15

The Future of Electric Vehicles

15.1 Introduction

In the previous chapter recent electric vehicles were discussed. Future development is always difficult to predict but there are several clear pointers as to how electric vehicles are likely to develop.

As was mentioned in Chapter 3, new lithium technology may develop substantially and specific energies of new lithium batteries are predicted to double in the next few years. This would allow the range of electric vehicles to double for the same battery mass. Doubling the range of electric vehicles would answer many of the criticisms of electric vehicles. In fact the Tesla Model S due to be released in 2012 has the option of a battery pack which gives a range of up to 300 miles (480 km). Another interesting development is the Honda FCX Clarity fuel cell car which has a similar range and can be refuelled as quickly as a petrol or diesel car. It is likely that battery electric vehicles and fuel cell electric vehicles will both play a role in the future.

The benefits of high-speed trains for rapid long-distance travel were discussed in Chapter 14. Maglev trains are already in use in China and it is believed that in the next decade these will become more widespread.

There has been little use of road–rail systems which combine the benefits of both road and rail. Such systems can enable long-distance travel using supply lines for recharging while allowing vehicles to travel to their destinations as a conventional road vehicle.

The above systems give a guide as to where the future of electric vehicles may lie and these are discussed in this chapter.

15.2 The Tesla S

Tesla is planning to release the Tesla S in 2012, illustrated in Figure 15.1. The Model S is a pure electric vehicle which again uses lithium ion batteries. There is an option for three battery packs giving ranges of 160 miles (256 km), 230 miles (368 km) or 300 miles (480 km) per charge. The Model S is expected to have swappable batteries. It is intended to compete with more luxurious cars such as the Mercedes E series, the Audi A6 and the BMW 5 series. The car seats five adults (plus two children in rear-facing child seats)

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Figure 15.1 The Tesla S (With kind permission of Tesla Motors)

and has a 0–60 mph (96 kph) time of 5.5 seconds. The body panels and chassis will be primarily aluminium. Rapid charge time of 30 minutes is being discussed.

What is particularly interesting about the Model S is that with the longer range it can compete with most journeys carried out by IC engine vehicles. Tesla has very much led the way with its previous vehicle, the Roadster, which was illustrated in Chapter 1. The Model S holds out the hope of a 5 (+2) quantity produced car with a considerable range and an appealing performance.

15.3 The Honda FCX Clarity

The Honda FCX Clarity is a fuel cell vehicle which uses hydrogen as a fuel. The FCX Clarity is currently available for lease in the USA, Japan and Europe. In the USA, it is only available to customers who live in southern California where fast-fill hydrogen stations are available.

This car is a five-seat saloon car which performs in a similar manner to its IC engine counterpart. It has a good range and given suitable infrastructure it can be refuelled quickly. The hydrogen is kept in a 171 l tank at a pressure up to 35 bar. The car uses an AC permanent magnet synchronous motor and contains a PEMFC along with a lithium ion battery. The vehicle is illustrated in Figure 1.16 and described in Table 15.1.

15.4 Maglev Trains

The world speed record for crewed trains is currently held by a maglev train developed in Japan, which in December 2003 reached a maximum speed of 581 kph (363 mph) The train was developed by the Central Japan Railway (CJR) company in conjunction with Railway Technical Research.

The principle of maglev is essentially simple in that the train is levitated by magnets allowing it to run without wheels, therefore eliminating friction or other problems associated with wheels. Linear motors drive the train forward. The record-breaking Japanese maglev system uses an electro-suspension system. Maglev trains have superconducting magnetic coils and the guide-ways contain levitation coils. As the train moves, its moving magnetic fields create a current in the levitation coils due to the magnetic field induction

Table 15.1 The Honda FCX Clarity

Assembly	Japan
Class	Mid-size
Body style	Four-door, five-seater sedan
Electric motor	AC permanent magnet synchronous motor, 100 kW output
Transmission	Single speed, direct drive
Wheelbase	110.2 in (2799 mm)
Length	190.3 in (4834 mm)
Width	72.7 in (1847 mm)
Height	57.8 in (1468 mm)
Curb weight	1600 kg (3528 lb)
Top speed	100 mph (160 kph)
Range	270 miles (432 km)
Refuel time	1 min

effect. These currents create a magnetic field that interacts with the magnetic field of the superconductive coils to create a force that holds up and stabilises the train.

Maglev transport is effectively a means of flying a vehicle or object along a guideway by using magnets to create both lift and thrust, albeit only a few centimetres above the guide-way surface. High-speed maglev vehicles are lifted off their guideway and thus move more smoothly, quietly and require less maintenance than wheeled systems – regardless of speed. This absence of friction also means that acceleration and deceleration can far surpass that of existing forms of transport. The power needed for levitation is not a particularly large percentage of the overall energy consumption; most of the power used is needed to overcome air resistance, as with any other high-speed form of transport.

Maglev advocates claim that, at very high speeds, the wear and tear from friction along with the concentrated pounding from wheels on rails accelerate equipment deterioration and prevent mechanically based train systems from achieving a maglev-based train system's high level of performance and low levels of maintenance. There is a good reason why the rest of the world's fast trains limit their operations to similar top speeds and why the CJR is planning to build its newest Shinkansen (Chuo) line using maglev technology.

There are presently only two commercial maglev transport systems in operation, with two others under construction. In April 2004, Shanghai began commercial operations of the high-speed Transrapid system. Beginning March 2005, the Japanese began operation of the HSST 'Linimo' line in time for the 2005 World Expo. In its first three months, the Linimo line carried over 10 million passengers. The Koreans and the Chinese are both building low-speed maglev lines of their own design, one in Beijing and the other at Seoul's Incheon Airport. High reliability and extremely low maintenance are hallmarks of maglev transport lines.

The Shanghai Maglev Train or Shanghai Demonstration Operation Line is a maglev line that operates in Shanghai, China, and is illustrated in Figure 15.2. It is the first commercially operated high-speed magnetic levitation line in the world. The train line was designed to connect Shanghai Pudong International Airport and the outskirts of central

Figure 15.2 Maglev train coming out of the Pudong International Airport in Shanghai (Source: Alex Needham, http://en.wikipedia.org/wiki/Shanghai_Maglev_Train)

Pudong where passengers could interchange to the Shanghai Metro to continue their trip to the city centre.

Construction of the line began in March 2001 and public commercial service commenced in January 2004. The top operational commercial speed of this train is 431 kph (269 mph), making it the world's fastest train in regular commercial service since its opening in 2004, faster than the TGV in France and also faster than the latest China Railway high-speed train in China at 350 kph (219 mph). During a non-commercial test run on 12 November 2003, a maglev train achieved a record speed of 501 kph (313 mph). The train and tracks were built by Siemens.

In normal operational use the fastest journey takes 7 minutes and 20 seconds to complete the distance of 30 km (18.75 miles) reaching 350 kph (219 mph) in 2 minutes; the maximum normal operation speed is 431 kph (269 mph).

15.5 Electric Road–Rail Systems

The idea of a road–rail system in which vehicles can travel on both roads and a track combines the benefit of a road vehicle with its free-ranging travel with train systems where vehicles can travel for considerable distances without hold-ups in relative safety and comfort.

A recent system was tried in Gothenburg, Sweden, in which a line of cars, each outfitted with advanced steering and sensory technology, follow behind a leader vehicle which guides the cars as they travel along a preprogrammed route. Each car in the 'train' communicates with the leader via Wi-Fi links, thus requiring little or no input from their individual drivers, who are free to take their eyes off the road and relax.

One of the authors proposes a road–rail system in which battery electric vehicles are used. The vehicles would run on their own tyres but would be automatically controlled while on the track. The track would consist of special lanes located on motorways or major roads. These would be fenced to prevent other vehicles from using the lane. The vehicles would either run individually or be joined together in trains.

An electrical supply to the vehicles using the system would be provided, either by electrical pickup from supply rails or ideally from inductive pickup rails such as those discussed in Chapter 2. While on the track the electric motors would take their electricity from the electrical supply line and at the same time the vehicles' onboard batteries would be recharged. In this way the vehicles using the system would leave with charged batteries.

Because the vehicles have onboard batteries the system would not need to supply electricity at all points along the route, which would give considerable advantages. Complex electrical power pickup systems at junctions could be avoided.

The system is considered to be particularly suitable for motorways and it is proposed that it would be initially installed along the centre of these to be used initially for cars and light vans. The central lanes would be devoted entirely to the system. Most parts of Britain lie well within 100 miles (160 km) of a motorway, a distance which would be covered by the battery. Hence the system would allow battery electric vehicles to travel place to place throughout the country. The system could also be used on trunk roads outside the motorway network.

Vehicles would be automatically controlled while on the system. This would give several advantages. Greater packing density in terms of number of vehicles per mile would result as braking distances would be kept to a minimum and lane widths could be minimised. Alternatively the vehicles could be bunched into road trains. The system would be inherently safer than vehicles under manual control so overall speed could be increased. Vehicles wishing to leave the system would be returned to the normal motorway where they would resume manual control.

Because steering would be under automatic control, lane widths would be kept to a minimum. The system could be extended into towns and cities. Computer checks would prevent vehicles which have not been serviced regularly from using the system. Run-flat tyres could be used to prevent vehicles becoming inoperable while on the system, and when tyre pressures fell below predetermined levels, vehicles would be forced to leave at the next junction.

There are no insurmountable technical problems which would prevent an electric road–rail system from being successfully developed. The system would allow drivers and passengers to travel considerable distances in comfort while allowing them the flexibility of conventional motor vehicles on leaving the system.

15.6 Conclusion

At this moment in time we stand to see electric vehicles making a substantial impact on the future of transport. Traditionally electric vehicles have made their mark in niche markets such as invalid carriages, golf carts, fork-lift trucks, electric personnel carriers and electric bicycles. Electric trains have made a substantial impact but electric road vehicles have remained in the minority.

For the first time, the new electric lithium batteries have been able to provide electric vehicles with sufficient range to encourage their mass production. Development of fuel cell vehicles continues and these still show continuing promise for the future. High-speed trains have been developing quietly and are starting to be able to compete commercially with air transport.

Continued environmental concerns are pressing society to find alternatives to IC engines which will stop burning oil and other fossil fuels. Environmental concerns encompass both worries about carbon dioxide emissions and the effect of exhaust gas emissions on health.

There has been a proliferation of commercially available battery electric vehicles such as the Nissan Leaf and Mitsubishi MiEV. Hybrid vehicles such as the Chevrolet Volt in which the batteries can be charged from the mains are now commercially available and will be introduced to Europe in the form of the Vauxhall or Opel Ampera. These vehicles can travel on shorter routes using mains electricity, but when a longer range is required they are able to use conventional fuels.

Most major vehicle manufacturers are also currently making developments in fuel cell vehicles. Clearly they see this as an area where electric cars could be produced, which would compete with conventional IC vehicles in terms of range, flexibility and cost. Fuel cell cars are further away from commercialisation than hybrids, but fuel-cell-powered buses are closer to the market. Fuel cell road passenger cars have received a boost from the introduction of the Honda FCX Clarity, which is available for lease in the USA.

As mentioned in Chapter 14, in addition to developing electric vehicles, close attention needs to be given to the infrastructure needed to supply power for electric vehicles. While small electric commuter vehicles use household electric sockets at present, and current commercially available hybrid vehicles solely use petrol or diesel, future fuel cell vehicles are likely to need sources of hydrogen. More widespread use of rechargeable battery vehicles will require charging points to be installed.

High-speed trains have continued to be developed and these are considered to be environmentally attractive as they consume a fraction of the energy per passenger mile than air transport. In addition the electricity which they use can be made from non-fossil-fuel sources. Conventional high-speed trains such as the Shinkansen are used effectively in a variety of countries and high-speed maglev trains are in use in China.

As mentioned earlier, the issue of energy sources also needs to be addressed. Introduction of electric vehicles undoubtedly cleans up the immediate environment where the vehicle is being used. However, in the case of rechargeable vehicles the emission of carbon dioxide is simply being transferred to fossil-fuel-burning power stations. Introduction of more solar and other alternative energy power stations as well as modern nuclear power stations to match the introduction of electric vehicles would ensure real zero-emission transport.

It is therefore worth repeating that, with current technical developments in the energy sources for electric vehicles, coupled to the desire for less environmentally damaging transport, the future for electric vehicles looks extremely promising.

Further Reading

Tesla (2012) http://www.teslamotors.com (accessed 2 April 2012).
Honda (2012) http://automobiles.honda.com/fcx-clarity/drive-fcx-clarity.aspx (accessed 2 April 2012).
Wikipedia (2012) http://en.wikipedia.org/wiki/Shanghai_Maglev_Train (accessed 2 April 2012).