

# History of Electric Cars

## *The Early Years (1890 to 1930)*

The electric vehicle is not a recent development. In fact, the electric vehicle has been around for over 100 years and has an interesting history of development that continues to the present.

France and England were the first nations to develop the electric vehicle in the late 1800s. It was not until 1895 that Americans began to devote attention to electric vehicles. Many innovations followed and interest in motor vehicles increased greatly in the late 1890s and early 1900s. In 1897, the first commercial application was established with a fleet of New York City taxis.

Early electric vehicles, such as the 1902 Wood's Phaeton, were little more than electrified horseless carriages and surreys. The Phaeton had a range of 18 miles, a top speed of 14 mph, and cost \$2,000.



*1902 Wood's Electric Phaeton*

By the turn of the century, America was prosperous and the motor vehicle, now available in steam, electric, or gasoline versions, was becoming more popular. The years 1899 and 1900 were the high point of electric vehicles in America, when they outsold all other types of cars. Electric vehicles had many advantages over their competitors in the early 1900s. They did not have the vibration, smell, and noise associated with gasoline cars. Changing gears on gasoline cars was the most

difficult part of driving; in contrast, electric vehicles did not require gear changes. Steam-powered cars also had no gear shifting, but they suffered from long start-up times of up to 45 minutes on cold mornings. Steam cars had less range before needing water than an electric car's range on a single charge. The only good roads of the time period were in towns, which caused most travel to be local, a perfect situation for electric vehicles, because their range was limited. The electric vehicle was the preferred choice of many because it did not require a manual effort to start, as with the hand crank on gasoline vehicles, and there was no wrestling with a gear shifter.



*New York City electric taxis*

While basic electric cars cost under \$1,000, most early electric vehicles were ornate, massive carriages designed for the upper class. They had fancy interiors, with expensive materials, and averaged \$3,000 by 1910. Electric vehicles enjoyed success into the 1920s with production peaking in 1912.



*1918 Detroit*

Decline of the electric vehicle was brought about by several major developments as follows:

- By the 1920s, America had a better system of roads connecting cities, and bringing with it the need for longer-range vehicles.
- The discovery of Texas crude oil reduced the price of gasoline, making it affordable to the average consumer.
- The invention of the electric starter by Charles Kettering in 1912 eliminated the need for the hand crank to start internal combustion engines.
- Initiation of mass production of internal combustion engine vehicles by Henry Ford made these vehicles widely available and affordable in the \$500 to \$1,000 price range. By contrast, the price of the less efficiently produced electric vehicle continued to rise. In 1912, an electric roadster sold for \$1,750, while a gasoline car sold for \$650.

### *The Middle Years (1930 to 1990)*

Electric vehicles had all but disappeared by 1935. The years following 1935 until the 1960s were dead years for electric vehicle development and for personal transportation use.

The 1960s and 1970s saw a need for alternative-fueled vehicles to reduce the problems of exhaust emissions from internal combustion engines and to reduce dependency on imported foreign crude oil. Many attempts to produce practical electric vehicles occurred during the years from 1960 to the present.



*1971 Battronic electric truck*

During the early 1960s, the Boyertown Auto Body Works jointly formed the Battronic Truck Company with Smith Delivery Vehicles, Ltd., of England, and the Exide Division of the Electric Battery Company. The first Battronic electric truck was delivered to the Potomac Edison Company in 1964. This truck was capable of speeds of 25 mph, a range of 62 miles and a payload of 2,500 pounds. Battronic worked with General Electric from 1973 to 1983 to produce 175 utility vans for use in the utility industry and to demonstrate the capabilities of battery-powered vehicles. Battronic also developed and produced about 20 passenger buses in the mid-1970s.



*Jet Industries electric van conversions*

Jet Industries of Austin, Texas was active in converting vehicles to electric propulsion. Jet Industries produced a number of vehicles, including the Electrica. Most Jet Electricas were based on a Ford Escort and Mercury Lynx chassis purchased new from Ford as “gliders” (body and chassis without engines). To convert the Escort to electric, Jet mated a Prestolite 96 volt traction motor to the original Ford transaxle, fabricated battery boxes front and rear, filled them with 6-volt flooded lead-acid batteries, and added a motor controller and an on-board battery charger using 120-volt alternating current power.



*Jet Industries EV Electrica sedan conversion*

During this time, Sebring-Vanguard produced over 2,000 “CitiCars.” These cars had a top speed of 44 mph, a normal cruise speed of 38 mph, and a range of 50 to 60 miles. Another company was Elcar Corporation, which produced the “Elcar.” The Elcar had a top speed of 45 mph, a range of 60 miles, and cost between \$4,000 and \$4,500.



*Sebring-Vanguard CitiCar*

*Elcar*

In 1975, the United States Postal Service purchased 350 electric delivery jeeps from the American Motor Company to be used in a test program. These jeeps had a top speed of 50 mph and a range of 40 miles at a speed of 40 mph. Heating and defrosting were accomplished with a gas heater and the recharge time was 10 hours.



*1975 electric postal vehicle*

To demonstrate the capabilities of electric cars, the first ever cross country trip in an electric car was made by Arizona Public Service in a MARS II Electric Car built by Electric Fuel Propulsion Inc. of Detroit, Michigan. The trip started in Detroit on September 20, 1967, and ended in Phoenix on October 5, 1967, with 37 stops along the way for fast charging of the car’s lead cobalt batteries. Arizona Public Service purchased the MARS

II and a 50-kW fast charger built by Electric Fuel Propulsion Inc. for this historic 2,226-mile trip.



*Clair Titus, Vice President of Research and Development, Arizona Public Service, takes delivery of MARS II in Detroit, Michigan, September 20, 1967.*

Unique Mobility Inc., based in Longmont, Colorado was involved during the late 1970s in building the Unique Mobility Electrek vehicle, which is a two-door 2+2 seater made of fiberglass-reinforced plastic and powered by 16 six-volt batteries. The Electrek featured regenerative braking and could reach a claimed maximum speed of 75 mph and an urban driving range of 75 miles.



*Unique Mobility Electrek vehicle*

The EVcort was an experimental electric car produced from 1981 to 1994 by Electric Vehicle Associates of Cleveland, Ohio and later by Soleq Corporation. of Chicago, Illinois. The car consisted of a stock body and transmission from the Ford Escort, retrofit with an electric propulsion system, and every component was engineered and manufactured specifically for the car. It incorporated features such as regenerative braking and a multistep charging algorithm that are common on

modern electric vehicles, but were quite innovative at the time. The intent was to produce a practical alternative-fueled vehicle with performance comparable to gasoline-powered cars. The EVcort was used extensively by a variety of institutions for electric vehicle demonstration and testing programs, including the U.S. Department of Energy's Site Operator Program.



*EVcort*

## *The Modern Generation of Electric Vehicles (1990 to 2010)*

Several legislative and regulatory actions renewed electric vehicle development efforts. Primary among these actions is the 1990 Clean Air Act Amendment, the 1992 Energy Policy Act, and regulations issued by the California Air Resources Board. In addition to more stringent air emissions requirements and regulations requiring reductions in gasoline use, several states issued Zero Emission Vehicle requirements.

The “Big Three” automobile manufacturers (i.e., Chrysler, Ford, and General Motors) and the U.S. Department of Energy, as well as a number of vehicle conversion companies, were actively involved in electric vehicle development through the Partnership for a New Generation of Vehicles. Electric conversions of familiar gasoline-powered vehicles, as well as electric vehicles designed from the ground up, were available that reached highway speeds with ranges of 50 to 150 miles between recharging.

One example of these vehicles was the Chevrolet S-10 pickup truck, converted by U.S. Electricar. It was powered by dual alternating current motors and lead acid batteries. It had a range of about 60 miles and could be recharged in less than 7 hours.



*U.S. Electricar S-10 electric pickup truck*

Another example was the Geo Metro, converted by Solectria Corp., which was an electric-powered four-passenger sedan powered by an alternating current motor and lead-acid batteries. It had a range of 50 miles and could be recharged in less than 8 hours. During the 1994 American Tour de Sol from New York City to Philadelphia, a 1994 Solectria Geo Metro cruised over 200 miles on a single charge using Ovonic nickel metal hydride batteries.



*Solectria's Geo Metro electric conversion*

The “Big Three” automobile manufacturers were also developing electric vehicles. An early 1990s vehicle was the Ford Ecostar utility van with an alternating current motor and sodium sulfur batteries. The top speed was 70 mph and it had a range of 80 to 100 miles. While about 100 Ecostars were produced, it was considered a research and development vehicle and was never offered commercially.



*Ford Ecostar*

However, Ford did offer an electric version of its Ford Ranger pickup. It had a range of about 65 miles with its lead acid batteries, a top speed of 75 mph, it accelerated from 0 to 50 mph in 12 seconds, and the payload was 700 pounds. Ford later came out with a Ranger version equipped with a nickel metal hydride (NiMH) battery that weighed 1,100 pounds. Depending on how it was driven, the range was about 85 miles.



*Ford Ranger electric pickup*

General Motors designed and developed an electric car from the ground up instead of modifying an existing vehicle. This vehicle, called the EV1, was a two-passenger sports car. The lead acid EV1 had a top speed of 80 mph, a range of about 80 miles, and it could accelerate from 0 to 50 mph in 6.3 seconds. The battery pack in the lead acid EV1 weighed 2,600 pounds.

Not long after the lead acid version, General Motors introduced a NiMH battery-equipped EV1. The NiMH version had a range of about 150 miles, but under optimal driving conditions it could exceed 200 miles per charge. The NiMH EV1 also had a top speed of 80 mph and an acceleration time from 0 to 50 mph in 6.3 seconds. The battery pack in the NiMH EV1 weighed 1,600 pounds.



*General Motors EV1*

In addition to the EV1, General Motors also offered an electric Chevrolet S-10 pickup that initially had lead acid batteries. This vehicle had a range of 40 miles, it accelerated from 5 to 50 mph in 10 seconds, it had a payload of 950 pounds, and the lead acid battery pack weighed 1,270 pounds. Chevrolet later came out with an S-10 pickup equipped with a NiMH battery that weighed 1,100 pounds. Depending on how it was driven, the range was about 95 miles.



*Chevrolet electric S-10 pickup*

Chrysler's first electric vehicle from this generation was an electric conversion of the Dodge Caravan. This vehicle was a five-passenger van. It had a range of about 50 miles with its lead acid batteries, a top speed of 62 mph, it accelerated from 0 to 50 mph in 31 seconds, and the payload was 800 pounds. Chrysler later came out with a Dodge Caravan Epic that was equipped with a NiMH battery that weighed 1,200 pounds (with coolant). It had a range of about 80 miles, a top speed of 78 mph, it accelerated from 0 to 50 mph in 12 seconds, and the payload was 945 pounds.



*Dodge Caravan electric with lead acid battery*



*Dodge Caravan electric with NiMH battery*



*BMW Mini E*

Other electric vehicles available in some states included the Toyota RAV4 sport utility and the Honda EV Plus sedan. Both of these vehicles were equipped with NiMH battery packs. Nissan had Altra EV station wagons in California fleets that were equipped with a lithium-ion battery pack.

The Toyota RAV4 was a five-passenger sport utility vehicle with a range of about 95 miles, a 1,000-pound NiMH batteries, a top speed of 79 mpg, acceleration from 0 to 50 mph in 13 seconds, and a payload of 785 pounds.



*Toyota RAV4 sport utility vehicle*

BMW also came out with the Mini E in a limited numbers of states. The Mini E was a two-passenger hatchback with a range of about 120 miles with its 575-pound lithium ion batteries, a top speed of 81 mpg, acceleration from 0 to 50 mph in 8 seconds, and a payload of 354 pounds.

In 1999, the U.S. Postal Service contracted with the Ford Motor Company for the purchase of 500 electric carrier route vehicles. The electric carrier route vehicles were phased into service at 22 post office locations, with 20 in California and one each in New York State and Washington, D.C., between February 2001 and October 2002 for the purpose of assessing the current state of battery technology. The U.S. Postal Service has been testing electric vehicles in various missions since 1899.



*U.S. Postal Service electric carrier route vehicles charging*

Toward the end of this period, several conversion companies started to convert original equipment manufacturers' hybrid electric vehicles into plug-in hybrid electric vehicles by adding a second lithium ion traction battery pack. The most common hybrid electric vehicle model converted was the Toyota Prius. While there were several conversion companies, A123 Hymotion was the largest of the conversion companies and they

used 5-kWh lithium ion batteries from A123 to convert hundreds of Prius hybrids into plug-in hybrid electric vehicles. In order to recharge this second battery pack, the converted Prius had to be plugged into the electric grid.



*A123 battery installed in the trunk of an A123 Hymotion conversion*

This period of electric vehicle development witnessed most original equipment manufacturers introducing electric vehicles in at least some states. Importantly, this was the first period when lighter weight and higher energy density advanced battery chemistries (i.e., NiMH and lithium ion) were introduced into the marketplace in large numbers.

### *Today's Generation of Electric Vehicles (2011 to Present)*

Today's electric vehicle technology can really be broken down into four technologies:

- Hybrid electric vehicle
- Battery electric vehicle (BEV)
- Plug-in hybrid electric vehicle (PHEV)
- Extended-range electric vehicle (EREV).

Taken together, BEVs, PHEVs and EREVs are all considered plug-in electric vehicles (PEVs) because they all must be plugged into the electric grid in order to fully recharge their traction battery packs. Hybrid electric vehicles are not considered a PEV because they cannot be plugged into the electric grid to recharge the traction battery pack.

#### **Hybrid Electric Vehicle Features**

- Gasoline fueled only
- Onboard traction energy storage in the form of gasoline and electricity

- All energy originates from gasoline
- Battery recovers braking energy and it is charged by the internal combustion engine powered by the onboard generator
- Electric motor normally provides propulsion assistance and sometimes all-electric propulsion at low speeds
- Also includes start-stop hybrids, also called "mild" hybrids with no electric propulsion.



*Hybrid electric vehicle technology*

#### **BEV Features**

- Sometimes also referred to as an all-electric vehicle
- Only electricity fueled
- Electricity is the only onboard energy source
- Must be plugged into the electric grid to recharge.



*Battery electric vehicle technology*

#### **PHEV Features**

- Gasoline and electricity fueled
- Gasoline engine may not be used when the battery is above a certain state-of-charge, or is used in a blended mode when both the electric traction motor and internal combustion engine provide propulsion power at the same time
- When the battery is nearly empty, a PHEV operates like a typical hybrid electric vehicle.

## EREV Features

- Is fueled similar to a PHEV in that it is fueled with both gasoline and electricity from the grid
- The main difference between an EREV and a PHEV is that the EREV control system keeps the car operating only on electric propulsion until the traction battery is discharged to a certain level
- After the battery is discharged to a certain level, the gasoline engine turns on and the vehicle operates similar to a hybrid electric vehicle
- EREVs are sometimes considered a PHEV and not a separate technology.



*PHEV and EREV technologies*



*Nissan Leaf BEV*



*Tesla Model S BEV*



*Ford Fusion Energi PHEV*



*Chevrolet Volt EREV*

For additional information about plug-in electric vehicles, hybrid electric vehicles, the charging infrastructure used for charging, and other classes of vehicle technologies, see Idaho National Laboratory's websites:

- Energy Storage and Advanced Vehicles Group - <https://at.inl.gov/SitePages/Home.aspx>
- Advanced Vehicles and Infrastructure Group testing reports - <https://avt.inl.gov/>