

Alternative-Fueled Vehicles – Education is the key to success

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Introduction

Alternatively fueled vehicles are sweeping the nation. From electric plug-ins to hybrids and even hydrogen fuel cells, finding unconventional ways to power our vehicles is a topic of interest throughout the automotive community worldwide.

Since the introduction and subsequent extinction of electric vehicles (EV's) a century ago, we as a global community have begun to rediscover how to utilize the benefits and opportunities associated with alternative-fueled vehicles. Today's challenges consist of how to educate consumers to the socio-technological benefits of alternatively fueled vehicles, and why the success of these technologies is based on educating students, teachers, and consumers.

The federal government requires private and public fleets to use more fuel efficient and alternative fueled vehicles to meet the requirements of the Clean Air Act. Related legislation such as the Energy Independence and Security Act of 2007 and its amendments reinforce the need for such vehicles. Along with the manufacture and acquisition of alternative-fueled vehicles, there is a heightened need for understanding their systems, operations, and maintenance.

Understanding basic and plug in electric (EV-PHEV), along with hybrid electric (meaning the use of two types of propulsion - HEV) systems, safety education, needs awareness, and technical information for students and teachers is critical to preparing a knowledgeable and responsive workforce. The job of leaders in the automotive education and training community will be to provide comprehensive overviews and assist those who need information in preparing for this challenge.

Educators at the secondary and post-secondary level are being encouraged to develop curricula as a part of Section 131(d) of the Energy Independence and Security Act of 2007. According to Automotive Engineering magazine, there are currently 10 schools that have been awarded grants for Advanced Electric Drive Vehicle Education Program. In addition, a post secondary vehicle competition to be known as the "Dr. Andrew Frank Plug-in Electric Vehicle Competition" will be made available to institutions of higher learning. [1]

On the manufacturing level, The American Recovery and Reinvestment Act of 2009 has opened federal funding for low cost loans to companies who are willing to develop and produce more fuel efficient vehicles [2].

This article will cover information related to the fundamentals of the Electric Vehicles (EV), Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric

Vehicles (PHEV). It is also important to understand that in addition to personal vehicles several current alternative-fueled and concept vehicles applications for EV, HEV and PHEV are used in heavy off-road equipment, class 8 truck, city buses, delivery vehicles and taxi fleets are already in use.

A discussion related to the need for alternative vehicle education for engineering, engineering technology, technician and consumer education will also be addressed.

A Little History

The first electric car was a model was developed in 1828 in Hungary. In the 1830's a crude electric car was put together in Scotland by Robert Anderson, however, there were no surviving pictures, plans or vehicles for the unit. [3]

The Parker electric vehicle was developed in London in 1884, and may have been the first electric car ready for full-scale production. It is thought that its inventor, Thomas Parker, may have actually built it to combat London's growing smoke and pollution.

Jacob Lohner & Co in Vienna, Austria produced electric cars from 1898 to 1906. Dr. Ferdinand Porsche (later known for the Volkswagen, Porsche and Audi Motor Companies), one of Lohner's employees, developed a drive system based on fitting an electric motor to each front wheel. These early hybrids used electric motors to assist the gasoline combustion engine in providing acceleration when needed. In 1900, history saw the first hybrid-electric vehicle entered in a race. The car was a front wheel drive vehicle, developed and driven by Dr. Ferdinand Porsche.

In the early twentieth century, gasoline combustion engine vehicle began to gain popularity. These automobiles were powerful and affordable thanks to Mr. Henry Ford. Gasoline was becoming more readily available in rural areas, and the invention of the starter motor in 1911 made gas vehicles easier to start. Although electric and hybrid electric vehicles were reliable, the lack of vehicle range between charges had become a major issue many rural areas had limited access to electricity to charge the batteries. The perceived lack of driving range continues to be an electric vehicle issue today. Battery technology, in terms of ability to store a large amount of energy in a small cell is one of the greatest breakthroughs in recent past. The latest lithium-Ion based technology is expected to replace Nickel Metal Hydride cells used as recently as last year. For example, the new Mercedes-Benz S400 is the first production hybrid electric vehicle equipped with Lithium-Ion battery cells. These strides in better battery efficiency are aimed at providing consumers with a whopping 250-300 mile range per charge. The acceptance of electric and hybrid electric vehicles by consumers will in part be contingent on how far they can drive between charges. Presently, the race is one to develop an increased range and build the consumers perception of their practicality.

Types of Architectures

In the series architecture design an engine drives a generator, which converts mechanical energy into electric energy and in turn drives an electric motor. The electric motor provides the vehicle propulsion at the wheels. Some advantages of the series systems are that the electric motor helps the engine accelerate the vehicle using a simple control strategy and a single gear box (no transmission needed). The engine operation can be optimized and it is possible to use a smaller engine in many applications. In the battery alone mode, vehicle is powered by battery only. The engine alone mode will provide power solely from the engine. The combined mode in this type of architecture used both the engine and battery to provide power at the traction motor/mechanical transmission. Series architecture disadvantages involve additional weight due to added components and the need to convert energy twice (from the engine to the motor and the chemical conversion from the battery). This type of system is often used on buses and mail delivery vehicles.

Parallel architecture differs from series design because the engine and motor are mechanically coupled as opposed to being attached in series. Although providing option for many different configurations, its disadvantages lie in its complex transmission and control strategies.

The series-parallel system combines a compact, simple structure and optimizes engine performance. This is accomplished with operational modes of motor alone, electric alone, combined, and regenerative braking. This configuration is becoming increasingly popular on production vehicles and is being used on the Toyota Prius.

Many systems use regenerative braking to recharge the batteries in stop and go traffic. Regenerative braking is accomplished by capturing the vehicles momentum, or kinetic energy while braking. This energy is then used to recharge (regenerate) the battery/batteries. In essence, the motor is both a source of propulsion and a generator. In

In addition to gasoline and diesel engines, other sources of propulsion include Hydrogen Fuel Cells, Liquefied Petroleum Gas (LPG) engines, Compressed Natural Gas (CNG) engines, a new concept called hydraulic engines.

Additional efforts are being made to bring about the use of full electric vehicles (EV). One such effort is the development of Plug-in Hybrid Electric Vehicles (PHEV). This vehicle is also known as an extended range electric vehicle. It is fitted with extra battery capacity and is plugged into the wall the same way that an electric vehicle would be recharged. The idea is to have an electric vehicle that will have a range of at least 40 miles before the gasoline engine would have to start. The 40 mile figure is used because the average commute in the United States is has been determined to be 40 miles or less per day. The vehicle could be driven just on electricity for most days of the week. Going past the charge range would merely result in the engine starting to complete the journey

Needs Awareness

While determining course content, audience needs must be considered. Engineers, engineering technologists, enthusiasts, sales people, technicians, and those who will be operating these vehicles will all have specific areas of interest.

According to Automotive Engineering magazine, “the electrification of the vehicle is boosting demand for engineers with new competencies and skill sets.” Educating engineers is an important step in the right direction. In the same article, JB Staubel, the Chief Technology Officer for Tesla, is quoted as saying, “Education is the really important foundation for where the industry is headed in this field. Over time there will be a lot more classes created the blend electrical, mechanical, software, and chemical engineering.” [5]

Some special needs groups have already begun to be identified such as the engineering technologists who have formed the “The Electric Vehicle Association of Long Island”, a club that shares a passion to modify existing vehicle with varying electric vehicle technologies. Sales people are in desperate need of understanding how systems work so they can competently the vehicle benefits to potential buyers. Technicians who will need to maintain and repair alternative fueled vehicles are curious to discover how new technologies are achieving the goal of traditional combustion engines. Interestingly, many Internet blogs and interactive websites have taken the topic of alternatively fueled vehicles to a new level. Consumers want information so they can make informed purchasing decisions, providing factual information in an easy to understand language is in great demand.

Safety Education

Safety education and training are major concerns due to the extremely high voltages inherent to electric vehicle technology. The high voltage systems of many hybrid electric vehicles have converted energy from the traditional 12-volt battery upwards to energy levels above 60 Volts DC and 25 Volts AC (MBUSA Learning). Exposure to high currents can result in pain, muscle cramps, difficulty breathing, cardiac arrest and/or death. Although high current carrying conductors are often color coded bright orange, all service and development personnel must be trained as to the hazards inherent of working with high voltage systems.

First responders also need training in such areas as safely de-powering a hybrid vehicle, safely performing high-voltage disconnects, understanding unique service issues related to HEV high voltage electric systems, correctly using appropriate personal protective equipment and understanding hazards while driving, moving and hoisting hybrid electric vehicles. [6]

Engineers and Engineering Technologists

To meet the educational challenges associated with electric and hybrid electric vehicles, an increasing number of engineering schools in North America have started the academic discipline of Advanced Vehicle Technologies in both their

graduate and undergraduate programs [7]. The need for engineers who can develop skills leading to actual hands-on experience with electric drive propulsion systems, whether they are in EV, HEV or PHEV, are already in great industry demand.

To best prepare students for these challenges, middle and high school curriculums must place emphasis on building student skills in science, technology, engineering and math (STEM). The International Technology Education Association has released a new publication titled *The Overlooked STEM Imperatives – Technology and Engineering – K-12 Education*. The description of the publication is as follows:

“Take this opportunity to gain a better understanding of the need for STEM education and its critical role in creating a technologically literate society. The rationale for the “T” and “E” has been specifically addressed in order to gain support for these subjects as part of the overall STEM effort.

You are invited to explore the power and promise of a STEM (science, technology, engineering, and mathematics) education through this publication, but more importantly, to seek to understand the importance of ensuring that the “T” and “E” are equal partners within STEM to adequately prepare the next generation workforce as well as valued contributors to our communities and society.” [8]

There will also be a conference related to this initiative by ITEA in Charlotte, NC in March, 2010 titled: “Green Technology: STEM Solutions for the 21st Century.” (<http://www.iteaconnect.org/Conference/AtAGlance.pdf>)

The publication by the *Engineering Technology Council* (1992) defines the of the Engineering Technologist as follows:

Engineering Technology is the profession in which knowledge of mathematics and natural sciences gained by higher education, experience, and practice is devoted primarily to the implementation and extension of existing technology for the benefit of humanity.

Engineering Technology Education focuses primarily on the applied aspects of science and engineering aimed at preparing graduates for practice in that portion of the technological spectrum closest to product improvement, industrial processes, and operational functions. *Engineering Technology Council, 1992* [9]

With the above definition of Engineering Technology, it is clear the education of this group of people is changing at the same rate as the engineer. The education

of this group should meet the needs of future Green Technology to remain in the forefront in the development of future vehicles.

Enthusiasts

An enthusiast anxiously awaits for technology to evolve. Their passion drives their curiosity. Webster's Dictionary defines an enthusiast as:

“One who is filled with enthusiasm: as a: one who is ardently attached to a cause, object or pursuit <a sports car enthusiast> b: one who tends to become ardently absorbed in an interest.”

The following quote from “Build Your Own Electric Vehicle” asks, “Why would anyone buy, convert, or build an electric vehicle today? The answer, simply put, “they are the cleanest, most efficient, and most cost effective form of transportation – *and* they are really fun to drive.” [10]

The enthusiast may be quite versed technically, or may just possess minimal technological literacy. He may be someone who wishes to drive a specific vehicle or may be simply driven by his passion to step outside of the box. Often it is the enthusiast with engineering background who strives for more power, higher efficiency and greener technology.

Many things must be taken into consideration when this is done. Some of these are; cost, knowing what type of vehicle (EV, HEV, PHEV) best meets the needs of the person who will be driving the vehicle. What chassis should be used to meet not only the needs but also of the person who will be driving the vehicle, but, also will meet federal, state and local standards for many years to come is a major consideration. The technical knowledge related to electric motors, internal combustion engines, batteries, controllers, charging systems and electrical systems are also important when determining practicality of a new technology.

Sales People

A salesperson that is selling alternate-fuel vehicles need to be knowledgeable as to the necessary procedures in the unlikely event of a vehicle failure. These may include such areas as the general precautions which should be taken in the event of an accident or emergency, and what to do if the vehicle battery discharges. Consumers may be intimidated by media projections of high voltage dangers and likely need reassurance of the many safeguards that are in place to prevent electrical shock.

The initial cost of these vehicles may be a little higher than their conventional counterparts; however over time the fuel cost savings will justify the original investment. Another noteworthy savings is in reduced maintenance costs. The EV does not have an internal combustion engine (ICE) and therefore, NEVER needs its oil changed. Although the HEV and PHEV's have internal combustion engines, their engines do not run as much or as often as the engine of a non-hybrid vehicle, and therefore require less maintenance. These are important

consumer concerns, and information the salesperson needs to acquire if he is to close the sale.

Technicians

The technicians that will be working on these vehicles will need training in many areas that may not have been considered in the past. Some examples of these areas are safety, and high-powered electronic systems. An understanding of how these systems operate and interact with the rest of the vehicle will be necessary to perform proper and accurate diagnosis. A continuing education program will need to be put into place that will allow technicians to keep up to date on these vehicles. This will be most important in the first decade that these vehicles are on the road in large numbers. The main reason will be the different designs, service procedures and safety practices that will need to be followed if a specific vehicle has some specialty system that may not be found on other vehicles.

It should also be pointed out that many vehicle owners prefer going to “their mechanic” rather than the dealership. These technicians will have the greatest amount of knowledge to learn. Their training will be more rigorous than that of the dealer technician.

Another factor in the equation is that fleet technicians will initially account for the repairs on the highest number of EV, HEV and PHEV due to the regulations that are required of their employers to purchase vehicles that use alternative forms of energy to assist in the reduction of carbon based emissions. Even without this consideration, approximately 30% of the vehicles in use today are operated by fleets and repaired by their technicians. Currently, fleets operate more alternatively fueled vehicles than private citizens.

The General Public and People Who Operate these Vehicles

The people who will eventually make up the largest group that will need training are the general public and people who will operate these vehicles. When we look at this task as educators many questions arise as to what type of training this group will need? One consideration is age groupings? If the person is younger, just learning to drive, they will most likely be introduced to these vehicles by relatives that own one and in school through driver’s education courses. The older they are, the more likely they will get most of their training from the person who sells them the vehicle; whether it be the salesperson that sells the vehicle to them from a dealership or from the person who sells it to them privately.

Another way to train these people would be through informational advertising done by the people who manufacture and sell the vehicles. There could also be public service educational courses offered by safety groups and federal, state and local authorities. Ultimately, this group will need to be trained. Whether it is done by any of the above or by some other means will be dictated by the need for the training related to public interest, safety and the cost of the training.

Conclusion

Along with the manufacture and acquisition of alternative-fueled vehicles, there is a heightened need for understanding their systems, operations, and maintenance. Understanding basic electric, hybrid and plug-in hybrid systems, safety education, needs awareness, and technical information for students and teachers is critical to preparing a knowledgeable and responsive workforce.

[1] Department of Energy, *H.R. 6: The Energy Independence and Security Act of 2007*, Public Law 110-140, Washington, DC, United States Government Printing Office. 2007

[2] Appropriations Committee, *The American Recovery and Reinvestment Act of 2009*, Washington, DC, United States Government Printing Office, 2009

[3] Ashley, Steven, *Priming the Green-Car Pump*, *Automotive Engineering International*, Volume 117, Number 9, 2009, pp. 17 to 20

[4] Electric Car Conversion News and Information. (n.d.). [History of the electric car](http://www.electrincarconversionblog.com/electric-cars/history-of-the-electric-car/), Retrieved July 27, 2009 from <http://www.electrincarconversionblog.com/electric-cars/history-of-the-electric-car/>

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