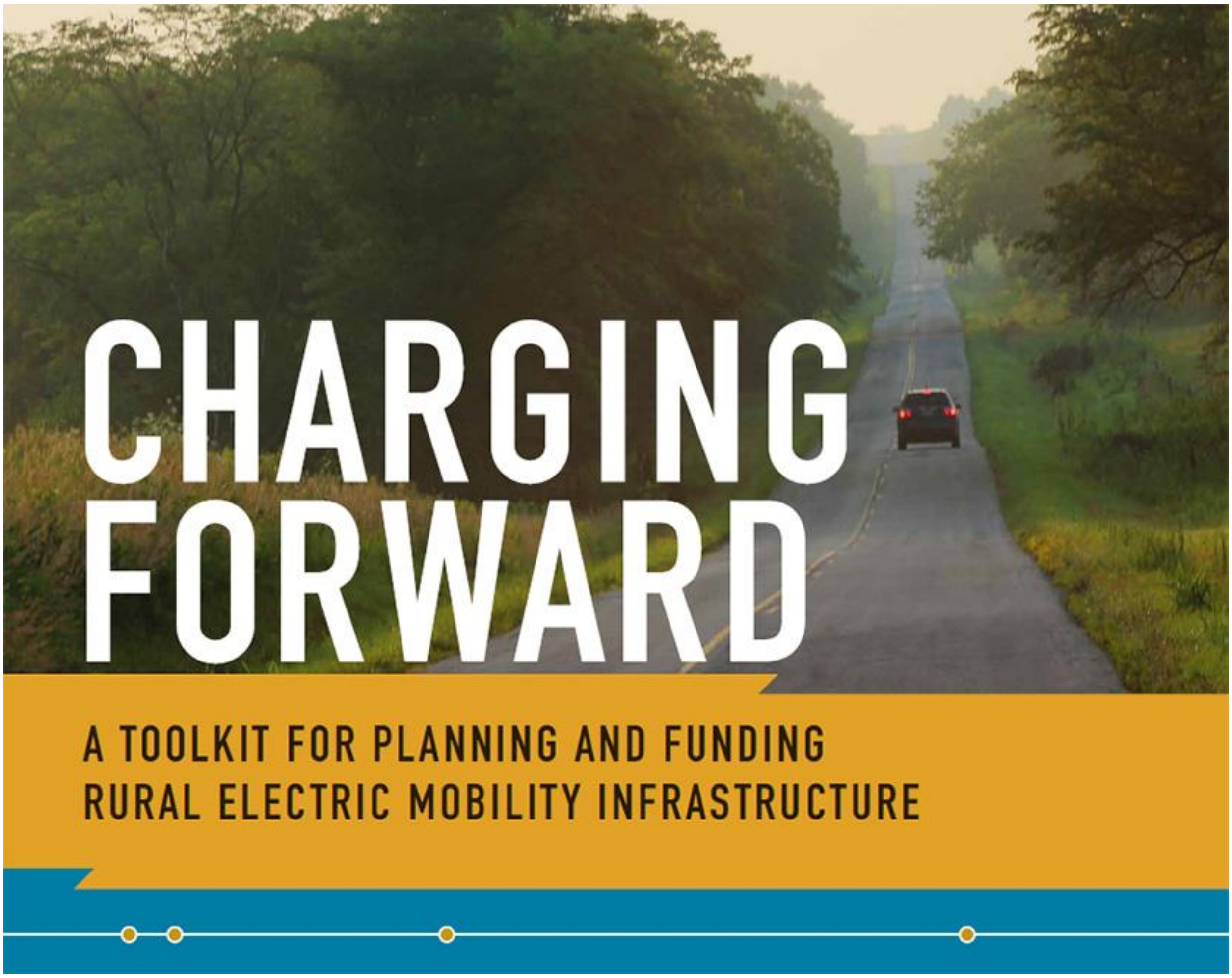
Rural EV Education Toolkit

A Summary from "Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructure"



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Mainstream Electric Vehicle Types

Battery Electric Vehicles (BEVs)

Battery electric vehicles (BEVs)—also referred to as "all-electric vehicles"—run on electricity only and are recharged from an external power source. They are propelled by one or more electric motors powered by rechargeable battery packs. Almost all BEVs can travel at least 100 miles on a charge, and many new vehicles coming on the market offer an all-electric range of 200-300 miles or more.

Plug-In Hybrid Electric Vehicles (PHEVs)

PHEVs also use batteries to power an electric motor and can be recharged from an external power source, but they incorporate a smaller internal combustion engine that can recharge the battery (or in some models, directly power the wheels) to allow for longer driving ranges.

PHEVs can usually drive moderate distances in "EV mode" using only the battery, typically from 20 to 50 miles in current models. This significantly reduces their gasoline use and emissions under typical driving conditions, since most trips are short. PHEVs use 14 to 47 percent less fuel than conventional vehicles if their batteries are fully charged. When electricity is unavailable, PHEVs can run on gasoline alone. There is no range anxiety with PHEVs.

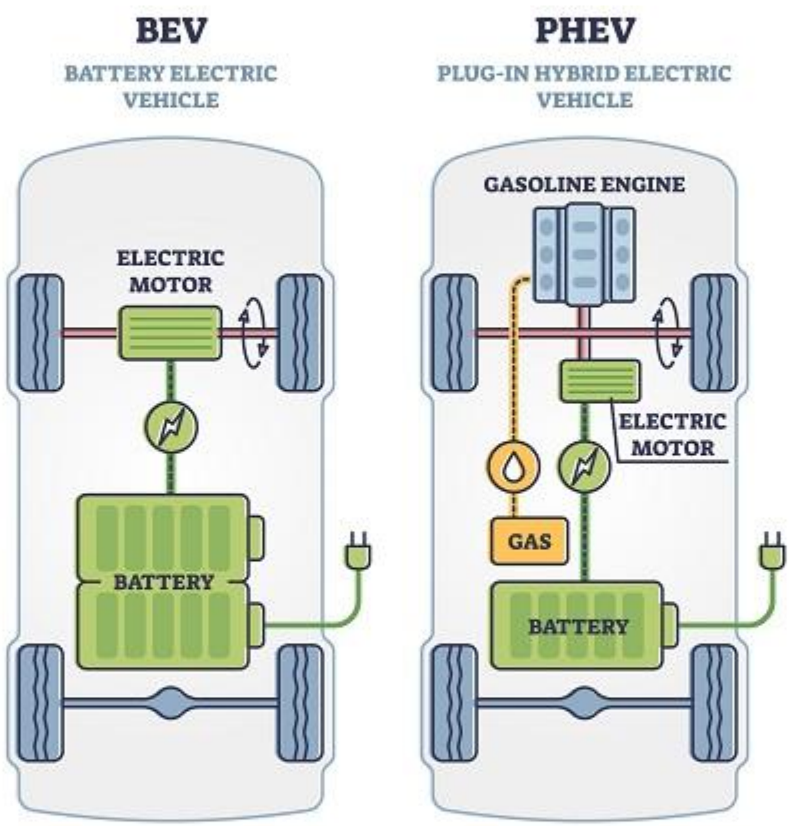


Figure 1 Both BEVs and PHEVs can be recharged from external sources and are capable of operating with zero tailpipe emissions. (VectorMine/stock.adobe.com)

Electric Vehicle Options

The number of EV models in the United States is growing at a rapid pace. In 2010, there was only one EV model on the market, while by 2023, that number had grown to 136 models. There are various types of EVs including electric sedan, electric pickup truck, electric SUV, electric cargo/passenger vans. Scan QR code for more options.

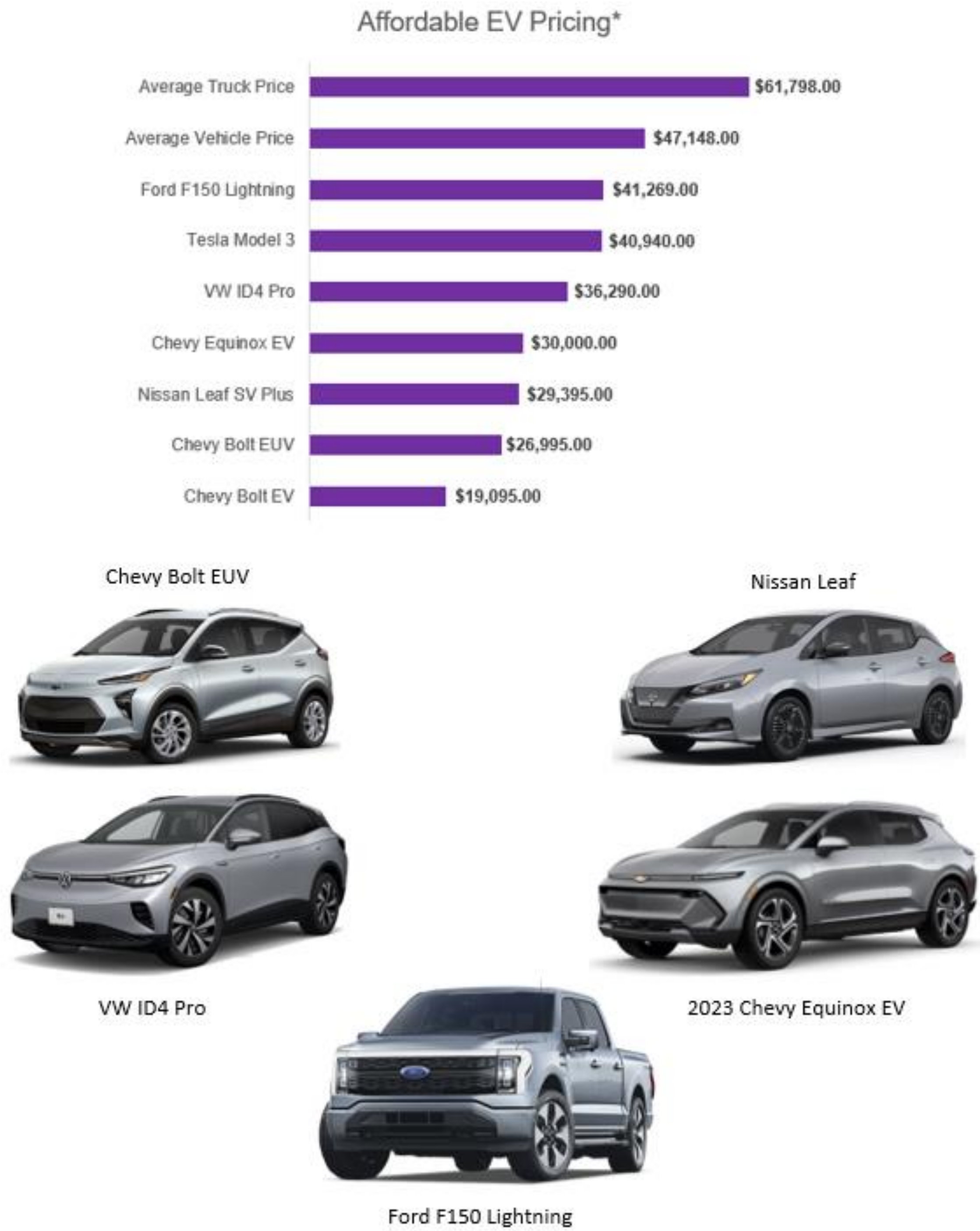


Figure 2 List of Affordable EVs in the Market (data source: CarMax)

Overview of EV Chargers (three charging speeds)

Level 1

It provides charging through a common residential 120-volt (120V) AC outlet.

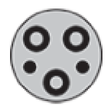
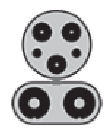
Level 2

Level 2 equipment offers charging through 240V or 208V.

Direct Current Fast Charging (DCFC)

The fastest speed, direct current fast charging (DCFC) equipment, enables rapid charging along heavy-traffic corridors at installed stations. DCFC equipment can charge a BEV to 80 percent in just 20 minutes to 1 hour. Most PHEVs currently on the market do not work with fast chargers.

Overview of EV chargers: power output, plug type, and charge time for light-duty vehicles. (Adapted from the Alternative Fuels Data Center)

	Level 1	Level 2	DC Fast Charging
Connector Type[1]	J1772 connector 	J1772 connector 	CCS connector  CHAdeMO connector  Tesla connector 
Typical Power Output	1 kW	7 kW - 19 kW	50 - 350 kW
Estimated PHEV Charge Time from Empty[2]	5 - 6 hours	1 - 2 hours	N/A
Estimated BEV Charge Time from Empty[3]	40 - 50 hours	4 - 10 hours	20 minutes - 1 hour[4]
Estimated Electric Range per Hour of Charging	2 - 5 miles	10 - 20 miles	180 - 240 miles
Typical Locations	Home	Home, Workplace, and Public	Public

Individual Benefits of Rural Vehicle Electrification

Lower Vehicle Fuel and Maintenance Costs

Fuel economy of EVs is typically measured in miles per gallon of gasoline equivalent (MPGe). Most light-duty BEVs and PHEVs in electric mode can exceed 130 MPGe and can drive 100 miles consuming only 25–40 kWh. At the same time, EVs generally perform better than their conventional counterparts, with higher acceleration, better towing capacity, and smoother speed transitions, due to the fact that electric motors generate full torque at all revolutions per minute (RPMs) and EVs do not need a transmission.

While the cost of charging will depend on the cost of electricity in particular areas, the high fuel economy of EVs leads to lower fueling costs compared to gasoline or diesel vehicles. For example, the electricity required to drive an EV 15,000 miles in a year costs an average of $546, while the gasoline required to drive the same distance averages $1,255, representing a savings of over $700 per year.

In addition to fuel savings, **average maintenance and repair costs for an EV are up to 50 percent lower than a conventional vehicle**, as EVs are free of many vehicle components that require regular maintenance (e.g., engine oil, spark plugs, air filter, transmission fluid). The use of regenerative braking also reduces brake maintenance costs. Rural drivers who switch to EV could potentially save thousands of dollars in maintenance cost over the life time.

Table 1 Average annual transportation expenditures of urban and rural households in 2020. (Source: U.S. Bureau of Labor Statistics)

	Urban	Rural
Mean annual household transportation expenditure	$9,822	$9,866
Transportation share of all annual household expenditures	15.7%	20.0%

Readily Available Fueling Infrastructure

EVs can be charged at home, as well as at workplaces, public facilities, grocery stores, and other locations that offer parking with EV chargers. In fact, more than 80 percent of EV drivers rely on home charging. For longer trips, the growing number of publicly available fast-charging stations can provide a near-full charge (80 percent) in under an hour.

Vehicle Options

The number of EV models for sale in the United States is growing at a rapid pace. In 2010, there was only one EV model on the market, while by 2023, that number had grown to 136 models. There are various types of EVs including electric sedan, electric pickup truck, electric SUV, electric cargo/passenger vans.

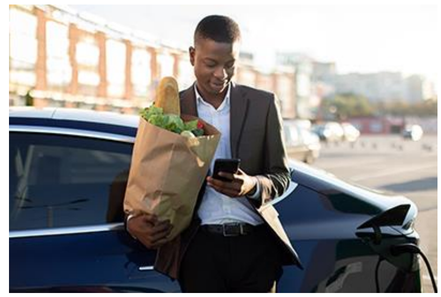
Resilience and Power on the Go

Some EVs can themselves serve as a power source for electrical tools, equipment, and lighting for commercial and recreational purposes. When coupled with bidirectional chargers, EV batteries can even power homes during blackouts and extreme weather events in place of diesel generators.

Community Benefits of Rural Vehicle Electrification

Four Key Community Benefits from EVs.

Economic Development



Given current limits on the range of EVs, those drivers may be especially attuned to the availability of charging stations along their routes, and plan their stops accordingly. Given the significant time required even when using fast charging infrastructure, EV drivers may also be inclined to combine their refueling stops with other activities, including visits to local stores, restaurants, parks, and attractions in the vicinity. Providing EV charging stations can thus enable rural communities to draw regional travelers driving EVs and to stay connected to the broader EV charging network, benefiting both local residents and outside visitors alike, as well as bringing in revenue for local businesses.

Health Benefits

> Transitioning to a nationwide electric transportation system by 2050 would save about 6,300 lives every year and avoid 93,000 asthma attacks and 416,000 lost work days annually.
>
> *- American Lung Association*

According to the American Lung Association, transitioning to a nationwide electric transportation system by 2050 would save about 6,300 lives every year and avoid 93,000 asthma attacks and 416,000 lost work days annually. The tailpipe emissions from internal combustion engine vehicles cause air pollution, which leads to adverse health impacts. Battery electric vehicles run with zero tailpipe emissions, while plug-in hybrid electric vehicles produce some emissions when they operate on gasoline, but less than comparable conventional vehicles. As a result, EVs can reduce air pollution around rural homes and businesses and provide health benefits.

Lower Greenhouse Gas Emissions

The transportation sector is responsible for 29 percent of all U.S. greenhouse gas (GHG) emissions, more than any other U.S. sector, and approximately 60 percent of these emissions come from passenger vehicles. Compared to conventional vehicles, EVs have significantly lower GHG emissions, especially if electricity is generated with renewable energy sources like hydroelectric, solar, or wind. Transitioning from conventional vehicles to EVs can contribute to climate change mitigation and national emission reduction goals.

EV Manufacturing and Employment in Rural America

The manufacturing and supply chains for EVs, their components, and charging equipment present an opportunity to expand investment in the American workforce and local communities. In 2020, the EV sector added 6,000 jobs (8 percent growth). Recent announcements promise further strong investment—for example, in late 2021, Ford and partner companies announced plans for three plants for EVs and batteries in Kentucky and Tennessee, investing more than $10 billion and creating more than 10,000 jobs.

EV Challenges and Evolving Solutions for Rural Communities

While the electric vehicle (EV) market has accelerated substantially and EV infrastructure continues to grow, several key challenges remain.

Up-Front Vehicle, Charging Infrastructure Costs, Total Cost of Ownership

While the cost of EVs continues to decrease, the initial expense of EV charging infrastructure and the higher cost of most EVs available today still pose a barrier to EV purchases. In 2020, the average cost of a new light-duty vehicle overall was just over $31,000, while comparable EVs available cost over $40,000 before applicable tax credits. Affordable new and used EVs exist in the market (e.g., Nissan Leaf, Chevy Bolt EV/EUV). **EVs have a lower total cost of ownership than conventional vehicles** due to lower fuel and maintenance costs, and have the potential to yield significant savings for rural households.

Limited Infrastructure Availability and Geographic Distribution

While home-, business-, and fleet-based charging are expected to remain the primary ways EV drivers charge their vehicles, the need for expanded public fast charging continues to rise with the growth of EVs—especially for rural drivers, who typically drive longer distances than urban drivers and for whom existing DCFC stations are spaced much farther apart.

Solution: Placing public DCFC and Level 2 charging along rural travel corridors and at key destinations in rural areas can help to address these concerns and provide drivers with the confidence that they will be able to charge their vehicles when and where they need to. National Electric Vehicle Infrastructure (NEVI) Formula Program will install EV charging infrastructure **every 50 miles along the designated corridors**.

Public Awareness and Exposure to EVs

As a result, public awareness and exposure to EV technology has typically been lower in rural areas than in urban areas. Without targeted outreach on the benefits of EVs and without higher visibility of EVs on the road, consumers, businesses, and public fleets are likely to continue investing in conventionally fueled vehicles. Poor or lacking infrastructure signage along roadway corridors, along with generally insufficient information on the availability of charging infrastructure, also stymies the EV market.

For these reasons, public outreach efforts by entities such as the DOE-designated national network of Clean Cities coalitions are critically important for bolstering EV awareness, equitable access, and adoption among rural entities. Such outreach efforts can include public education workshops, ride-and-drive events, fleet outreach and trainings, and highway corridor signage.

Lack of EV Riding and Driving Experience

EV operates similarly like conventional vehicles but have several unique features. EVs are quiet with fast acceleration (take-off). Most of EVs offers one-pedal driving features. EVs will need to be periodically charged. Where and how EVs need to be charged depends on the trips and travel patterns. This information can be provided through EV ride-and-drive events and EV test-drive programs.

Learnings from DOE-supported Rural EV Projects

Project 1: Developing an Electrified Vehicle Demonstration. Testbed in the Upper Cumberland Region of. Tennessee, an Economy Distressed Rural Region

Sponsor: U.S. Department of Energy Vehicle Technologies Office, 10/01/2022 – 12/31/2022

Partners: Tennessee Technological University (lead), The University of Texas at Austin, Nissan North America, Phoenix Motorcars, East Tennessee Clean Fuels Coalition, Seven States Power Corporation, ChargePoint, Upper Cumberland Human Resource Agency, Oak Ridge National Laboratory

PI: Prof. Pingen Chen, Tennessee Technological University, Email: pchen@tntech.edu, 931-372-3310

Project Overview: This project will create a proof-of-concept demonstration testbed for EVs and charging infrastructures in UC region in Tennessee, which is a representative rural and economically distressed region, to provide the experience, research, demonstration and educational opportunities needed to address EV adoption issues. Comprehensive data will be collected and analyzed to report the operation cost, issues and performance of EV to help potential fleet owners and the public at large make informed decisions in EV adoption for rural areas before making significant financial investment.

Project 2: Rural Reimagined: Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia

Sponsor: U.S. Department of Energy Vehicle Technologies Office, 08/01/2022 – 10/31/2025

Partners: Tennessee Technological University (lead), Tennessee Clean Fuels Coalition, Kentucky Clean Fuels Coalition, State of West Virginia Clean Cities, Virginia Clean Cities, Clean Fuels Ohio, Nissan, VW, ChargePoint, Siemens, EVmatch, TN DOT, Oak Ridge National Lab, West Virginia University, Appalachian Region Commission, University of Texas at Austin, TCAT, and others (64 in total)

PI: Prof. Pingen Chen, Tennessee Technological University, Email: pchen@tntech.edu, 931-372-3310

Project Overview: the project objective is to build the underpinnings of a comprehensive EV ecosystem and green economy in the most economically distressed Appalachian region to transform the lives of rural and low-income communities, through strong regional collaboration. This project aims to provide clean and affordable mobility options to the underserved communities by developing needed charging infrastructure, and adopting and demonstrating various cost-effective EVs in diverse applications. In addition, by partnering with a broad set of EV stakeholders, this project aims to create outreach, training and education opportunities to residents in rural and low-income Appalachian communities to kick-start electric vehicle adoption and clean-energy job opportunities where it is needed most.

Note: Please scan QR Codes to learn more about the two projects, and reach out to the PI, if interested.

References

1. Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructure, U.S. Department of Transportation.

2. DOE Alternative Fuels Data Centers, https://afdc.energy.gov/.