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SPECIFIC WORKING GUIDE "ELECTRIC VEHICLE OR HYDROGEN-POWERED VEHICLE. A STRATEGIC DECISION "

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Introduction

Road transport is one of the most dependent sectors on fossil fuel and in which it has been most difficult to find a sustainable alternative that reduces dependency on other countries (in the case of Europe and Spain we need to import oil for transport) and emissions of greenhouse gases.

Other sectors, such as the electricity sector, have started but somewhat timidly on the right track to become less dependent on fossil fuels, and have found a solution for it; renewable energy.

For example, in the Spanish case more than 40% of electricity comes from renewable energy, mainly wind power and hydropower and a growing presence of solar photovoltaic and solar thermal energy. Electric vehicles can make a valuable contribution by incorporating renewable energies in the transport sector. The only option on a large scale to reduce dependence on fossil fuels for transport until now has so far been the incorporation of biofuels.

The implementation of biofuels in the motorway transport sector is done directly with vehicles already on the market, through existing suppliers that offer biofuels directly blended with gasoline (bioethanol) or diesel (biodiesel). The main advantage of using C from abroad; reducing greenhouse gas emissions.

Electric transport is currently the most promising possibility to transform the current system into one that is environmentally sustainable. In some special situations, such as mobility in cities, it is the only solution to solve the additional problem brought about by pollution in cities, which has already become alarming in some cases. The electric vehicle does not generate any emissions during use in electric mode only, and significantly reduces ambient noise levels.

Alongside these environmental benefits, there are other reasons why electric transportation will become an unstoppable reality. On the one hand, electric propulsion systems are much more efficient than traditional internal combustion engines. Yields of electric motors are much higher; an internal combustion engine only has a yield of 20%. Modern systems require incorporation of more energy efficient systems in times of increasingly expensive and scarce resources.

Electric vehicle

There are essentially two technologies that can be used in electric vehicles, on the one hand there are electric vehicles with batteries, and on the other, hydrogen-powered vehicles.

Hydrogen, as an energy source, can be used in two ways. One is in fuel cells, and the other is use in internal combustion engines, equipped to operate with hydrogen instead of a traditional fuel (in this case electrical power is only used in the hydrogen production phase). From here on in, we will refer to hydrogen cars as those equipped with a fuel cell, leaving other types of hydrogen-powered vehicles for later. Below, some of the features of each of these technologies will be outlined.

Electric vehicles with batteries

In this section, vehicles in which the propulsion comes entirely, or in part, from electricity, from batteries that replace, or supplement, the fuel tank, recharging the batteries using an external system such as the national grid.

There are currently three different technologies for electric vehicles that can be connected to the mains (plug-in vehicles) in both the Spanish market and the world market.

Pure Electric – BEV (Battery Electric Vehicle)

The first purely electric vehicle. A vehicle which is powered entirely by an electric motor, powered by batteries that are recharged via an outlet connected to the mains. Their range is limited by the capacity of the battery. Current technology allows a range of 130 km - 300 km.

Recharging the battery takes place exclusively from the mains, although some have systems for energy recovery from the brakes.

Extended-range electric vehicle (EREV)

Secondly the extended-range electric vehicle.

An electric vehicle which also incorporates a small termal engine that drives a generator to recharge the batteries. The propulsion is exclusively electric, but charging of the electric motor is carried out by to the auxiliary combustion system. With this setup, it is possible to extend the range of vehicles to levels similar to those using traditional fuels. It offers a range of approximately 80 km in electric mode.

Plug-in hybrid vehicle (PHEV)

Thirdly, the plug-in hybrid vehicle. This vehicle combines electric propulsion from the energy obtained from the national grid with the propulsion supplied by a gasoline or conventional diesel when electric batteries run out. The electric range is greater than in the conventional (non-pluggable) hybrids, and also usually includes a system for energy recovery during braking.

Battery

The battery is the determining factor in this type of electric vehicle; in the battery a reversible chemical reaction takes place in which an electric current is produced, which is able to power an electric motor. In the opposite direction, by applying an electric current to the battery, ions and electrons return to their original position.

There are three types of batteries used in electric vehicles, lead-acid batteries, nickel-metal batteries and lithium ion batteries.

The lead acid batteries are the lowest-cost option, and have been used for decades for starter motors in combustion engines. Their main advantage is their low cost, but they can only store in the order of about 40 Wh/kg, a very poor energy density compared to other storage systems.

Nickel-metal batteries were the next step in electric vehicles; they have more than 10 years of experience, especially in their incorporation in hybrid vehicles. Their specific power is higher than the previous ones (60 Wh/kg), they have a long life cycle, and do not present such serious environmental difficulties as lead batteries.

Lithium-Ion batteries, of which there are many varieties on the market, are those that will undergo the greatest adaptation for use in the automotive industry. One of the most important features, along with useful battery life and number of charge & discharge cycles, is that the power density can reach over 120 Wh/kg. The development of such batteries, has given electric vehicles almost unstoppable momentum.

Charging systems

There are several ways to recharge an electric vehicle:

Conductive recharge (through connecting wires), which is the most common and best developed, and that is done by connecting the vehicle to an electrical outlet through a cable, either in a household socket or through a loading point.

The conventional type of charge is called trickle charge, which usually lasts about eight hours and employs the same current and voltage level as the house itself. This solution is best suited to recharge the car overnight in a home garage.

There is also a system of semi-fast charging, employing higher levels of current and voltage (e.g. levels in the order of 32 amps of current) that are not possible in home systems without installing power supply equipment and control systems. With this system, the charging process can last about four hours.

Finally there is a third method of recharging: fast charging, which is about 15 minutes long, and using which you can load up to 65% of the total battery charge.

Fast charging employs more electrical intensity; energy delivery by direct current. This solution, from the point of view of the driver, is the most similar to the current fuel filling systems in a service station.

For this type of quick charge it is necessary to go to one of the charging stations.

Recharging by battery replacement, which involves replacing the electric vehicle battery with another battery charged to 100%, in an operation a few minutes. Currently there are models like the Tesla S that are designed to carry a spare battery, but perhaps, where this option is presented as more doable is in the two-wheeled vehicle sector (motorcycles and bicycles), where vehicles have a removable battery.

Inductive charging, or wireless charging by magnetic induction, is one of the most promising markets for powering electric vehicles given its advantages over other systems that require cable connection.

By using induction technology, the user only has to place his vehicle, equipped with a receiver element on the underside, on a charging platform in the floor. When the system detects the car on the platform, a wireless connection begins and energy transfer and charging begins. It ends when recharging has finished, when interrupted manually or when the vehicle leaves the loading point. This system would allow, for instance, recharge of the vehicle when stopped at traffic lights, or simply by passing over plates that are embedded in the asphalt.

In Spain there are technology companies that have developed efficient systems for electric vehicle charging by induction, such as that shown in the image on the right, developed by the research centre CIRCE. (Figure 1. System electric vehicle charging by induction. CIRCE Foundation)

Currently the number of operational Spanish electric vehicles is around 10,000 units. The charging stations in operation are estimated to total 200.

The current strategy developed by the administration for promoting alternative energy vehicles would reach a total fleet of approximately 150,000 electric vehicles by 2020.

As for public infrastructure access to charging points for electric vehicles, around 1,200 charging points would be required under Directive 2020.

Hydrogen-powered vehicles

The other type of electrically powered vehicles are electric vehicles powered by fuel cells, generally called hydrogen cars. One of the fundamental advantages of these cars is greater range and faster recharging; in this case drivers hardly have to change the habits acquired when using of conventional cars.

A vehicle with a hydrogen fuel cell could be considered as an extended range electric vehicle, in the sense that it has the same components as an electric vehicle. It also has two additional components: the fuel cell, and storage tanks of hydrogen. The following sections describe these two specific components. (Figure 2. schematic diagram of a hydrogen vehicle).

Fuel Cells

Fuel cells are electrochemical, capable of directly converting chemical energy contained in a fuel into electrical energy.

This electrochemical transformation (without combustion) is not limited by the performance of the combustion process which allows achieving relatively high yields (in practice at around 40 or 50%, although in theory could be considerably higher). They are presented as devices with enormous application potential.

Primarily a fuel cell is a grouping of individual cells with internal connections in series. These cells consist of two electrodes (positive pole and negative pole) where hydrogen oxidation and oxygen reduction occur, respectively, and an electrolyte (which may be either an acidic or basic medium) that allows the exchange of ions generating both reactions.

A fuel cell is a kind of high-tech battery which converts chemical energy in the fuel into electrical energy. There is a big difference between them and batteries; a battery stores inside chemical energy and converts it into electricity, and when that chemical energy is terminated, the battery is replaced by another or recharges connecting to the grid as described in the previous section.

With the fuel cell, however, electricity is produced from the chemical energy in a fuel received from the exterior of the battery, and is capable of supplying power continuously while the supply of the fuel is maintained.

One of the reactants in the stack is always oxygen, which comes from the air, and therefore need not be stored. The fuel itself is normally hydrogen, which can be supplied directly and electricity production is continuous whilst there is hydrogen in the tank.

In one of the best-known and simple types of fuel cell, the electrolyte is a membrane that allows exchange of protons between cathode and anode but not the passage of electrons moving through an external circuit providing electric current. In short, mixing the hydrogen from the vehicle tank and oxygen in the air, one generates electricity and steam, which exits the exhaust.

In Figure 3 a fuel cell incorporated in the vehicle is represented.

Hydrogen generation and storage

Hydrogen is one of the most abundant elements in nature, but not in a free state. Since the last century, it has been known that obtaining hydrogen by electrolysis of water is a clean process that also produces hydrogen of high purity.

Electrolysis requires considerable input of electricity. One of the ways to ensure the sustainability of the process of obtaining hydrogen is to use renewable energy for the production of that electricity.

The storage of hydrogen for use in automotive systems presents some restrictions on car size and weight, and there are some limits for hydrogen vehicles in order for them to have a range equivalent to conventional vehicles.

Hydrogen is a combustible gas that is highly flammable, non-toxic, colorless, without taste or characteristic odor, so safety is one of the most important factors in defining storage system criteria.

There are different ways to store hydrogen:
• In the form of pressurized gas
• A liquid (cryogenic storage at very low temperatures)
• In the form of stable compounds (metal hydrides)
• In the form of other chemical compounds
• In glass microspheres.

Of all these techniques, currently only the first three are mature enough to be employed in the transport sector.

Pressurized gas storage

It is the most widespread form of storage with which we have most experience. In H_2 production centres, gas at very high pressure (200 atmospheres) is compressed and packaged in bottles or containers. The bottles - In order to reduce the weight of the system, composite materials are used such as fiberglass and carbon fiber.

The hydrogen tank is one of the most expensive components of the whole system; it must withstand very high pressures and must be very airtight to avoid leakage of hydrogen. Hydrogen gas is the most volatile of all gases.

In the figure presented below, you can see a storage tank for hydrogen as pressurised gas.

Figure 4. Hydrogen storage tank from a Toyota vehicle.

Storage as liquid hydrogen

This is a system that is mainly applied in automotive and space industries. It requires keeping containers at very low temperatures, because the boiling temperature of the hydrogen at pressure of an atmosphere is -252 ° C. This means that in order to store liquid hydrogen at atmospheric pressure we have to maintain these low temperatures.

Herein lies the major drawback of storing and handling the liquefied gas in these conditions.

Storage as metal hydrides

Since the late 60s, various laboratories and research centers have begun working on certain metal compounds that have the property of combining with hydrogen in a reversible reaction.

From these studies it was found that the chemical reactions of the processes of formation and decomposition of metal hydrides are numerous and fast enough to consider their use in hydrogen storage systems

In figure 5, a hydrogen filling station can be seen.

In Figure 6, we can see detail of the hydrogen loading system.

Currently, the vehicle fleet at a European and Spanish level is very low, although they have developed several demonstration projects in cities such as Madrid and Barcelona, with buses powered by fuel cells.
It is estimated that, at European level, penetration of electric fuel cell vehicles will be at 3% in 2025 and could reach at least 5% of all motorists in 2015.

At present Spain has a lower level than the rest of Europe regarding implementation of hydrogen cars and infrastructure, but in the sector of capabilities in research and development of hydrogen technologies and fuel cells, Spain has some important centres.

Spain has four hydrogen filling stations in operation: two in Aragon (Zaragoza and Huesca), one in Albacete and one in Sevilla. During 2015 two new stations will be opened in Puertollano and Sevilla, completing a total of six operating stations.

Potential topics for discussion

- Have electric vehicles been used at other times?
- In the late 90s, several models emerged in the United States with comparable performance to gasoline models.
- What are the differences and similarities between the two technologies - electric vehicles with batteries and electric vehicles with fuel cells?
- We intend to deepen this reflection on the two technologies and address issues such as autonomy, security, ease of recharging, benefits, advantages and disadvantages that each technology presents.
- What commercial offers currently exist for each of the technologies mentioned?
- Now it is possible to find commercial offers of electric cars at affordable prices (relying on aid provided by various public authorities). This issue is to get an idea of the current level of development of each of the technologies of electric vehicles.
- The development of batteries: the case of batteries and TESLA cars.
- The electric car has stimulated a big push in the development of batteries. There is already a new generation of batteries (Li - ion etc ...) for transport, telecommunications and home use as a storage system for electricity. The carmaker TESLA announced new models of electric batteries to store energy in homes.
- Production and supply of hydrogen to the network of charging points for electric vehicles
- Systems and ease of recharging electric vehicles and hydrogen vehicles will be one of the determining factors which define the success of these technologies. This heading is to guide the search for information in areas such as car charging points, the charging of electric vehicles, hydrogen filling stations, etc ..
- Other applications of the various electric land transport vehicles.
- This section is intended to guide the search for information on aspects such as the application of technologies of electric vehicles and hydrogen to the air transport sector, where weight and autonomy are an essential factor, or the application of these technologies in maritime transport.

Information Sources

Available resources related to the topic in the database INVESTIGATE R & D + i corresponding to previous editions (http://www.programainvestiga.org)

- Combustibles para el futuro. Presentación y Guía (Edición 2011-2012).
- El almacenamiento de Energía. Presentación (Edición 2010-2011).
- El uso y la generación de Hidrógeno. Presentación (Edición 2010-2011).
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AEDIVE Asociación empresarial para el desarrollo e impulso del vehículo eléctrico. http://aedive.es/

Guía del vehículo eléctrico:
http://www.fenercom.com/pdf/publicaciones/Guia-del-Vehiculo-Electrico-II-fenercom-2015.pdf

AEH2 Asociación Española del Hidrógeno
http://www.aeh2.org/index.php?option=com_content&view=article&id=167

IDAE Vehículos y tecnologías alternativas
http://coches.idae.es/portal/CombustiblesAlternativos/CombustiblesAlternativos.aspx

Websites of energy companies and other agents of the electricity sector (most large utility companies as well as the system operator, have developed activities for the promotion of electric vehicles and charging systems in particular, you can find information on ENDESA pages and RED ELECTRICA DE SPAIN)

Web pages of carmakers (without claiming to be exclusive, at least the following manufacturers have developed models of electric vehicles, both with batteries and fuel cells: Renault, Nissan, BMW, PSA PEUGEOT CITROEN, TOYOTA, HONDA, etc .. TESLA