ELECTRIC VEHICLE HISTORY

The history of EVs is interesting. It includes the insurgence of EVs following the discovery of electricity and the means of electromechanical energy conversion and later being overtaken by gasoline-powered vehicles. People digressed from the environmentally friendly mode of transportation due to lack of technology in the early years, but they are again focused on the correct track today.

THE EARLY YEARS

Prior to the 1830s, the means of transportation was only through steam power, because the laws of electromagnetic induction, and consequently, electric motors and generators, were yet to be discovered. Faraday demonstrated the principle of the electric motor as early as in 1820 through a wire rod carrying electric current and a magnet, but in 1831 he discovered the laws of electromagnetic induction that enabled the development and demonstration of the electric motors and generators essential for electric transportation. The history of EVs in those early years up to its peak period in the early 1900s is summarized below:

- Pre-830-Steam-powered transportation
- 1831—Faraday's law, and shortly thereafter, invention of DC motor
- 1834—Non-rechargeable battery-powered electric car used on a short track
- 1851—Non-rechargeable 19 mph electric car
- 1859—Development of lead storage battery
- 1874—Battery-powered carriage
- Early 1870s-Electricity produced by dynamo-generators
- 1885—Gasoline-powered tricycle car
- 1900—4200 automobiles sold:
    - 40% steam powered
    - 38% electric powered
    - 22% gasoline powered

The specifications of some of the early EVs are given below:

- 1897—French Krieger Co. EV: weight, 2230 lb; top speed, 15 mph; range, 50 mi/charge
- 1900—French B.G.S. Co. EV: top speed, 40 mph; range, 100 mi/charge

• 1912—34,000 EVs registered; EVs outnumber gas-powered vehicles 2-to-1

• 1915—Woods EV: top speed, 40 mph; range, 100 mi/charge

• 1915—Lansden EV: weight, 2460 lb, top speed, 93 mi/charge, capacity, 1 ton payload

• 1920s—EVs disappear, and ICEVs become predominant

The factors that led to the disappearance of EV after its short period of success were as follows:

1. Invention of starter motor in 1911 made gas vehicles easier to start.
2. Improvements in mass production of Henry T (gas-powered car) vehicles sold for $260 in 1925, compared to $850 in 1909. EVs were more expensive.
3. Rural areas had limited access to electricity to charge batteries, whereas gasoline could be sold in those areas.

1960s

Electric vehicles started to resurge in the 1960s, primarily due to environmental hazards being caused by the emissions of ICEVs. The major ICEV manufacturers, General Motors (GM) and Ford, became involved in EV research and development. General Motors started a $15 million program that culminated in the vehicles called Electrovair and Electrovan. The components and specifications of two Electrovair vehicles (Electrovair I (1964) and Electrovair II (1966) by GM) are given below.

Systems and characteristics:

- Motor—three-phase induction motor, 115 hp, 13,000 rev/m
- Battery—silver-zinc (Ag-Zn), 512 V, 680 lb
- Motor drive—DC-to-AC inverter using a silicon-controlled rectifier (SCR)
- Top speed—80 mi/h
- Range—40 to 80 miles
- Acceleration—0–60 mi/h in 15.6 s
- Vehicle weight—3400 lb

The Electrovair utilized the Chevy Corvair body and chassis. Among the positive features was the acceleration performance that was comparable to the ICEV Corvair. The major disadvantage of the vehicle was the silver-zinc (Ag-Zn) battery pack that was too expensive and heavy, with a short cycle life and a long recharge time.

An additional factor in the 1960s that provided the impetus for EV development included "The Great Electric Car Race" cross-country competition (3300 miles) between an EV from Caltech and an EV from MIT in August 1968. The race generated great public interest in EVs and provided an extensive road test of the EV technology.

However, technology of the 1960s was not mature enough to produce a commercially viable EV.

1970s

The scenario turned in favor of EVs in the early 1970s, as gasoline prices increased dramatically due to an energy crisis. The Arab oil embargo of 1973 increased demands for alternate energy sources, which led to immense interest in EVs. It became highly desirable to be less dependent on foreign oil as a nation. In 1975, 352 electric vans were delivered to the U.S. Postal Service for testing. In 1976, Congress enacted Public Law 94–413, the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976. This act authorized a federal program to promote electric and hybrid vehicle technologies and to demonstrate the commercial feasibility of EVs.

1980s AND 1990s

In the 1980s and the 1990s, there were tremendous developments of high-power, high-frequency semiconductor switches, along with the microprocessor revolution, which led to improved power converter design to drive the electric motors efficiently. Also in this period, factors contributed to the development of magnetic bearings used in flywheel energy storage systems, although these are not utilized in mainstream EV development projects. In the last 2 decades, legislative mandates pushed the cause for zero-emission vehicles. Legislation passed by the California Air Resources Board in 1990 stated that by 1998 2% of vehicles should be zero-emission vehicles (ZEV) for each automotive company selling more than 35,000 vehicles. The percentages were to increase to 5% by 2001 and to 10% by 2003. The legislation provided a tremendous impetus to develop EVs by the major automotive manufacturers. The legislation was relaxed somewhat later due to practical limitations and the inability of the manufacturers to meet the 1998 and 2001 requirements.

The mandate now stands that 4% of all vehicles sold should be ZEV by 2003, and an additional 6% of the sales must be made up of ZEVs and partial ZEVs, which would require GM to sell about 14,000 EVs in California. Motivated by the pollution concern and potential energy crisis, government agencies, federal laboratories, and the major automotive manufacturers launched a number of initiatives to push for ZEVs. The partnership for next-generation vehicles (PNGV) is such an initiative (established in 1993), which is a partnership of federal laboratories and automotive industries to promote and develop electric and hybrid electric vehicles. The most recent initiative by the DOE and the automotive industries is the Freedom CAR initiative.

The trends in EV developments in recent years can be attributed to the following:

- High level of activity exists at the major automotive manufacturers.
- New independent manufacturers bring vigor.
- New prototypes are even better.
- High levels of activity overseas exist.
- There are high levels of hybrid vehicle activity.
- A boom in individual ICEV to EV conversions is ongoing.
- The fuel cell shows great promise in solving the battery range problem.

The case studies of two GM EVs of the 1990s are given below:

1. GM Impact 3 (1993 completed):

a. Based on 1990 Impact displayed at the Los Angeles auto show
b. Two-passenger, two-door coupe, street legal and safe
c. Initially, 12 built for testing; 50 built by 1995 to be evaluated by 1000 potential customers
d. System and characteristics:
    i. Motor—one, three-phase induction motor; 137 hp; 12,000 rev/m
    ii. Battery pack—lead-acid (26), 12 V batteries connected in series (312 V), 869 lb
    iii. Motor drive—DC-to-AC inverter using insulated gate bipolar transistors (IGBTs)
    iv. Top speed—75 mph
    v. Range—90 miles on highway
    vi. Acceleration—0 to 60 miles in 8.5 s
    vii. Vehicle weight—2900 lb
e. This vehicle was used as a test bed for mass production of EVs.

2. Saturn EV1

a. Commercially available electric vehicle made by GM in 1995.
b. Leased in California and Arizona for a total cost of about $30,000.
c. System and characteristics:
    i. Motor—one, three-phase induction motor
    ii. Battery pack—lead-acid batteries
    iii. Motor drive—DC-to-AC inverter using IGBTs
    iv. Top speed—75 mph
    v. Range—90 miles on highway, 70 miles in city
    vi. Acceleration—0 to 60 mi in 8.5 s
d. Power consumption:
    i. 30 kW-h/100 mi in city, 25 kW-h/100 mi on highway
e. This vehicle was also used as a test bed for mass production of EVs.

RECENT EVs AND HEVs

All of the major automotive manufacturers have production EVs, many of which are available for sale or lease to the general public. The status of these vehicle programs changes rapidly, with manufacturers suspending production frequently due to the small existing market demand of such vehicles. Examples of production EVs which are or until recently have been available are GM EVl, Ford Think City, Toyota RAV4, Nissan Hypermini, and Peugeot 106 Electric. There are also many prototypes and experimental EVs being developed by the major automotive manufacturers. Most of these vehicles use

AC induction motors or PM synchronous motors. Also, interestingly, almost all of these vehicles use battery technology other than the lead-acid battery pack. The list of EVs in production and under development is extensive, and readers are referred to the literature3,4 for the details of many of these vehicles.

The manufacturers of EVs in the 1990s realized that their significant research and development efforts on ZEV technologies were hindered by unsuitable battery technologies. A number of auto industries started developing hybrid electric vehicles (HEVs) to overcome the battery and range problem of pure electric vehicles. The Japanese auto industries lead this trend with Toyota, Honda, and Nissan already marketing their Prius, Insight, and Tino model hybrids. The hybrid vehicles use an electric motor and an internal combustion engine and, thus, do not solve the pollution problem, although it does mitigate it. It is perceived by many that the hybrids, with their multiple propulsion units and control complexities, are not economically viable in the long run, although currently a number of commercial, prototype, and experimental hybrid vehicle models are available from almost all of the major automotive industries around the world. Toyota, Honda, and Nissan are marketing the hybrid vehicles well below the production cost, with significant subsidy and incentive from the government. However, the cost of HEVs and EVs are expected to be high until production volume increases significantly.

Fuel cell electric vehicles (FCEV) can be a viable alternative to battery electric vehicles, serving as zero-emission vehicles without the range problem. Toyota is leading the way with FCEV, announcing the availability of its FCEV in 2003. The Toyota FCEV is based on the Toyota RAV4 model.

Reference:

[1] Iqbal Husain, “Electric-and-Hybrid-Vehicles-Design-Fundamentals”, CRC PRESS, 2005.