Electric Vehicles

An Online Continuing Education Course for Engineers

Course Number: M-3068

Credit: 3 Hours / 3 PDH / 3 CPD

Electric Vehicles

Lee Layton, P.E.

Introduction

The use of electric vehicles is growing worldwide, and the performance characteristics and supporting infrastructure are speeding the acceptance of electric vehicles in the market. This course explains electric vehicles' design characteristics, performance, battery technology, charging technology, and environmental aspects.

The Tesla Model 3 was world's best-selling electric vehicle by 2020 with a range of over 300 miles.

An electrically powered vehicle is any vehicle that uses electric motors for propulsion. *Electric vehicles* (EVs) take several forms, from "pure" electric vehicles that are exclusively battery-powered to hybrid gasoline engine/battery vehicles. Electric vehicles include automobiles, trucks, trains, airplanes, boats, etc. In the context of this course, the term "vehicle" refers to some form of electrically powered automobile. Compared to internal combustion engine vehicles, electric vehicles are quieter, have no exhaust emissions, and lower emissions overall.

Electric vehicles are not new. Electric vehicles were popular in the late 19th century and early 20th century until the mass production of cheaper gasoline vehicles led to a decline in electric drive vehicles. The internal combustion engine (ICE) vehicles had much quicker refueling times and cheaper production costs.

The emergence of *metal-oxide-semiconductor field effect transistor* (MOSFET) technology led to the development of modern electric road vehicles. The power of MOSFET and a microcontroller led to significant advances in electric automobile technology. MOSFET power converters allow operation at much higher switching frequencies, making it easier to drive, reduce power losses, and significantly reduce prices, while single-chip microcontrollers manage all aspects of the drive control and have the capacity for battery management. The advances in electronics in the late 20th century along with newer batteries with increased power densities (e.g., lithium-ion) led to the re-birth of the electric vehicle industry.

The adoption of electric vehicles has grown dramatically in the past 20 years with the global stock of electric vehicles increasing from virtually none in 2000 to over 6 million vehicles by 2020.

Modern electric vehicles can be categorized into four broad groups as shown in Figure 1.

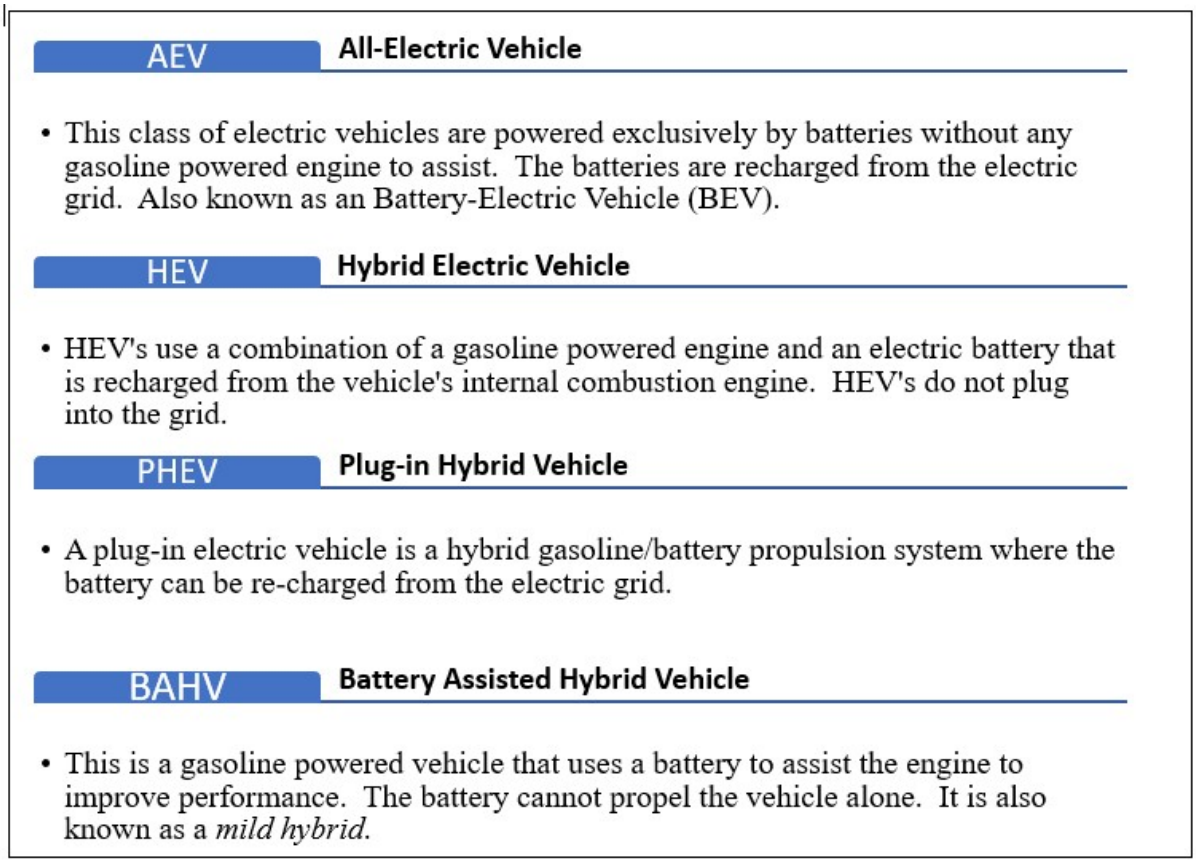

Figure 1

To further confuse the nomenclature, another term - Plug-in Electric Vehicles (PEV) - is used to describe the class of AEVs and PHEVs since both of these are capable of drawing power from the electric grid. There are other forms as well, such as fuel cell powered electric vehicles and solar powered electric vehicles. The focus of this course is primarily on plug-in and battery powered electric vehicles.

AEVs have a limited range, typically 100 miles or so, and a few luxury models have ranges up to 250 miles. When the battery is depleted, it can take from 30 minutes up to nearly a full day to recharge it, depending on the type of charger and battery.

PHEVs run on electricity for shorter ranges (6 to 40 miles), then switch over to an internal combustion engine running on gasoline when the battery is depleted. The flexibility of PHEVs allows drivers to use electricity as often as possible while also being able to fuel up with gasoline if needed. Powering the vehicle with electricity from the grid reduces fuel costs, cuts petroleum consumption, and reduces tailpipe emissions compared with conventional vehicles. When driving distances are longer than the all-electric range, PHEVs act like hybrid electric vehicles, consuming less fuel and producing fewer emissions than similar conventional vehicles. Depending on the model, the internal combustion engine may also power the vehicle at other times, such as during rapid acceleration or when using heating or air conditioning.

Most EV's use *regenerative braking*, which generates electricity from some of the energy normally lost when braking.

Electricity to charge the batteries in PEV's generally comes from the electric grid. In the United States the electric grids include coal, nuclear, natural gas, hydropower, and variable renewable energy resources such as solar and wind. The exact composition of fuel sources varies by state and the overall mix of the US electric fuel supply is shown in Figure 2.

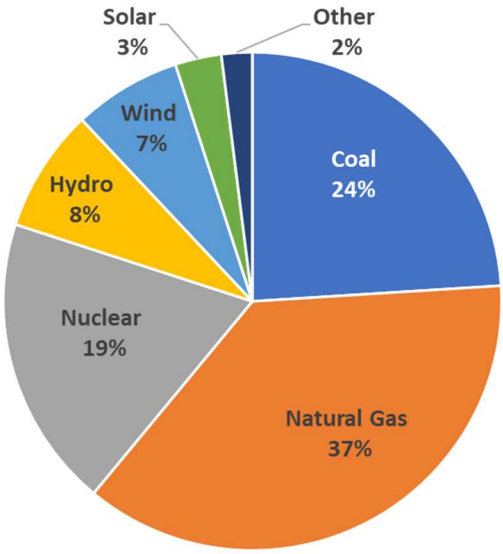

Figure 2

As you can see in the figure, coal, natural gas, and nuclear are the largest fuel types used in the US. The Energy Policy Act of 1992 considers electricity an alternative fuel source for transportation. In PEVs, onboard rechargeable batteries store energy to drive electric motors.

BEVs (which run only on electricity) do not produce any tailpipe emissions, though they still have upstream emissions associated with the production of electricity.

Fueling PEVs with electricity is cost effective compared to using petroleum fuels. Electricity for charging vehicles is especially cost effective if drivers can take advantage of off-peak residential rates offered by many utilities. Electricity costs can vary by region, type of generation, time of use, and access point.

PEVs require a fueling infrastructure including special battery chargers and unique adapters to connect to the vehicle. Most PEV's are charged at a home base, whether it be a residential home for an individual owner or a fleet facility for a large commercial business. Presently this is limited public infrastructure for charging PEV's though may cities, parking garages, restaurants, and shopping centers are adding charging centers.

This course is divided into five chapters. Chapter one describes the technologies of the various types of electric vehicles. Chapter two explains the performance characteristics of EVs. Chapter three is a detailed look at the current and proposed batteries for EVs and Chapter four explains the infrastructure issues such as battery chargers. Chapter five discusses some of the challenges facing the widespread adoption of electric vehicles.

Chapter 1
Electric Vehicle Design Characteristics

This chapter provides detailed characteristics of the primary forms of electric vehicles. Vehicle batteries are covered in Chapter 3. All-electric vehicles (AEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery assisted hybrid's (BAHVs) - called electric-drive vehicles (EV's) collectively - use electricity either as their primary fuel or to improve the efficiency of conventional vehicle designs. The d of each of type is explained in this chapter.

To ease the transition f
c
a
ge
co
par
and
sele
provi
of cre

When
braking
accelera
a familia
braking s
would in

All Electr

vehicles
ectrical energy that powers the
are charged by plugging the vehicle in to an electric power source. Although electricity production may contribute to air pollution, the U.S. Environmental Protection Agency categorizes all-

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.