internef®

ALL ELECTRIC VEHICLES

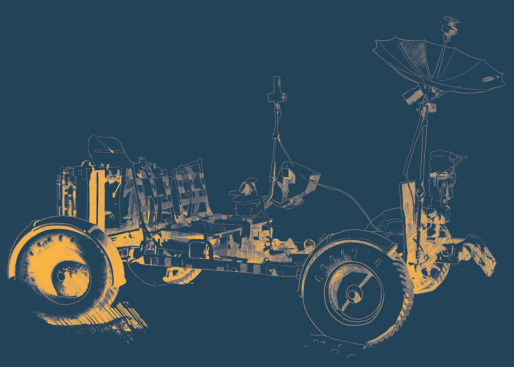
Energy Industry Spotlight:
Integrating Electric Vehicles into the Energy Grid – page 8

NEF™

HISTORY ELECTRIC

Decline of the early EV

The decline of the early EV was in great part a result of the discovery of Texas crude oil coupled with the mass-production of the Model T and the invention of the electric starter. The electric vehicle of the early 1900s could not compete with the gas-fueled vehicles of the future.



Faces of NEF: What EV would you like to see in the future?

Suzie Matheson
Program Administrator

It would be nice to have a truck (Ford or Dodge) become an electric vehicle. It seems like at one time or another, everyone needs a truck but going long distances in that type of gas guzzling vehicle is expensive. It would be nice to just unplug and go!

Gary Riehle
Web Developer

I would like to see "big rigs," tractors for long haul driving, become electric. Especially the Kenworth T1100 since it is a great truck with the best sleeper setup. For as much as we worry about cars driving, these things make America go.

Audrey Carlston
Production Administrator

Some sort of adventure vehicle. I think trucks would save a lot of energy if they were electric.

Emily White
Communications Manager

Jeep Wrangler. It would be awesome to travel the country (with my teardrop camper) living completely off energy resources of my choice and saving money.

OF THE

VEHICLE

Timeline Dates

1889
Debut in U.S. - William Morrison, Iowa built the first electric vehicle (known as an electric wagon)

1901
PORSCHE - first hybrid (battery + gas)

1912
Height of the early electric vehicle, accounting for ⅓ of cars in cities like New York, Chicago & Boston

1920

1960 – 1970
Increase in gas prices & Clean Air Act

1971

NASA's Lunar Rover & CitiCar keep the electric vehicle in the media and minds of consumers

1990s
New government regulations including the Clean Air Act Amendment establish need for alternative transportation

2000
TOYOTA Prius - first mass-distributed hybrid in US

2006

2009 – 2014
Major infrastructure & battery technology innovations by U.S Department of Energy, see page 7 for current research

2010
NISSAN Leaf - first mass-produced all electric vehicle, see page 5 for types and current makes & models of EVs

2018

Future
in 1901 PORSCHE had the first hybrid vehicle, check out *evrater.com/ev-timeline* to see when PORSCHE will have its first all-electric vehicle; 118 years in the making

How Tesla changed the EV landscape

In 2006, Tesla Motors announced production of a luxury electric sports car. Tesla's primary goal was to mainstream electric vehicles. Tesla has drastically changed the electric vehicle market in four ways:

1. Accelerated other automakers' work on their own electric vehicles
2. Through design and exclusivity, made electric vehicles sought after by average consumers
3. Driven down the price of electric vehicles with research into batteries and battery technology innovations
4. Investment into charging infrastructure, both speed of charge and charging station locations

Moving forward, Tesla's work with home energy storage and solar energy looks promising for concept developments in electric home-to-vehicle innovations.

Rise of the modern EV

November 2018

U.S. reaches one million electric vehicles on the road!

Charging at Home

Home charging is straightforward with a level one charger using a standard 120 V outlet and basic charging equipment. Level two chargers use higher voltage and deliver up to 60 miles for every hour of charging.

Level 1 electric vehicle supply equipment (EVSE) with no extra cost

- Best used with plug-in hybrid electric vehicle (PHEV)
- Plug right into your home electrical outlet 120 Volt AC plug
- 2 – 5 miles for every hour of charging

Level 2 EVSE requires special equipment and a dedicated circuit

- Best to use with an all-electric vehicle (AEV or BEV)
- Installed charging box by a professional & tested by local authority 240 V AC plug
- 10 – 60 miles for every hour of charging

EV owners charge at home over 80 percent of the time. Some take advantage of lower electricity prices by charging when electricity is off-peak. Smart charging also benefits the grid by reducing demand or storing electricity on its behalf.

Charging your EV at home is approximately the same as running your AC for six hours (at 12.6 cents/kWh).

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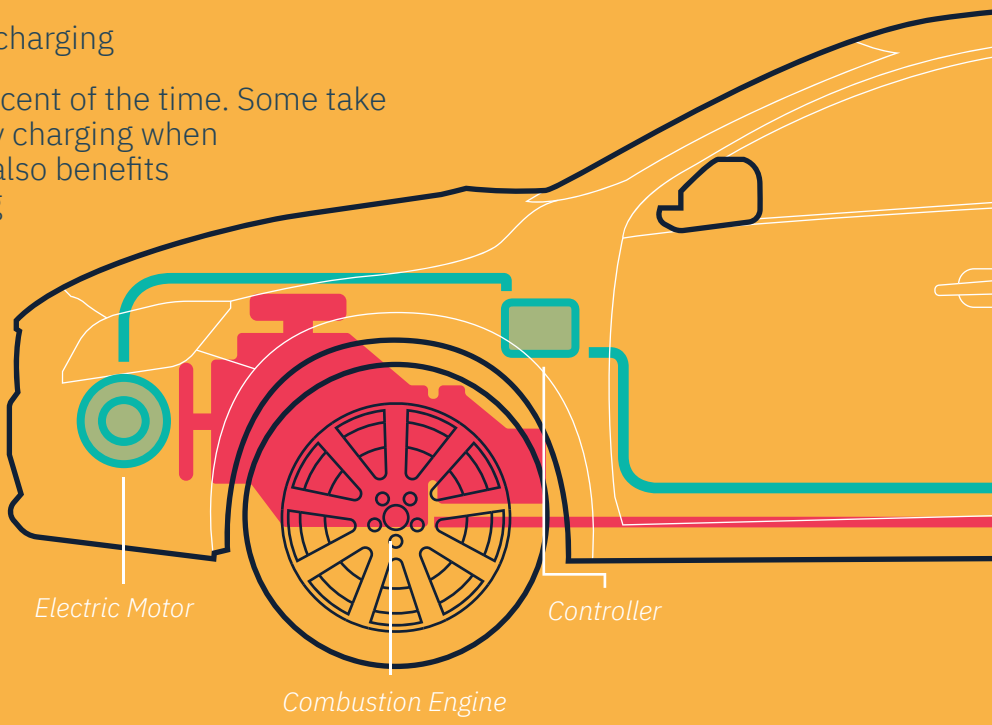


Advantages & Challenges of the EV

Advantages

Quiet and quick
Home or work recharging
Cheaper to operate
Lower emissions
Less maintenance
Energy efficient

Challenges

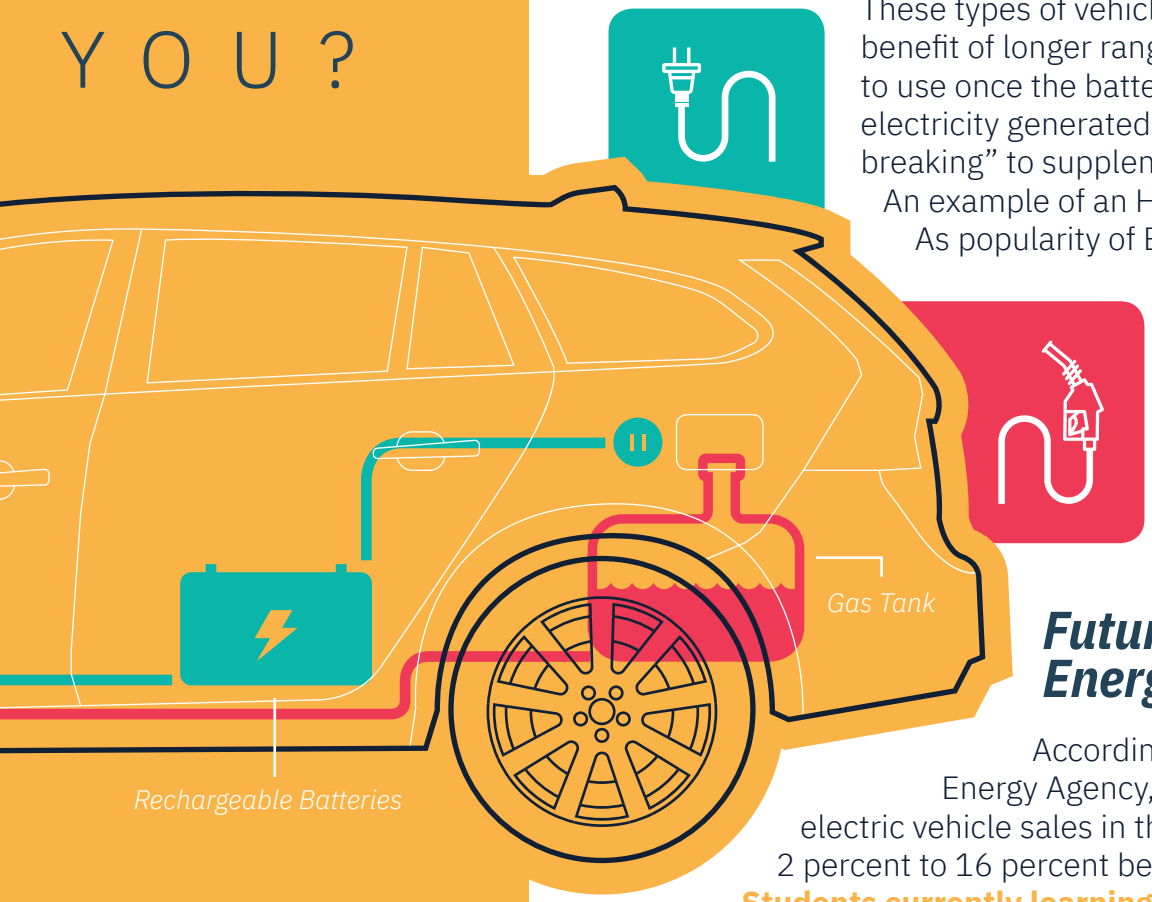
Limited range
Long recharge time
Limited choices and high purchase cost
Lack of infrastructure
Based on local fuel mix

TRIC
CLE
YOU?

Overview of Car Types

The all-electric vehicle (AEV) is fueled entirely by electric power. There are two types of AEVs, the fuel cell electric vehicle (FCEV) and the battery electric vehicle (BEV). The most commonly mentioned electric vehicle is the BEV with many being sold by standard car makers such as the Nissan Leaf, the Tesla Model S and the Chevy Bolt.

In addition to AEVs are the plug-in hybrid electric vehicles (PHEV) and the hybrid electric vehicle (HEV). These types of vehicles are known for the benefit of longer range with a gasoline engine to use once the battery runs out. HEVs use electricity generated from "regenerative breaking" to supplement the use of gasoline. An example of an HEV is the Toyota Prius. As popularity of EVs grew, but charging infrastructure was still underdeveloped, the PHEV was a great alternative as seen in the following options: Chevy Volt, Ford Fusion Energi, Kia Optima and Porsche Panamera SE.



Future Drivers & Energy Awareness

According to the International Energy Agency, the market share for electric vehicle sales in the United States rose from 2 percent to 16 percent between 2010 and 2016. **Students currently learning to drive are statistically more and more likely to drive electric cars**.

The National Energy Foundation's educational approach often includes teaching students about the fuel mix in their area. This is a great way to connect the dots from resource to behavior. Knowing the electrical generation of energy used when they plug in an electric vehicle will help students make energy aware choices.

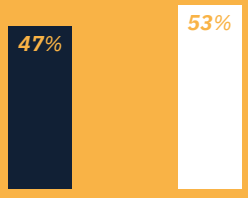
Sponsor a new EV high school initiative. NEF will custom design a program for you, helping students develop an understanding of EV technology and a desire to drive an EV in the future!

During the 2016-2017 school year, NEF launched an unprecedented initiative call the National Energy Literacy Survey. The energy survey measured high school students' knowledge, attitudes, and behaviors. *nef1.org/survey*

NATIONAL ENERGY LITERACY SURVEY™

Survey Question:

Electric vehicles use electricity generated only from renewable energy sources.



Student Answers:

True *False [CORRECT]*

Commuter Savings Spotlight

Chevy Sonic		Chevy Bolt
gas - 34mpg $1,099/yr*	**VS**	BEV - 28 kwh/100 miles $450/yr*

Commuter travels 12,500 miles a year from home to work. The electric vehicle can easily make the commute, using cleaner energy resources at 40 percent of the *fuel cost.

HOW FA
IELIE

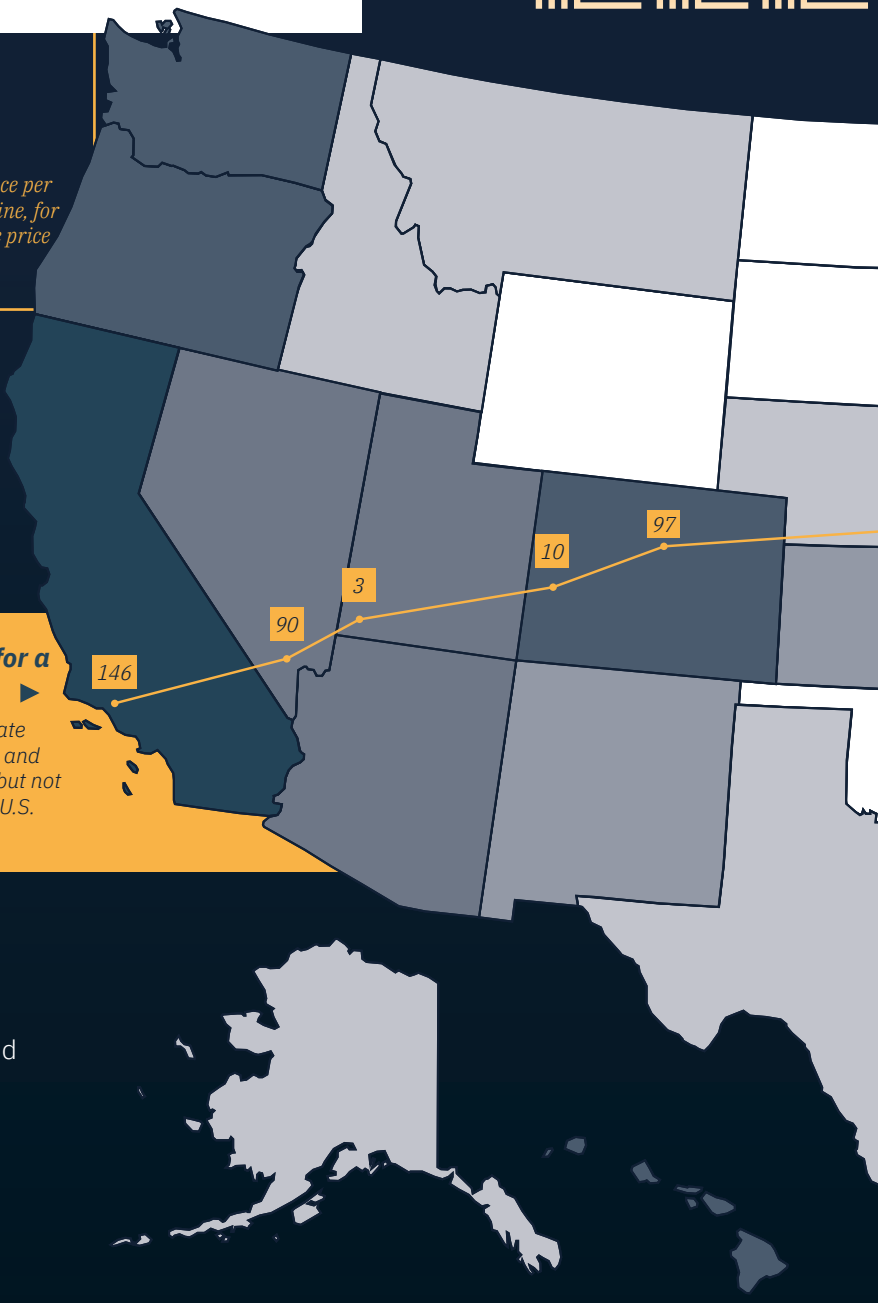
Miles per Year / ***Unit Measure of Energy*** X ***Cost of Fuel***

(for gas this is miles per gallon, for electric use the number of kWh per 100 miles divided by 100)

(for gas use price per gallon of gasoline, for electric use the price of kWh)

EV Coast-to-Coast Road Trip Charging Stations

The first, and since then fastest, EV cross county road trips were both made in Tesla electric vehicles and possible due to thousands of Tesla supercharger stations across the U.S. Affordable economy cars like the Chevy Bolt have begun to make similar road trips.



Charging stations for a coast-to-coast trip ▶

**Numbers are approximate for the greater city areas and include Level 2 and DC (but not Tesla) chargers. Source: U.S. Department of Energy*

Infrastructure Highlight

The options for charging electric vehicles are plentiful and improving. DC fast chargers can provide a 100 mile drive with a 20 minute charge. In the future, electric vehicles will not have to be plugged in at all. Wireless charging is being developed to quickly and efficiently transfer electricity through an electromagnetic field. Work and public charging stations are options for those with EVs, sometimes at no cost to the individual car owner.

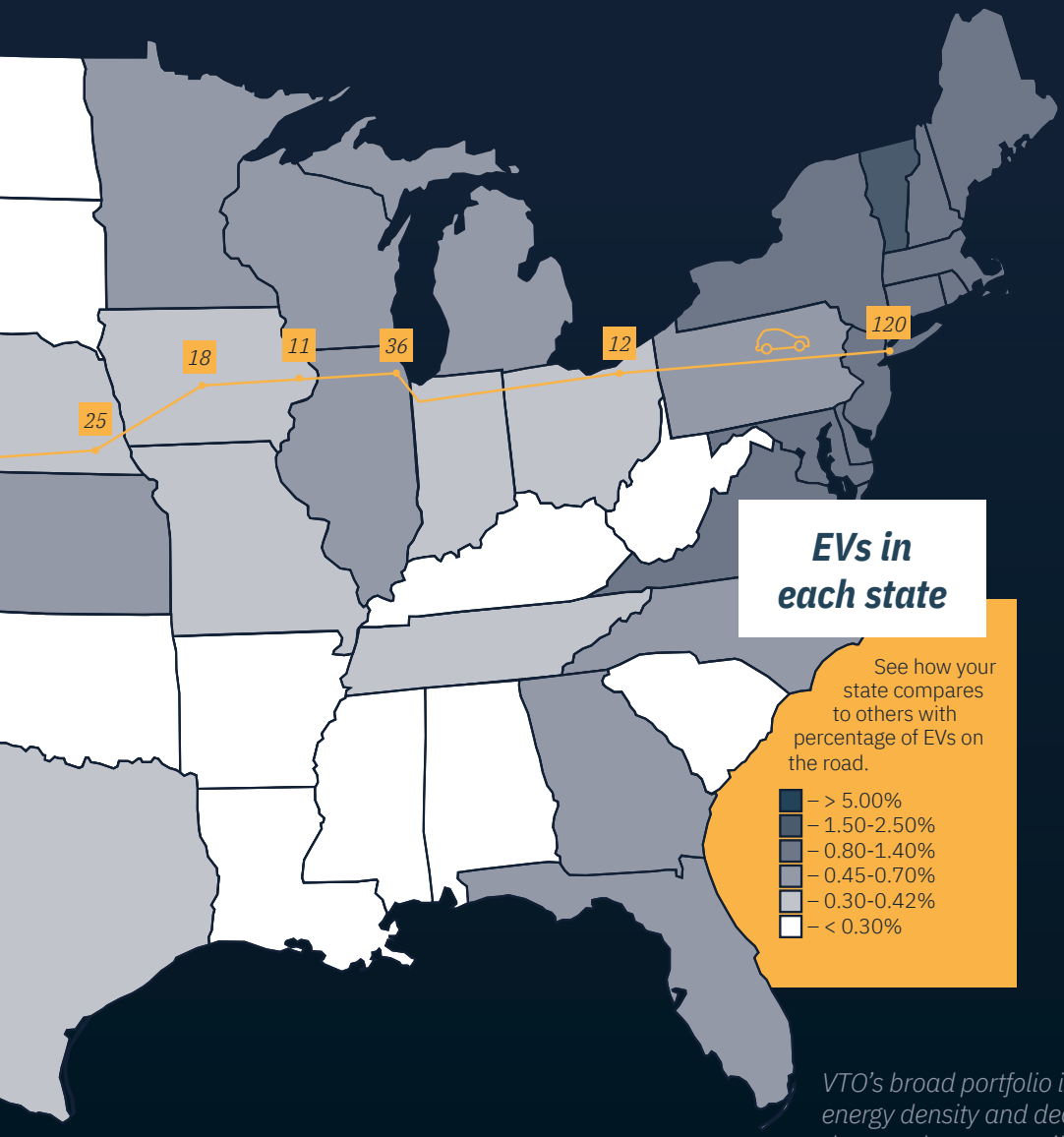
Route planning and charging station locator phone apps make the EV road trip easy. U.S. drivers have over 18,000 charging locations available and can increase range between charges with factors like good tire performance and nonaggressive driving.

Resources for charging station locations:

- *afdc.energy.gov/stations/#/find/route*
- Plugshare (app)
- ChargePoint (app)

The U. S. Department of Energy has a goal of decreasing EV charge time to 15 minutes or less and increasing range to 300 miles. Even now, Tesla reports that its Roadster model can achieve a range beyond that goal. Although EV driving range has been a concern, the future is looking bright.

AR CAN YOU TRAVEL IN AN CTRIC VEHICLE



Battery Highlight by Department of Energy's (DOE) Vehicle Technology Office (VTO)

In the future, energy storage may have to take on an entirely new chemistry and new physical form. Here are insights into the future of the EV battery.

What materials are currently used for batteries?

Batteries are composed of a cathode, an anode and an electrolyte. To learn more about the composition of a lithium-ion battery, see the DOE Office of Energy Efficiency and Renewable Energy blog on, "How Does a Lithium-ion Battery work?" (energy.gov/eere/articles/how-does-lithium-ion-battery-work)

There are over 16 cathode materials in use for lithium-ion batteries. Nickel based are the most common for electric vehicles. For vehicle batteries nickel manganese cobalt (NMC) and nickel cobalt aluminum (NCA) are the most common.

Currently, EV ranges per charge can vary from 100+ to 200+ miles. What's the projected change in miles per charge within the next 5 years?

VTO's broad portfolio is aimed at lowering the cost, improving energy density and decreasing charging time. Though VTO does not have a specific 5 year projection for miles per charge, VTO's technical targets will enable vehicle manufacturers to design vehicles to either reduce overall cost or increase vehicle range without increasing cost.

What kind of innovation in battery materials can we see in the near future?

Likely, more silicon in the place of graphite in anodes as well as the emergence of solid state electrolytes. Solid state electrolytes are being developed and are practical for several applications such as consumer electronics and drones. Solid state electrolytes need further development for use in vehicle applications because the performance and cost requirements are higher than other applications.

Classroom Activity

Near Town, Far Town

This activity explores how individual and societal values influence the purchase and use of electric vehicles as well as the energy efficiency of different kinds of transportation.

bit.ly/NearTownFar

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Integrating EVs into the Energy Grid for the Benefit of All Customers

By Becky Knox and Kellen Schefter, Edison Electric Institute

Sales of electric vehicles (EVs) are up 40 percent for the year and, by the end of 2018, more than one million EVs will be on U.S. roads. This is great news for customers and the environment: compared to an average new gasoline car, driving on electricity emits about 54 percent fewer carbon dioxide emissions for less than half the fuel cost. Often overlooked, but no less meaningful, is the benefit that EVs can provide to the energy grid.

Over half of all EVs on the road in the U.S. are in California and the state's three largest electric companies found that the impact of EVs on the energy grid today is immaterial.

As EV adoption increases, EV charging can be managed to minimize grid impacts. That's because EVs are a shapeable load: charging can be encouraged, through smart pricing or other strategies, to occur when it is beneficial to the energy grid – such as when there is available capacity or excess renewable generation.

EV charging stations can be installed in locations that make sense for both customer needs and the energy grid. Electric companies can help site charging infrastructure where the energy grid has the capacity to support it and help customers to understand the cost implications for new installations.

As the EV market grows and the energy grid increasingly powers transportation, electric companies are critical to ensuring that EV charging is integrated with the energy grid in an efficient manner.