list of possible EV contenders, consider calling a few different dealerships and asking for their go-to EV salespeople. If they can't point you in the right direction, then *call another dealership*. Visiting a showroom with at least one salesperson who knows EVs will make for a much more productive test driving experience.

Then, schedule your EV test drive. If you're interested in more than one model, ask them to have both vehicles charged up.

EV PRO TIP **Schedule your EV test drive. If you're interested in more than one model, ask a salesperson to have both vehicles charged up.**

If you're new to the EV world and you want a clearer sense of what it's like to drive one, a dealer-approved country-mile spin may not be enough. Let the salesperson know in advance that you'd like to take the car for an *extended* test drive. That way, you'll get a feel for acceleration, performance, city driving, parking and highway handling.

If you're clearly serious about buying the car, some dealers may even let you keep it overnight.

2: Rent an EV for a test drive.

Most major car rental companies offer EV rentals. Rent a car for a full day or an entire week and truly get a feel for what it's like to own an EV. If you decide to rent for an extended period, you'll want to have a plan for charging.

EV PRO TIP **Rent a car for a full day or an entire week, and really get a feel for what it's like to own and drive an EV.**

Most EV charging happens at home, so if you decide to buy an EV, many owners recommend having a Level 2 home charger installed. However, for an extended EV test drive, you have a couple of options that don't involve installing a charger.

Level 1 home charging uses a regular outlet (like the one you plug your outdoor holiday lights or cordless drill chargers into) and will work well for a short-term test drive. Level 1 "trickle charging" is the slowest way to charge an EV, but you'll add about five miles per hour of charging. So if you plug in after work and unplug in the morning, you'll have added about 65 miles of range. Just make sure the electric car you're test driving comes with a Level 1 charging cord! This will give you a feel for how easy EVs are to charge; but don't forget, a Level 2 charger will be about four times faster than a Level 1 charger.

On-the-go charging is probably the way to go. You'll want to look for chargers near your home; shopping centers or local recreation areas are good options.

You can also use public charging networks like ChargePoint, Electrify America and EVgo, or mobile apps to find chargers, like Chargeway and PlugShare.

Did you know that many automotive manufacturers have rental car programs, too? Audi, Nissan and Toyota, for example, all offer "try it before you buy it"-style rental programs.

(Please note: This is not an exhaustive list of charging networks or car rental agencies, and TVA does not endorse any particular charging company or car rental agency.)

3: Go for a ride-and-drive.

Visit the TVA EnergyRight website for an up-to-date listing of EV ride-and-drives and local events near you. Throughout the year, Plug In America organizes EV test drives and EV events all over the country. If you're looking for a fun, free, communal block party-type test drive, an EV ride-and-drive is a great way to go.

EV PRO TIP

Looking for a fun, free, communal block party-style test drive? Find an EV ride-and-drive at EnergyRight.com/EV.

4: Borrow an EV.

Although there aren't many carsharing services in our seven-state service region, potential EV owners can use services like Turo or Getaround to test drive an EV. If you're thinking about purchasing a used EV, this could be a good way to see what a 2018 Tesla Model S or a 2022 Ford Mustang Mach-E, for example, feels like.

Plus, you'll have the opportunity to chat with the owner about their experience with the vehicle.

Use the filter options to select "Electric" or "Hybrid." As with any "share" program—whether homeshare or carshare—there are risks involved with this approach, and rental costs and car quality may vary.

EV PRO TIP

Carsharing sites may be a good way to see what it's like to own a used EV.

5: Find a friend.

In these days of social interconnectedness, you may be surprised to find out how many of your friends and acquaintances drive electric vehicles. It can't hurt to ask around!

Most early EV adopters are more than happy to share their enthusiasm and passion for electric cars with anyone who'll listen. If they're *really* good friends, they may even be willing to hand over the keys for a few days.

Questions to ask before buying an EV.

Whether you're buying new from a dealership or purchasing a used EV directly from an owner, it's good to ask questions and verify the answers. Here are a few to get you started!

- What's the maintenance schedule?
- What's the powertrain warranty?
- What's the battery warranty?
- How do I manage battery life?
- Have any recalls been issued on the vehicle?
- Do you offer a battery recycling program?
- What's the observed/actual range? (NOTE: This may vary from the EPA's fuel economy label. For more information on how the EPA determines an EV's range, visit EPA.gov/greenvehicles.)
- How long does Level 1 charging take?
- How long does Level 2 charging take?
- How long does fast charging take?
- What's the maximum power in kW the vehicle can charge at?
- What charger port does the vehicle use?
- Do any state or federal tax incentives apply?
- Does the manufacturer offer charging discounts or credits?

Buying vs. leasing an EV.

The EV world is changing quickly, with new models and battery technologies being introduced regularly. Sure, over the long haul, buying a car—and keeping it—until it's no longer worth repairing is the cheapest way to go. However, there are plenty of drivers who enjoy that new car smell far too much for such practicalities. And for those who love technology, as most EV drivers do, leasing an EV may be a great solution.

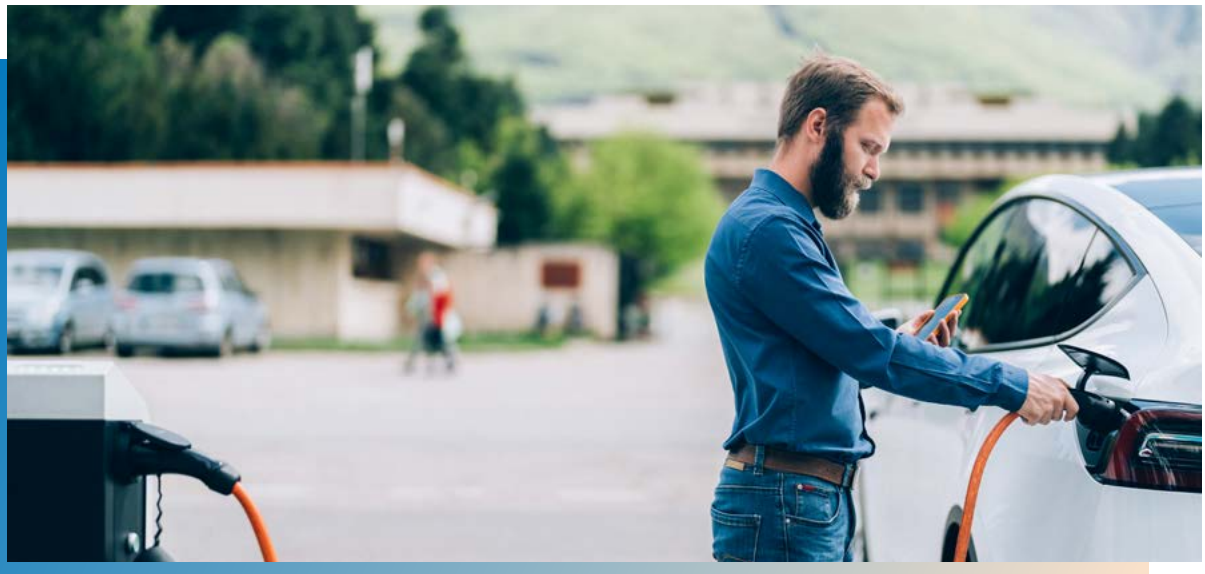
Buying an EV:

Pros

- When you own the vehicle outright, you can keep it for as long as you want.
- You can take advantage of available tax credits and incentives.
- Long-term EV ownership maximizes your return on investment, making EVs even more cost-effective in the long run.
- You can drive as many miles as you'd like.
- You don't have to worry about end-of-lease charges and penalties for things like excessive wear and tear.
- If and when you do decide to sell, you'll be able to keep the proceeds of the sale.

Cons

- The up-front costs of purchasing an EV are generally higher than the cost of leasing a vehicle.
- Like any vehicle, your EV will depreciate in value over time.
- EV technology is continuing to evolve, so you'll miss out on new features if you keep your vehicle for a long period of time. (Although convenient over-the-air updates help keep your vehicle equipped with many of the latest features.)



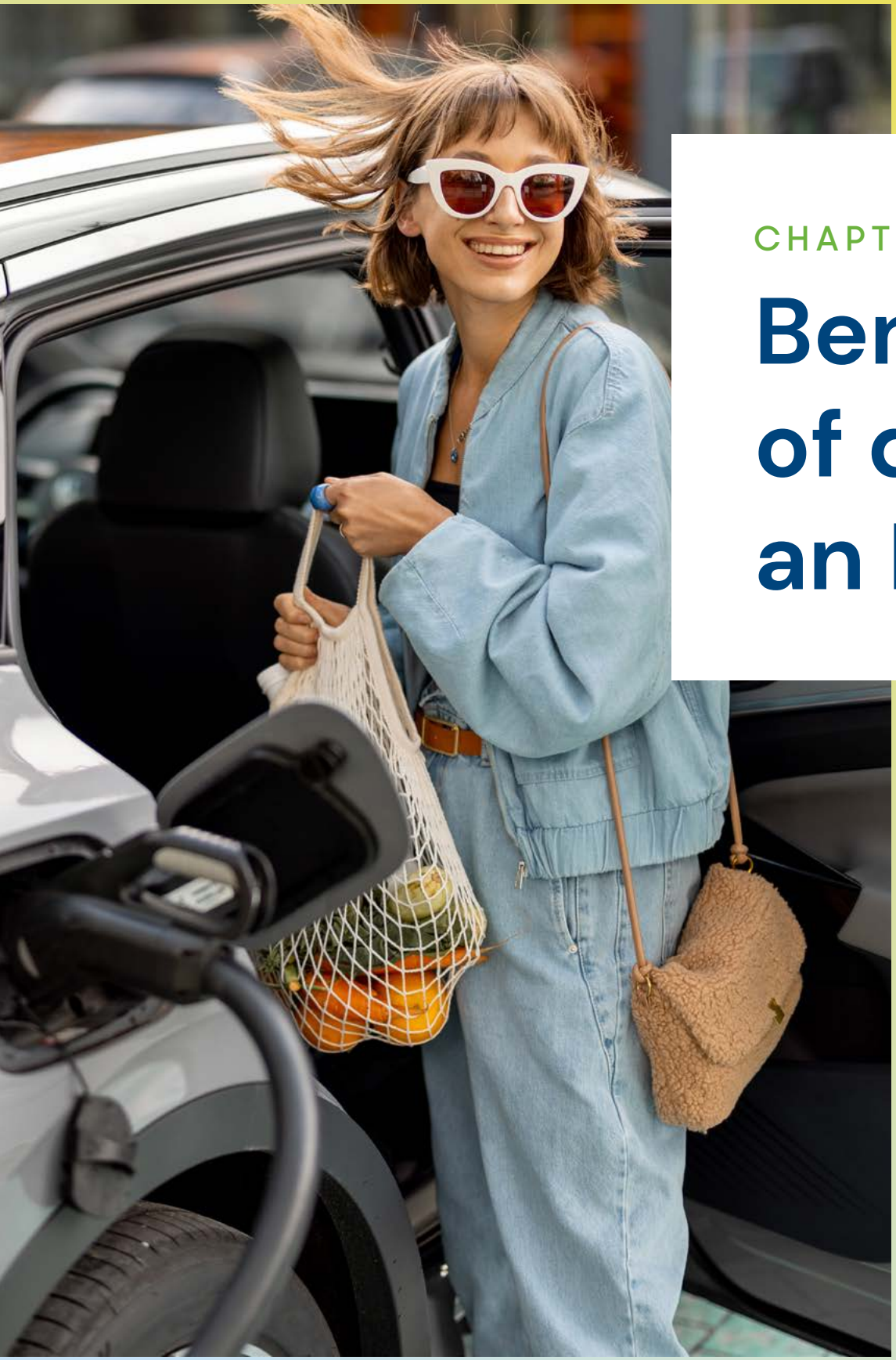
Leasing an EV:

Pros

- Leasing typically costs less up-front, making it a more accessible option for people with limited budgets.
- Leased EVs may qualify for an EV credit program that provides a $7,500 "commercial credit" for light-duty vehicles.
- Generally speaking, monthly lease payments are lower than loan payments.
- If you like to get a new car every few years, leasing enables you to drive a car with the latest features and technology.
- Generally, lease terms line up with warranties, so you don't have to worry about unexpected repair costs.
- Often, leases include free oil changes (for PHEVs) and scheduled maintenance.
- Leasing may enable you to drive a higher-priced, more feature-rich car than you could otherwise afford.
- It's easy to extend a lease, lease a new model, or even purchase the car once your lease expires.

Cons

- Leases usually come with mileage restrictions and if you exceed the limits, the charges can add up quickly!
- If you decide you don't like the car or cannot keep up with the payments, getting out of a lease early can cost you.
- Leasing is more complicated than buying a vehicle outright and it may be hard to determine whether or not you're benefiting from available tax credits.
- When you lease, you don't maintain any equity in the vehicle and you cannot sell it.
- You cannot customize the vehicle.
- Wear and tear penalties may be steep.



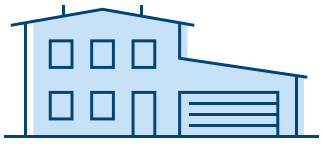
CHAPTER 6

Benefits of driving an EV

When the TVA EnergyRight Team began brainstorming ideas for our Driving EVolution blog series, we knew that creating fun, well-balanced articles citing reliable sources would be the key to developing content that friends and neighbors like you could trust. We tapped into your questions, we subscribed to news alerts and we immersed ourselves in all things EV-related.

If you're in the market for a new (or used) car, the odds are pretty good that you're at least *thinking* about getting an EV. J.D. Power's 2023 U.S. Electric Vehicle Consideration Study discovered that 26% of buyers are "very likely" to consider purchasing an EV and a whopping 61% of car shoppers say they're "overall likely" to consider purchasing an EV.

CHARGE ANYWHERE

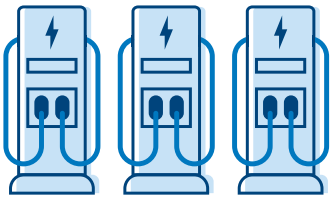


Home charging
Level 1 Charging

CHARGING TIME
10–20+ hours

Home, restaurants and hotels
Level 2 Charging

CHARGING TIME
4–10 hours



Interstates, public and retail charging
DC Fast Charging

CHARGING TIME
15–45 minutes

Convenience of home charging.

When the "pros and cons of electric vehicles" discussion is on the table, there's usually a lot of talk about the public charging infrastructure. While it's a very valid discussion, it detracts from the fact that most charging—and the most cost-effective charging—happens at home. Another recent J.D. Power report, "Level Up: Electric Vehicle Owners with Permanently Installed Level 2 Chargers Reap Benefits from Their Investment," noted that 88% of EV owners say they charge their vehicle at home "often" or "always."

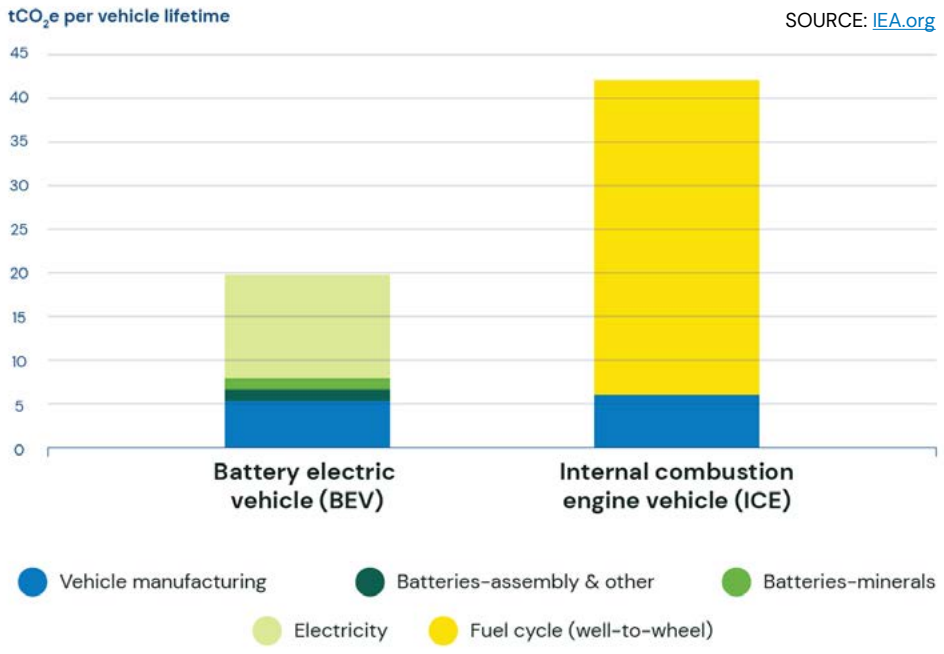
Plus, once you have your Level 2 charging station professionally installed, home charging is as safe and as easy as plugging your cell phone in for the night. In a nutshell: Not only is charging your EV at home convenient, but it will also save you the most money. The Washington Post summed it up nicely in 2023: "In all 50 states, it's cheaper for the everyday American to fill up with electrons [than gasoline]."

Much lower overall emissions.

The International Energy Agency (IEA) found that the comparative life-cycle greenhouse gas emissions of a mid-sized BEV are significantly lower than those of a similarly sized internal combustion engine (ICE) vehicle, even accounting for battery assembly and the minerals contained in an EV's batteries.

LIFE-CYCLE GREENHOUSE GAS EMISSIONS.

Mid-size BEV vs. ICE

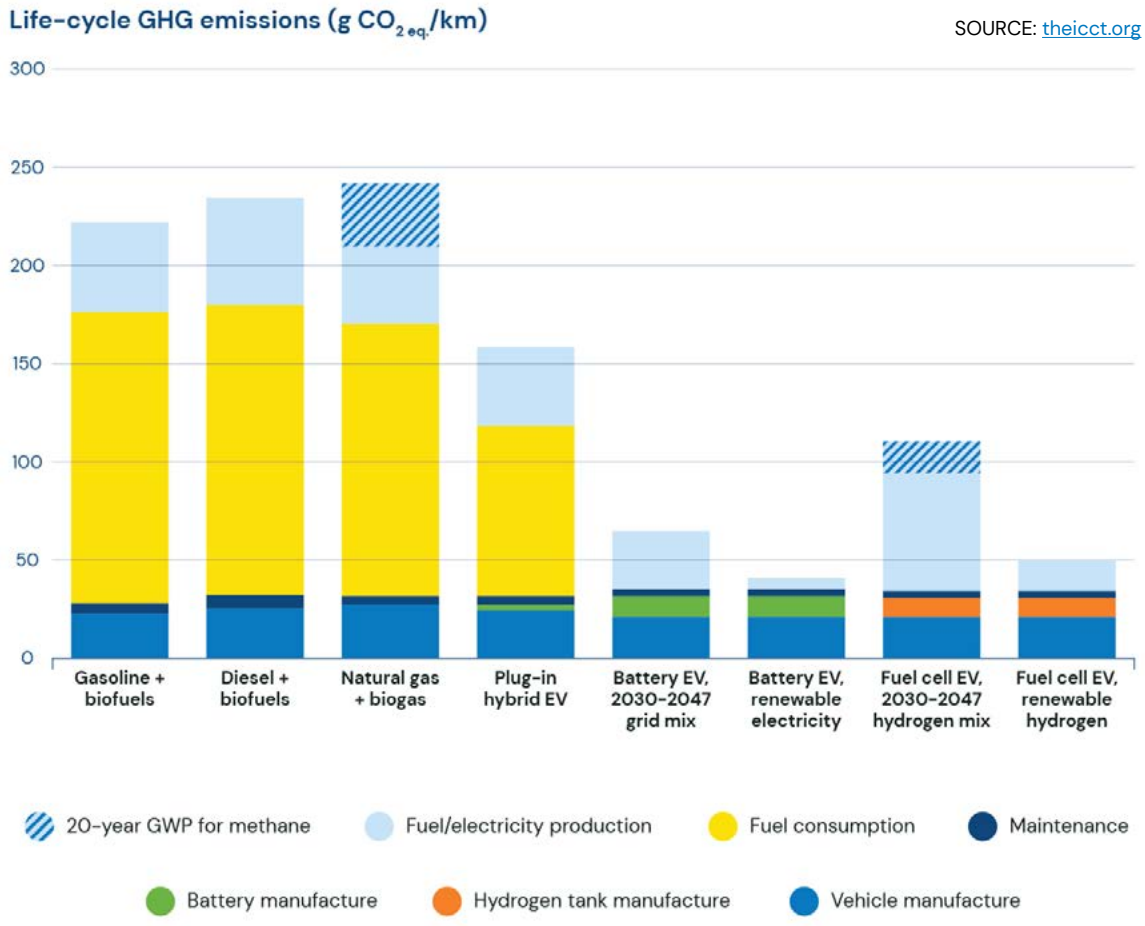


The Office of Energy Efficiency & Renewable Energy's fun Fact of the Week #1208 declared that the "Life-cycle greenhouse gas emissions for a 2020 small electric SUV were half those of a conventional gasoline small SUV." And, yes, that's a cradle-to-grave, well-to-wheels, battery-to-bumper fact.

Confirming the IEA's findings, the International Council on Clean Transportation's most recent life-cycle assessment also shows that battery-only EVs (BEVs) and fuel cell EVs (FCEVs) have the potential to be very low greenhouse gas (GHG) emitters.

The report notes, "The emissions from manufacturing batteries, solar panels and wind turbines are small when compared to the GHG savings from the greater efficiency and cleaner energy supply of EVs compared to conventional vehicles."

LIFE-CYCLE GREENHOUSE GAS EMISSIONS.



EVs are fun to drive.

With instant torque (that's car nerd talk for that feeling you get when you hammer the GO! pedal and your head hits the headrest while your cheeks try to hide behind your ears), they're just fun to drive.

There are more than 20 EVs that can blast a 0-60 mph time of 3.0 seconds or less. We'd like to take credit for this sentence, but all credit goes to MotorTrend: EVs in the under-3.0-second club "don't feel as if they're accelerating down the road so much as they're dropping you off a horizontal cliff."

For some of us, that's a good thing.

(CAUTION: We'd be remiss if we didn't state clearly, and for the record, the importance of following speed limits and local traffic laws. Have fun, but obey speed limits, use your turn signals, leave plenty of room between you and the car in front of you, and just drive safely out there, y'all.)

They're good for the seven-state Tennessee Valley region.

EVs use locally produced energy.

One of the reasons TVA EnergyRight is working to increase awareness and understanding of EVs throughout the region is that not only are EVs good for our air quality, but they can also help you save on fuel costs while keeping energy dollars in the area.

ICE-powered cars rely on fossil fuel imported from outside of our region or from foreign countries. EVs are fueled primarily by electricity produced in our region and supplied through local power companies, supporting local jobs and investments. Plus, TVA's energy is nearly 60% carbon-free and TVA has aspirations to be net carbon-free by 2050.

EV manufacturing is good for the region.

Electric vehicles and EV battery manufacturing have been great for our economic development. The numbers are clear: Driving electric is a big driver for our local economy. According to TVA Economic Development, automakers and suppliers have invested $17.2 billion in the region, creating more than 14,000 new jobs over the past 10 years.

REGIONAL EV ECONOMIC IMPACT 2012-2022.

$17.2 billion
in EV-related investments

14,000+
jobs created

SOURCE: TVA Economic Development

"We are pleased to have attracted so many players in the EV business," said John Bradley, senior vice president of TVA's Economic Development, last year, after TVA received a Top Utility award. "We are now considered a national hub for electrical vehicle production, which is highly beneficial to consumers, and that points to a prosperous future for the Tennessee Valley."

Plus, cars produced locally, with locally made parts, leave a much smaller carbon footprint than those produced and shipped overseas.

Lower overall cost of car ownership.

A Consumer Reports analysis from 2022 found that EV owners can lower their operational costs by $1,800 to $2,600 per 15,000 miles driven, compared to ICE owners. The Office of Energy Efficiency and Renewable Energy reports that the estimated maintenance cost for an EV totals 6.1 cents per mile, while a conventional internal combustion engine vehicle totals 10.1 cents per mile.

Lower fueling costs.

Fueling with electricity remains less expensive than gasoline and the price fluctuations for electricity are far less volatile. Even with TVA's 2023 rate adjustment, those of us who live and work in the region enjoy electric rates that are lower than rates in 70% of the nation's top 100 utilities.

EV FAST FACT

Electric rates are lower in the Valley than rates in 70% of the country.

Happily, TVA's low and stable energy rates are great for EV owners throughout the seven-state service territory.

Use this formula to estimate how much fueling with electricity will cost you:

miles per day **x** **30** days per month **x** **#** kWh kWh per mile* **x** **0.10589**** base rate **=** **$$** per month electricity use

* Find miles per kWh for common EV makes and models on pages 63-64. Note: mi/kWh = 1 ÷ (kWh/mi)

** Example BrightRidge residential rate as of 2/29/24.

Possible tax incentives.

Saying "see ya" to the gas station is only one way EVs save drivers money. Some new EVs qualify for a hefty federal income tax credit of up to $7,500, and used EVs may qualify for incentives up to $4,000. Use our Compare EVs tool at EnergyRight.com/EV to find out which vehicles qualify.

Lower scheduled maintenance costs.

Gas-burning engines experience a lot more wear and tear and require a lot more work during scheduled maintenance pit stops than an EV. When you drive an EV, you'll still have to take it in for a checkup, but the to-do list will be a lot shorter. Although brakes last longer thanks to regenerative braking, you'll want to make sure that your car is fitted with tires made for the heavier curb weight of your electric vehicle.

It's easier to budget transportation costs for an EV.

Because scheduled maintenance costs are lower and fuel costs are more consistent, month-to-month budgeting is a lot easier with an EV. Plus, the MSRPs of electric vehicles are coming down. Prices on used EVs are down 33% in 2023 compared to 2022 and new EVs dropped approximately 15%. Although up-front costs are often higher, the gap between EVs and ICE cars is shrinking quickly.

DRIVING EVOLUTION DRIVING EVOLUTION

CHAPTER 7

EV glossary: From amps to ZEV

Electric vehicle terms you need to know.

The Ultimate Electric Vehicle Glossary

Keeping up with the latest electric vehicle terms, topics and trends can seem like a pretty daunting task. Luckily for you, we're plugged into the electric transportation scene and we're amped to share our Ultimate Electric Vehicle Glossary with you.

If electricity moves it, we're ready to fuel it.

Our EV team has been on the road a lot, visiting with people from all over our seven-state Valley region and sharing information about EVs.

During the course of our conversations, we've been asked plenty of questions about the EV lingo. We hope this glossary answers your questions!

This glossary is dedicated to all the great people we've met and all of the wonderful questions they asked about EV terms, technology and breaking news.

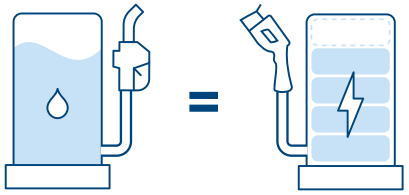
All-electric range (AER): The driving range of a vehicle using only power from its battery pack. Also known as range per charge.

Alternating current (AC): A term that describes the flow of electricity. In the U.S. the direction of the current changes (alternates) direction every 60 seconds. AC powers Level 1 and Level 2 EV chargers.

A SIMPLIFIED LOOK AT AMPS & VOLTS.

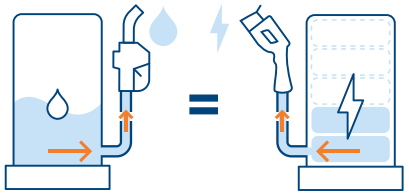
Let's compare filling a tank with gasoline to filling a battery with electricity and find out how amps and volts determine the time it takes to charge your EV battery.

Gasoline
(flowing from the pump to your tank)



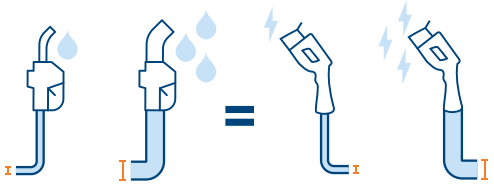
Electricity
(flowing from the charger to your EV battery)

Pressure
(from the pump and the nozzle)



Voltage/Volts
(pushing electricity through the circut)

Rate of flow
(amount of liquid that can pass through a nozzle or hose)



Current/Amps
(the amount of electricity that can flow safely through a circuit)

Amps (A): Also known as amperes, an amp is a unit of measure for electrical current flow. An EV's amp rating (or the charging station's amp rating) is one factor that determines the maximum amount of power that can be delivered to your car's battery. If **voltage** is to electricity as pressure at the gas pump is to gasoline, then **amps x volts = watts** all work together to measure how quickly you can fill up your battery with power.

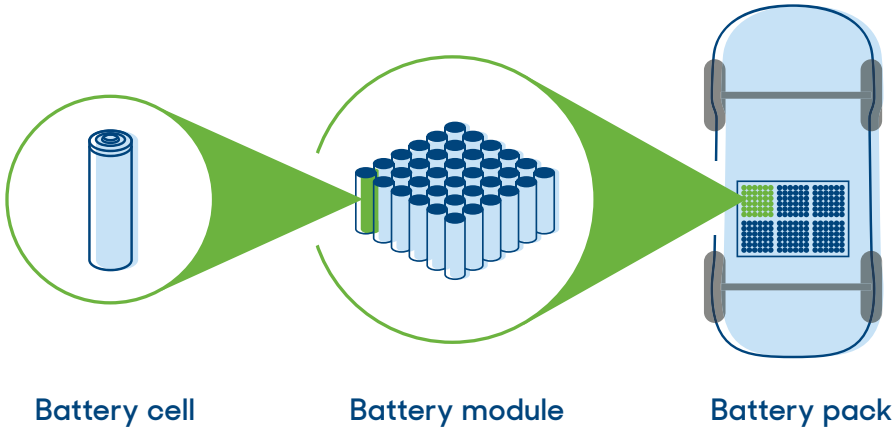
Battery cell: The smallest unit in an EV's battery pack. Think of it like a gallon of gas.

Battery electric vehicle (BEV): An EV that relies entirely on electric power stored in its battery pack.

Battery module: A group of battery cells bundled together. Think of it as a few gallons of gas.

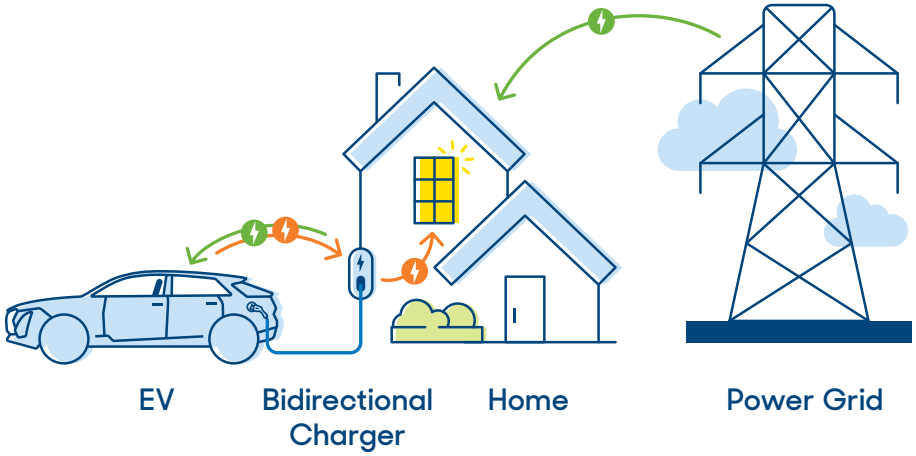
Battery management system: This system makes sure that the battery pack is operating at ideal temperatures. This helps prolong battery life and improve charging speed.

THE BATTERY BUNCH.



Battery pack: A group of battery modules. An EV's battery is where the electricity that powers your car is stored. Think of it as the fuel in your EV's "tank."

BIDIRECTIONAL CHARGING



Bidirectional charging: A technology that allows energy to flow two ways: from the electricity grid to your EV, and from your bidirectional EV charger to the grid. See **vehicle to grid (V2G)** (future state) and **vehicle to home (V2H)** (select EVs and charger stations).

Capacitor: A temporary power storage module in an electrical circuit that helps regulate spikes in power.

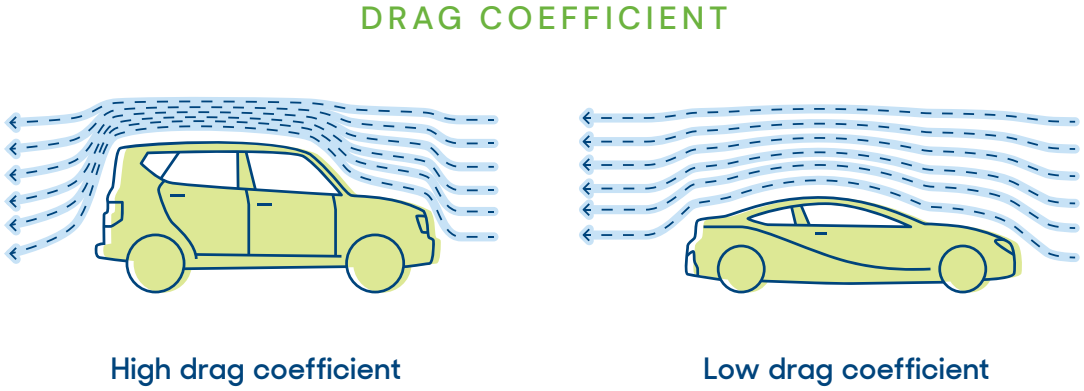
Charging: Fueling your EV with electricity.

Charging station: See **electric vehicle supply equipment (EVSE)**.

Combined charging system (CCS): A standard for charging electric vehicles that can accommodate Type 1 and Type 2 AC charging and DC fast charging because it also includes a J1772 outlet.

Connector: A general EV term that includes a variety of standardized plugs used to charge electric vehicles. It may include the Type 1 J1772, CCS and NACS connections.

Direct current (DC): A current that provides constant voltage and flows in one direction. It doesn't change or vary over time. DC powers EV fast chargers because the direct flow of current—delivered directly to the battery—can charge more quickly.



Drag coefficient (Cd): A measurement of a vehicle's wind resistance. The higher the drag coefficient, the harder the motor has to work to push your EV through the air. The lower the drag coefficient, the better!

Dynamic electric vehicle charging (DEVC): This future-state method of wireless charging is being tested and would enable EVs to recharge while driving on public roads.

Electric vehicle (EV): Any vehicle, whether it's a car, bicycle, boat, forklift or scooter, that's powered by electricity stored in batteries.

Electric vehicle supply equipment (EVSE): What you'll need to safely charge your EV at home. It includes the cables, connectors and charging points.

Fast Charge Network: TVA EnergyRight is collaborating with state agencies, local power companies and third-party charging developers to develop the Fast Charge Network, which will place fast charging stations at least every 50 miles along major travel corridors in the seven-state region.

Fast charging: Also known as Level 3 charging, it refers to the number of **watts (W)** that are delivered to an EV's battery. Most fast chargers are **direct current (DC)** and deliver over 19 **kilowatts (kW)**. These chargers and superchargers are most commonly found at shopping centers, travel centers, dealerships and other public locations.

Frunk: It's that space in the front where the engine lives in gas-powered vehicles. We recommend putting your junk in it.

Fuel cell electric vehicle (FCEV): A vehicle that uses a fuel cell, usually hydrogen-based, to generate electricity that runs an onboard motor.

Home charging: Approximately 80% of EV charging is done at home. Home charging systems—**EVSEs**—enable EV owners to charge up at home. It's just as convenient as plugging in your cell phone overnight.

Hybrid electric vehicle (HEV): Also known as "conventional," "self-charging" or "mild" hybrids, these EVs use gas-fueled ICE engines and electricity-fueled motors. Hybrid vehicles—like the Toyota Prius or Honda CRV—use regenerative braking to store energy and typically have a smaller **all-electric range**.

Incentives: You may be eligible for federal tax credits on qualified plug-in electric vehicles. Learn more about credits for clean vehicles purchased in 2023 or after at IRS.gov.

Internal combustion engine (ICE): A heat engine that converts energy from the heat of burning gasoline into torque that powers the vehicle.

Inverter: An electrical device that converts electricity from a **DC** source to **AC**.

J1172: Also known as a J plug or SAE J1772, a North American standard for electrical connectors for EVs.

Kilowatt (kW): Equivalent to 1,000 **watts**, a unit of measure for power. Power tells us how fast energy is moving at any moment in time.

Kilowatt-hour (kWh): How many **watts** are consumed in an hour.

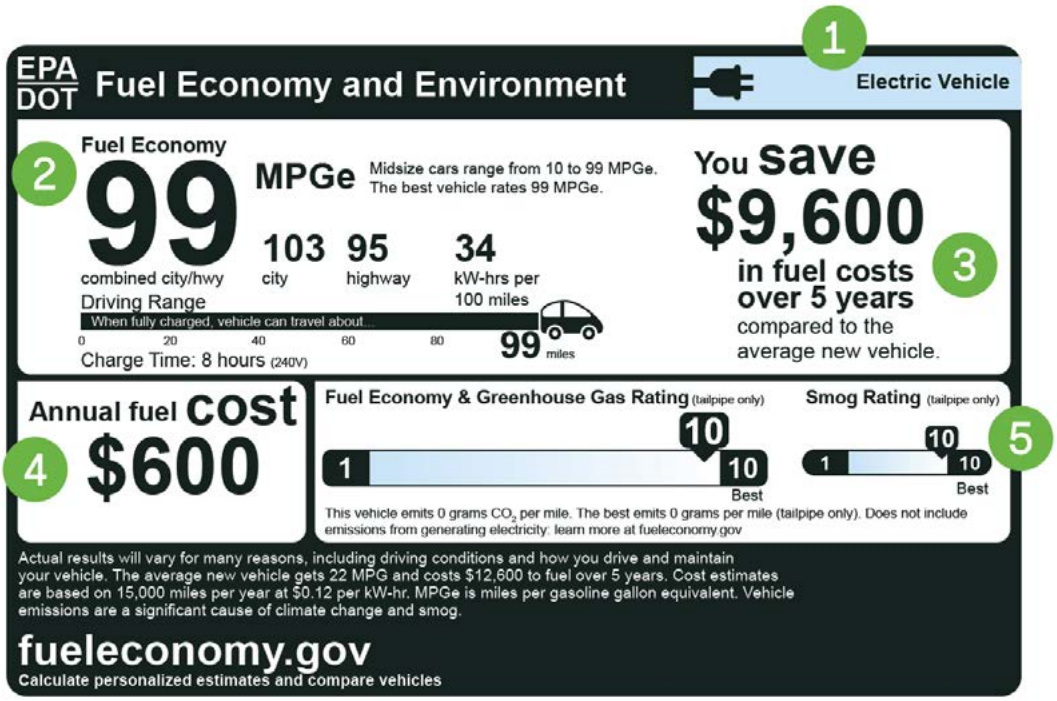
Level 1 charging: Also known as "slow chargers" or "trickle chargers," Level 1 chargers can plug into any standard 120-volt home wall outlet, the very same type of outlet you use to plug in your cell phone or coffee pot.

Level 2 charging: These 240-volt chargers are just like the ones your dryer plugs into and can charge a **BEV** in 4-10 hours, which makes them perfect for overnight home charging.

Level 3 charging: See **Fast charging**.

Lithium-ion: A rechargeable battery that uses lithium ions to store energy.

ELECTRIC VEHICLE LABEL



1. Type of vehicle
2. Fuel economy and MPGe = mileage
3. Amount you save over five years compared to average gas-powered vehicle.
4. Annual fuel cost is based on annual mileage of 15,000 and projected cost of electricity.
5. Fuel economy, greenhouse gas and smog rating

Miles per gallon equivalent (MPGe): An energy-efficiency metric introduced by the Environmental Protection Agency (EPA) to compare the amount of energy consumed by alternative fuel vehicles to that consumed by gas-powered cars.

Miles per kilowatt hour (mpkWh): A measurement of an EV's efficiency that demonstrates how an EV's power output translates into real distance traveled.

North American Charging Standard (NACS): Previously known as the Tesla charging connector, this charging standard is used in Tesla's Supercharger network. By 2024, most major automotive manufacturers had announced that their drivers would be able to charge their cars (with an adapter) at Tesla charging stations across the country. And in 2023, seven of the world's largest automakers announced that they're building a new nationwide network of 30,000 electric vehicle charging stations that will accommodate NACS and CCS plugs.

Off-peak charging: Charging your EV at times when demand for electricity is lower (typically overnight) helps maintain a healthy grid and keeps rates low for everyone.

On-board charger (OBC): A device that converts AC to DC to charge an EV's batteries. Fast chargers bypass an EV's OBC because they're already DC.

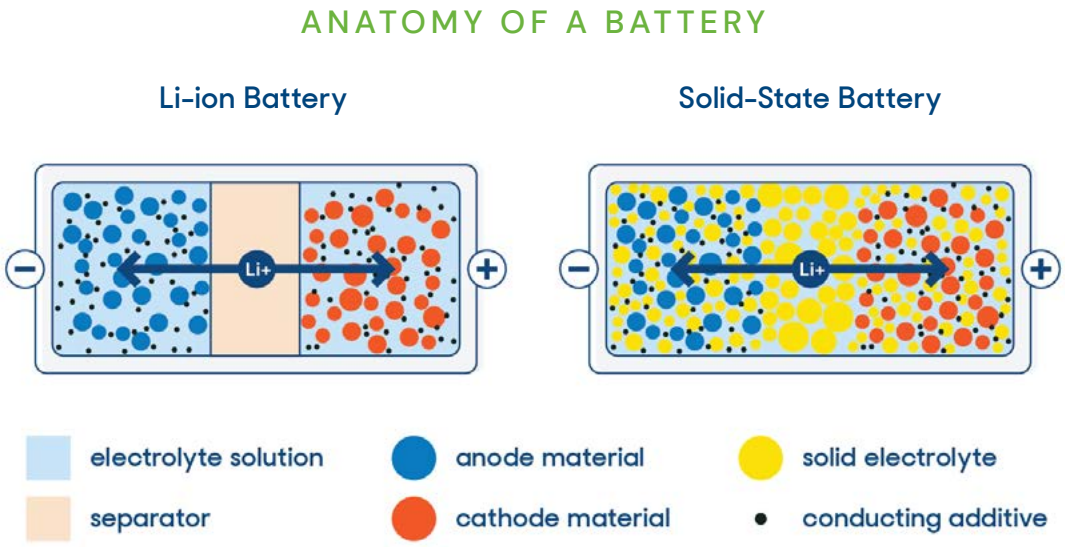
Parallel hybrid: Vehicles with a parallel hybrid drive enable the engine and electric motor to work together to generate power to drive the wheels.

Plug-in hybrid electric vehicle (PHEV): A plug-in vehicle featuring a rechargeable battery, electric propulsion and **regenerative braking**. PHEVs also rely on a gas-powered internal combustion engine (ICE) for propulsion once the battery is depleted.

Regenerative braking: Also known as "regen braking," these systems are unique to EVs. They turn a vehicle's kinetic energy (energy that relates to motion) back into electric energy. Regenerative braking helps improve fuel efficiency, reduce total tailpipe emissions and minimize wear and tear on brakes.

Renewable energy: Energy that is generated by natural resources that are replenished faster than they are consumed, such as solar, hydroelectric and wind. Nearly 60% of TVA's electricity comes from carbon-free sources.

Residential charging: See **Home charging**.



Solid-state battery: Like lithium-ion batteries, solid-state batteries store energy; however, instead of an organic liquid electrolyte solution sandwiched between the cathodes and anodes, solid-state batteries use solid electrolytes. Some manufacturers are planning to roll them out as early as 2027. Solid-state batteries offer higher energy density, greatly extended range and faster charging times.

State of charge (SOC): The level of charge an EV battery contains compared to its capacity. 0% SOC = empty; 100% SOC = full.

Supercharger: A kind of EV charger developed by Tesla designed for fast charging.

Torque: A force that produces rotation. Motors deliver torque to the drive shaft. Electric cars achieve maximum torque immediately and deliver instant torque to the vehicle's wheels, which leads to excellent acceleration off the line (or from a red light).

Vehicle to grid (V2G): Power that flows from your vehicle back to the grid. This future-state capability has the potential to support the power grid during peak demand hours. (See **Bidirectional charging**.)

Vehicle to home (V2H): Power that flows from your EV to your home, essentially acting as a generator during weather-related power outages. (See **Bidirectional charging**.)

Volts (V): A unit of electrical force that measures the amount of effort required to move an ampere between two points. A higher voltage rating on a charging station equals a higher charging speed for your EV. Calculation: Volts x Amps = Watts (See **Amps**.)

Watts (W): A unit of measure for power. Power tells us how fast energy is moving at any moment in time. A kWh tells you how many of those units are consumed in an hour. Calculation: Volts x Amps = Watts (See **Amps**.)

Zero emission vehicle (ZEV): A vehicle that emits no tailpipe pollutants during operation. Battery electric cars, bicycles, motorcycles and hydrogen fuel cell vehicles are examples of ZEVs.

Calculate your EV fueling cost.

# miles per day		30 days per month		# kWh kWh per mile*		Energy Rate**	=	$$ per month electricity use
	X		X		X		=	
	X		X		X		=	
	X		X		X		=	

* Find miles per kWh for common EV makes and models on pages 63-64. Note: mi/kWh = 1 ÷ (kWh/mi)

** You can locate your residential energy rate on your electric bill. Or visit your local power company's website.

To determine how much power will flow to your car's battery, multiply the volts by the amps and divide by 1,000. For example, a 240-volt Level 2 charging station with a 50-amp rating will supply 12 kilowatts per hour. After one hour of charging, your EV will have an added 12 kilowatt hours (kWh) of energy.

To calculate how long it will take to charge your entire battery based on your EV charging station, take the vehicle's battery capacity, in kWh, and divide that by the charging station's kW output.

Compare EV models.

Visit EnergyRight.com/EV and use our online comparison tools to get started. When you're ready to go kick the tires, you can keep track of your EV impressions here.

MAKE	MODEL	EV TYPE (circle one) **BEV** **PHEV**
MSRP $	ESTIMATED INCENTIVES $	BATTERY SIZE kWh
TIME TO CHARGE (Level 2) minutes	ELECTRIC RANGE miles	MILES PER GALLON ELECTRIC MPGe
TEST DRIVE NOTES		

MAKE	MODEL	EV TYPE (circle one) **BEV** **PHEV**
MSRP $	ESTIMATED INCENTIVES $	BATTERY SIZE kWh
TIME TO CHARGE (Level 2) minutes	ELECTRIC RANGE miles	MILES PER GALLON ELECTRIC MPGe
TEST DRIVE NOTES		

A selection of EVs available in the U.S. as of April 2024.

There are currently well over 300 EVs and PHEV makes, models and trim levels on the market, with more coming soon!

mi/kWh = 1 ÷ (kWh/mi)

Make/Model	EV Type	EPA Range	Battery (kWh)	Miles/kWh
Audi e-tron	BEV	222	95	2.34
Audi Q4 e-tron	BEV	265	82	3.23
Audi Q5 TFSI e PHEV	PHEV	23	18	1.28
BMW 330e	PHEV	23	12	1.92
BMW i4 eDrive40	BEV	301	84	3.58
BMW X5 xDrive 45e	PHEV	31	17	1.82
Cadillac LYRIQ	BEV	312	100	3.12
Chevrolet Bolt EUV	BEV	247	60	4.12
Chevrolet Bolt EV	BEV	259	60	4.32
Chrysler Pacifica Hybrid	PHEV	32	16	2
Ford Escape PHEV	PHEV	37	14	2.64
Ford F-150 Lightning	BEV	320	98	3.27
Ford Mustang Mach-E	BEV	300	70	4.29
Genesis Electrified GV70	BEV	236	77	3.06
Genesis GV60	BEV	248	77	3.22
GMC Hummer EV	BEV	320	205	1.56
Hyundai IONIQ 5	BEV	303	77.4	3.91
Hyundai Kona Electric	BEV	258	64	4.03
Hyundai Santa Fe PHEV	PHEV	31	12	2.58
Hyundai Tucson Plug-In Hybrid	PHEV	33	14	2.36
Jaguar I-PACE	BEV	234	90	2.6
Jeep Grand Cherokee 4xe	PHEV	26	17	1.53
Jeep Wrangler 4xe	PHEV	22	17	1.29
Karma GS-6	PHEV	61	28	2.18
Kia EV6	BEV	310	77	4.03
Kia Niro PHEV	PHEV	26	9	2.89
Kia Sorento Plug-in Hybrid SX	PHEV	32	14	2.29
Kia Sportage PHEV	PHEV	34	14	2.43
Land Rover Range Rover PHEV	PHEV	19	13	1.46
Lexus NX 450h+	PHEV	37	18	2.06

Make/Model	EV Type	EPA Range	Battery (kWh)	Miles/kWh
Lincoln Aviator Grand Touring	PHEV	21	14	1.5
Lincoln Corsair Grand Touring	PHEV	28	14	2
Lucid Motors Air	BEV	516	118	4.37
Mazda CX-90 PHEV	PHEV	26	68	-
Mercedes-Benz EQB	BEV	250	67	3.73
Mercedes-Benz EQB SUV	BEV	232	71	3.27
Mercedes-Benz EQE Sedan	BEV	305	91	3.35
Mini Cooper Electric SE Hardtop 2 door	BEV	114	33	3.45
Mini Countryman SE PHEV	PHEV	18	10	1.8
Mitsubishi Outlander PHEV	PHEV	24	14	1.71
Nissan Ariya	BEV	216	65	3.32
Nissan LEAF	BEV	149	40	3.73
Polestar 2	BEV	233	78	2.99
Porsche Panamera E-Hybrid	PHEV	17	11	1.55
Porsche Taycan	BEV	201	79	2.54
Rivian R1S	BEV	295	135	2.19
Rivian R1T	BEV	314	135	2.33
Subaru Crosstrek PHEV	PHEV	17	9	1.89
Tesla Model 3	BEV	267	60.5	4.41
Tesla Model S	BEV	375	100	3.75
Tesla Model X	BEV	332	100	3.32
Tesla Model Y	BEV	318	75	4.24
Toyota bZ4X	BEV	252	75	3.36
Toyota Prius Prime	PHEV	25	9	2.78
Volkswagen ID.4	BEV	260	77	3.38
Volvo C40	BEV	225	78	2.88
Volvo S60 T8 Recharge PHEV	PHEV	40	19	2.11
Volvo V60 Recharge	PHEV	40	19	2.11
Volvo XC40	BEV	223	78	2.86
Volvo XC90 T8 PHEV	PHEV	18	19	0.95

SOURCES: EVAdoption.com • fueleconomy.gov

Driving change.
Boosting the economy.
Putting the brakes on emissions.

EnergyRight.com/EV

TVA EnergyRight®

Updated 5/3/2024