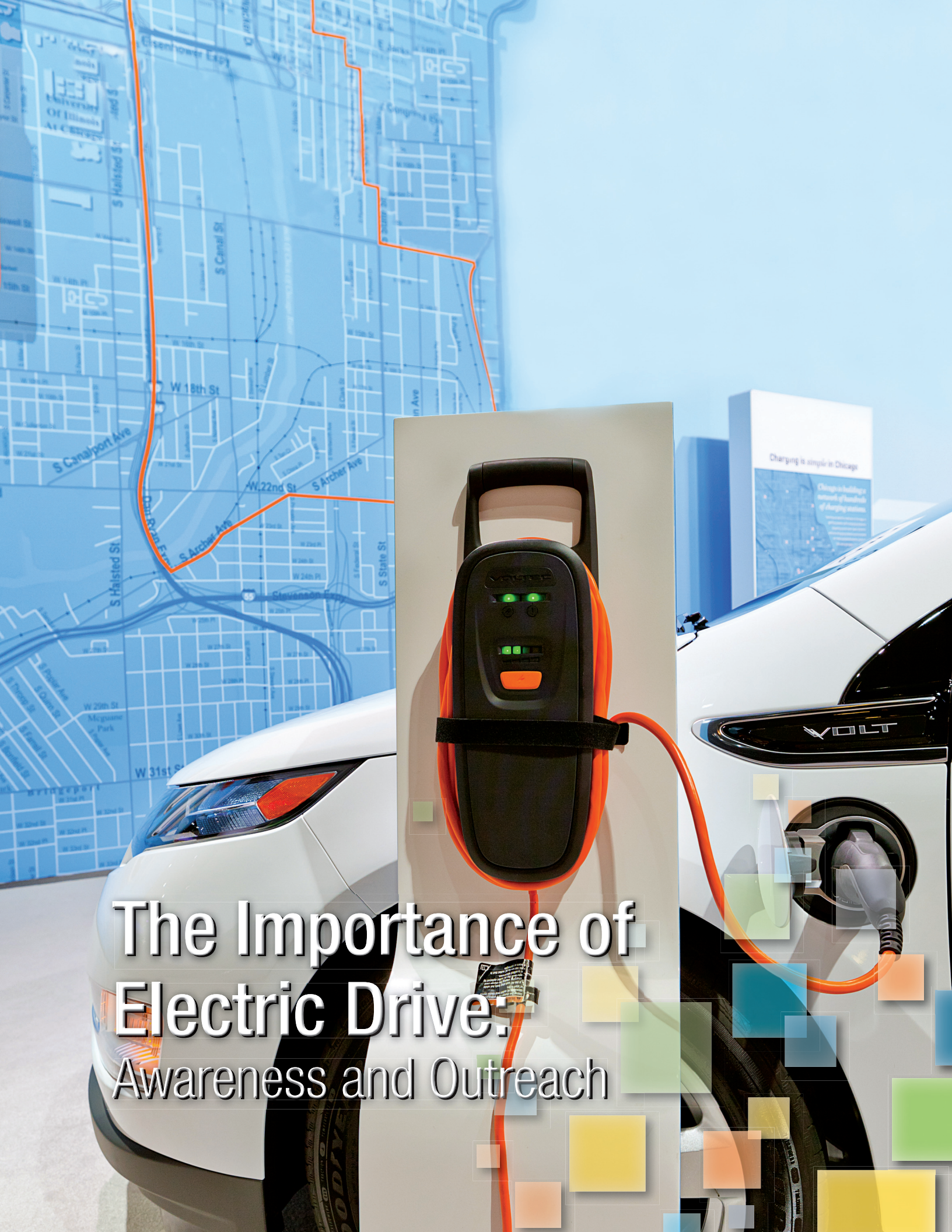

The Importance of Electric Drive:

Awareness and Outreach

Notes

The Importance of Electric Drive
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National Alternative Fuels Training Consortium
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The Importance of Electric Drive

This material will discuss the importance of electric drive vehicles. The advantages and reasons to consider implementing electric drive vehicles will be explored. There will be a discussion of how using electric drive vehicles will benefit human health, the environment, the economy, and U.S. energy security. Finally, some suggested actions will be provided to see in order to support the continued and expanded use of electric drive vehicles.

Objectives

- Describe how electric drive vehicles may help improve public health
- Describe the benefits of electric drive vehicles to the environment
- Explain how electric drive vehicles may help stimulate the economy
- Describe what energy security is and how using electric drive vehicles can help attain it
- Explain the future of electric drive vehicles
- Explain the suggested actions to support electric drive vehicles

Why Consider Electric Drive?

There are many reasons why EVs are an attractive alternative to conventional vehicles. EVs do not produce any tailpipe or evaporative emissions that contribute to air pollution and global warming such as carbon monoxide (CO) and carbon dioxide (CO_2) at the point of use. Emissions are typically produced from the production of electricity for use with EVs.

Most of the electricity used to charge EVs is produced by power plants that use domestic resources such as coal, oil, natural gas, and nuclear energy. Thus, driving an EV could help reduce U.S. dependence on foreign oil. It is also possible to use what the DOE refers to as renewable energy sources to generate the electricity required by EVs. These renewable resources include solar, wind, hydroelectric, and geothermal power. Using these energy sources could further reduce U.S. dependence on nonrenewable resources such as coal and oil.

Using electric vehicles as a mode of transportation has many advantages, including significant environmental benefits. EVs have been around for a long time and are being used today in airports, warehouses, industrial applications, and for personal transportation.

Advantages of Electric Drive Vehicles

HEV designs combine the inherent benefits of gasoline and electric vehicle drive systems. The ICE provides the unlimited range familiar to consumers while the higher efficiency of the electric motor provides fuel savings at lower speeds. For the driver, operating an HEV is essentially no different from a conventional vehicle,

making the transition to electric vehicles easy for many consumers. Many ICE vehicles have complex automatic transmissions that are operator friendly. EVs do not require the use of such complex transmissions and therefore yield the drivability of an automatic transmission with the efficiency benefits of manual transmissions.

BEVs do not produce any of the typical emissions or pollutants associated with transportation, in fact some environmental agencies refer to this type of vehicle as a "zero-emissions vehicle." Additionally, most HEVs and PHEVs are expected to emit less greenhouse gases (GHGs) than conventional vehicles.

Increased use of EVs would reduce U.S. dependence on foreign energy supplies. For example, according to the DOE, PHEVs are expected to use about 40% to 60% less petroleum than conventional vehicles.

EVs can be charged using existing sources of electricity. Since most vehicles can be charged during **off-peak** hours, the electrical grid would not be negatively impacted. This could help to balance demand and help the grid to operate more efficiently.

EVs have low maintenance costs. EVs do not require engine oil changes, which is the most common maintenance associated with conventional ICE powered vehicles. EVs do not have other components such as timing belts, water pumps, radiators, fuel injectors, or tailpipes — all components that require maintenance. The Leaf receives an EPA-estimated 99 MPGe and has an EPA-estimated range of approximately 73 to 100 miles before recharging.

Additional Points to Consider

The batteries in an EV are a key component. Currently, batteries for an EV have a high cost, high weight, high volume, and relatively low energy density. This means that EVs have a limited range before having to charge the batteries. Recharging the battery typically takes several hours, but a "quick charge" to 80% capacity may take as little as 30 minutes.

Although EVs themselves do not produce pollutants that can harm the environment, they do use electrical power that has been generated by existing power plants. Perhaps the "trade-off" with EVs is that the source of pollution is in one place and may be dealt with in a variety of ways, rather than millions of vehicles producing emissions everywhere across the nation. By moving the primary location of emissions generation, EVs could be of more benefit in congested areas where air quality is poor.

Another item to consider is that an EV may have a higher price tag than a comparable conventional vehicle. However, this may be offset by the reduced cost of operation and maintenance over the life of the vehicle. Also, federal, state, and local tax incentives are usually available for consumers that purchase these vehicles.

Electric Drive Benefits

Electric vehicles have the potential to allow for the U.S. to become completely reliant upon domestic energy sources. In addition, BEVs do not burn any fuel, and therefore rely solely upon the energy produced by a power plant. While this energy might be produced by burning fuels, like coal or natural gas, these vehicles produce lower local emissions. HEV and PHEVs, when running on battery power, function in the same way.

Convenience also can be a great factor in using these vehicles. Even though EVs have limited range, they may be charged at home, work, or elsewhere using dedicated charging stations. They do not require any special trips beyond where the driver would wish to go.

There are many benefits in expanding the development of EVs and charging infrastructure – for the betterment of human health, the environment, the economy, national energy security, and reduction of dependence on foreign oil.

Health Benefits

According to recent studies by the DOE, about half of the U.S. population lives in areas where air pollution levels are high enough to negatively impact public health and the environment. Emissions from gasoline and diesel vehicles—such as oxides of nitrogen (NO_x), hydrocarbons, and particulate matter (PM)—are major sources of this pollution.

Vehicles with ICEs using conventional fuels produce several byproducts. The PM is referred to as soot. When ejected into the air and breathed by humans the soot can cause asthma, lung cancer, and other diseases. Vehicles that run on electricity have no tailpipe emissions; therefore do not release harmful byproducts into the air near their immediate area of operation. This could benefit congested cities where local emissions produce poor air quality for humans.

Environmental Benefits

The use of EVs also can contribute less CO_2 to the atmosphere since they have a higher MPGe than conventional vehicles. Carbon dioxide is a greenhouse gas (GHG) believed to cause global warming. Conventional vehicles are continually being improved to reduce harmful tailpipe emissions. However, the number of ICE vehicles on the road is growing every year. One way to alleviate the increasing pollution caused by road transportation is to develop emission-free vehicles such as EVs.

While BEVs themselves are emission-free, the combustion of fossil fuels is still used to produce the electricity that provides energy for the vehicle in some locations. However, when charged with renewable sources of energy, such as solar or wind, BEVs do not contribute any CO_2. The DOE reports that HEV emissions vary by vehicle type, and that PHEV emissions are projected to be lower than HEV emissions since they are driven on electric during certain times. It also should be noted that battery systems do have a finite life. The processing of battery systems that no longer function must be addressed to ensure additional negative environmental effects are mitigated.

Economic Benefits

According to the AFDC, due to the improved fuel economy, HEVs are less expensive to operate compared to conventional vehicles and usually have fuel costs of $.05 to $.07 per mile to operate compared to conventional vehicles that cost $.10 to $.15 per mile. PHEVs also are said to be less expensive to operate that HEVs, usually costing $.02 to $.04 per mile based on average U.S. electricity rates.

According to the Electric Drive Transportation Association (EDTA), the advanced vehicle component sector now employs 155,000 American workers. The EDTA also reports that additional economic benefits include almost $700 million of improvements in the balance of trade and a $2.3 billion contribution to the GDP from manufacturing alone.

Federal, state, and local tax policies can address the substantial first-cost hurdles for consumers purchasing new electric drive vehicles. Electric drive offers oil savings in consumer cars, commercial trucks and off-road vehicles. Electricity is domestically produced, and readily available across the nation.

Did You Know?

Many states, particularly California, have public access electric charging stations at libraries, shopping centers, hospitals, and businesses.

Source: DOE

Energy Security Benefits

According to a recent study by Pacific Northwest National Laboratory, if 73% of the nation's light-duty vehicles were fueled by electricity, the U.S. could displace an estimated 6.2 million barrels of oil a day — about 52% of current oil imports.

In a 2010 report by the Congressional Research Service, oil meets nearly 40% of total U.S. energy requirements, including 94% of the energy used in transportation and 41% of the energy used by the industrial sector. Unlike other forms of energy such as coal and natural gas, which are largely supplied from domestic sources, about half of U.S. oil consumption is currently supplied from foreign sources.

Notes

The demand for petroleum imports is increasing. Much of the worldwide petroleum reserves are located in politically volatile countries, making the U.S. extremely vulnerable to supply disruptions. EVs hold the promise of an end to the nation's "addiction to foreign oil" and an overall reduction in petroleum consumption.

Electric Drive – Today and Tomorrow

HEVs now come in many more makes and models since their reinvention in the late 1990s. Hybrid electric vehicles range from small sedans, to pick-up trucks, SUVs, buses and heavy-duty trucks.

As improvements to EV technology are continually made, the commercialization of EVs will increase. Several companies are researching developments within the EV propulsion system and the employment of advanced batteries to improve the vehicle's energy storage. The next generation of EVs will be able to travel farther before having to charge.

It is believed that EVs will continue to find a niche market in community transportation, industrial applications, and places where electricity is inexpensive and easy to access and in cities with a zero-emission mandate.

As concerns for the environment and energy security continue to grow, electric vehicles will be pushed to the forefront. One way to achieve the crucial goal of clean, efficient, and intelligent energy for road transportation is the use of EVs.

There many options for consumers to purchase light-duty hybrid vehicles. There are also additional HEVs and EVs still in the prototype stages that are not yet available for purchase. Following are some of currently available options. This list is not all-inclusive.

Parallel HEVs
Toyota: Prius, Camry, Highlander
Honda: Civic, Insight, CR-Z
Lexus: CT 200h, HS 250h, LS 600h, RX 450h
Ford: Fusion, Escape
Hyundai: Sonata
Kia: Optima
Chevrolet: Malibu, Silverado, Tahoe
Buick: LaCrosse, Regal
Lincoln: MKZ
Infiniti: M35h
Porsche: Panamera S, Cayenne S
Mercedes-Benz: S 400
BMW: ActiveHybrid 7L
GMC: Sierra, Yukon
VW: Touareg
Cadillac: Escalade

Series HEVs
Chevrolet: Volt*

Plug-in HEVs
Chevrolet: Volt
Toyota: Prius

EVs:
Nissan: Leaf
Mitsubishi: iMiEV

* By definition of series, the Volt mostly operates as a series hybrid, but has the ability to operate as a parallel. It should also be noted that General Motors uses the term extended range electric vehicle (EREV) to describe the Volt.

There are also medium- and heavy-duty HEVs and EVs available for industrial and commercial use. These applications include: chassis cab tractors, heavy-duty trucks, utility vehicles, cargo vans, and numerous other service specific vehicles. Some of the manufacturers of HEVs that utilize either gasoline or diesel as their fuel: Freightliner, Kenworth, Mack/Volvo, Navistar, Inc., and Peterbilt. There are also PHEVs available for such applications made by: Bright Automotive, GMC, and Navistar, Inc. Full EV or BEVs are also available from the following companies: Modec, Navistar, Inc., and Smith Electric Vehicles.

The Future of Electric Drive

Fuel Cell Electric Vehicles

One promising future technological development may be the use of fuel cells in EVs. A fuel cell is an electrochemical energy conversion device that produces electricity through a process that converts hydrogen and oxygen into water. An EV powered by a fuel cell (also called a fuel cell electric vehicle or FCEV) has a driving range comparable to that of a conventional vehicle. However, current fuel cell technology requires the use of platinum, making fuel cells very expensive. There are also many fueling issues for fuel cells that must be solved before they become practical.

Fuel cell electric vehicles (FCEVs) represent the most advanced technology available for electric drive vehicles. Most use hydrogen gas to power the fuel cell that generates electricity (other fuels are being researched). Electrical power then propels the vehicle. FCEVs do not require such large batteries – this greatly reduces the weight of the vehicle.

FCEVs (see **Figure 1**) have a fuel cell and fuel storage tank that will generate electricity on demand for the vehicle. They offer similar MPGe to BEVs, but with the range of HEVs. Some of these vehicles use onboard reformation with fuels such as methane (CH_4) to produce onboard hydrogen (H_2).

Figure 1: *Mercedes-Benz F600 fuel cell prototype. Source: NAFTC.*

Fuel cells contain a proton exchange membrane (PEM) (see **Figure 2**). This device facilitates a chemical reaction that in turn creates an electric current. In essence, this device takes the hydrogen stored within the vehicle's tanks, creates a chemical reaction, and captures the electricity created as a result of this reaction. The product of this reaction is water and heat. Fuel cell electric vehicles typically use hydrogen to create energy. Hydrogen — the most abundant element in the universe — is refined from natural gas, and natural gas is a domestic natural resource. When used as a fuel for an EV, the emissions from using this energy source produce the byproduct of pure water!

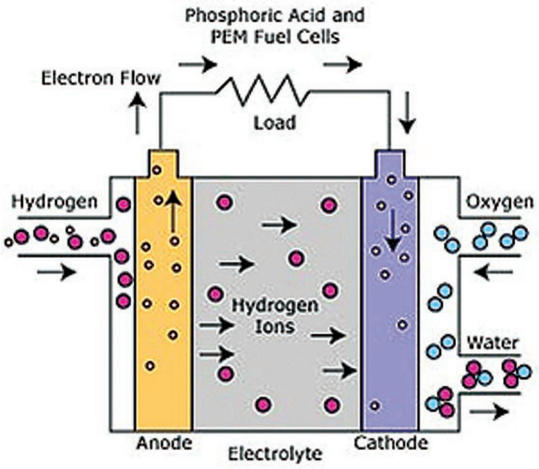

Figure 2: *FCEV proton exchange membrane. Source: NAFTC.*

Wireless Charging

The newest developments in charging electric vehicles are truly astounding. Wireless charging has come to the forefront of electric vehicle development, providing means with which to speed up charging and extend the range of electric vehicles. Wireless charging systems are becoming available that consist of a simple, small charging pad that will lie on the floor of a garage, under the parked vehicle. With about 90% efficiency, these pads will automatically charge the vehicle's batteries and shut themselves off without damaging the battery through overcharging. Wireless home charging currently operates at 240VAC which will fully charge the batteries in a conventional battery operated vehicle in four to six hours. However, the current standard is still a plug-in connector in accordance with SAE standard J1772.

Suggested Actions

In an effort to reduce America's dependence on foreign oil, reduce emissions and greenhouse gases, the federal government, state governments, and even regional and local governments have implemented incentives to encourage the purchase and use of EVs.

HEVs are available from most vehicle manufacturers. Go to your local dealership and request information or a test drive to better understand the current options. There are BEVs available for purchase by both Nissan and Mitsubishi but are not usually available for a test drive at all dealerships. Many drivers require vehicles that have a long range (greater than 100 miles). Drivers may purchase HEVs or PHEVs, which allow for the growth of the electric drive vehicle population with the benefit of unlimited range. These vehicles may be a great step for consumers and fleet managers who are interested in electric drive vehicles but need the range of conventional vehicles. Drivers can check with local governments and businesses to see if any of them utilize or could utilize the various types of EVs.

The following website posts updates, additional information on electric drive vehicles, and tax incentives that are available in different areas. This information will include operating mode, range, and fuel economy information necessary to make informed decisions about purchasing electric drive vehicles.

To learn more please visit: http://www.afdc.energy.gov/afdc/fuels/electricity.html

Summary

Alternative fuel and advanced technology vehicles have the potential to virtually eliminate high gasoline prices, but require qualified, trained automotive service technicians to understand, diagnose, and maintain these vehicles to keep them on the road. Furthermore, it is imperative that everyday consumers understand how electric vehicles work and the benefits that these advanced technology vehicles offer to human health, environment, and economy. Electric vehicles utilize an existing distribution network and ensure America's energy independence. The use of HEVs, PHEVs and BEVs can decrease localized emission production improving air quality. These vehicles also offer higher MPGe than conventional vehicles. Many options are available for light-duty and even heavy-duty EVs. As battery technology continues to improve the niche market of EVs will continue to grow.

Notes

Upon completing this material, can you

- Describe how electric drive vehicles may help improve public health?
- Describe the benefits of electric drive vehicles to the environment?
- Explain how electric drive vehicles may help stimulate the economy?
- Describe what energy security is and how using electric drive vehicles can help attain it?
- Explain the future of electric drive vehicles?
- Explain the suggested actions to support electric drive vehicles?

Test Your Knowledge

1) Give an example of an EV vehicle that is successfully reducing carbon emissions.

2) **True or False:** An extensive electrical grid acts as the distribution network.

3) **True or False:** There are many tax incentives for alternative fuel and advanced technology vehicles.

Answers: 1) Nissan Leaf; 2) True; 3) True

Conclusion

Electric vehicles are advanced technology vehicles that have great potential for the future of alternative transportation. EVs do not produce any local tailpipe emissions and the electricity to power them can come from domestic resources and renewable energy sources. Charging systems are simple and safe to use. An infrastructure of public recharging stations may emerge in the future, as many communities operate trial programs today.

There are many options of HEVs, PHEVs and BEVs. These vehicles offer similar drivability to conventional vehicles while reducing overall fuel consumption and are already available for use by consumers.

There are challenges to consider when considering the use of EVs including battery cost, weight, energy density, charging time, and disposal— all are being addressed and may be reduced or eliminated in the future. The future holds exciting possibilities for electric vehicles. Some advantages of using EVs include:

- Reduction in overall and localized emissions
- Independence from foreign oil supplies through reduction in petroleum consumption
- Lower maintenance costs and quieter operation
- Ability to utilize electricity produced from renewable resources, wind, water, solar, and geothermal.

Notes

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For questions or further information, please contact:
National Alternative Fuels Training Consortium
Attention: Executive Director
1100 Frederick Lane
Ridgeview Business Park
Morgantown, WV 26508
Telephone: 304-293-7882
Fax: 304-293-6944
http://www.naftc.wvu.edu

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National Alternative Fuels Training Consortium

Ridgeview Business Park
1100 Frederick Lane
Morgantown, WV 26508

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