Electric Cars, Vans and Bikes

written by Jeff Allan
illustrated by Maddie Cottam-Allan

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DEDICATION

for
Professor Sir David McKay
whose book “Sustainable Energy - without the hot air”
was my inspiration.

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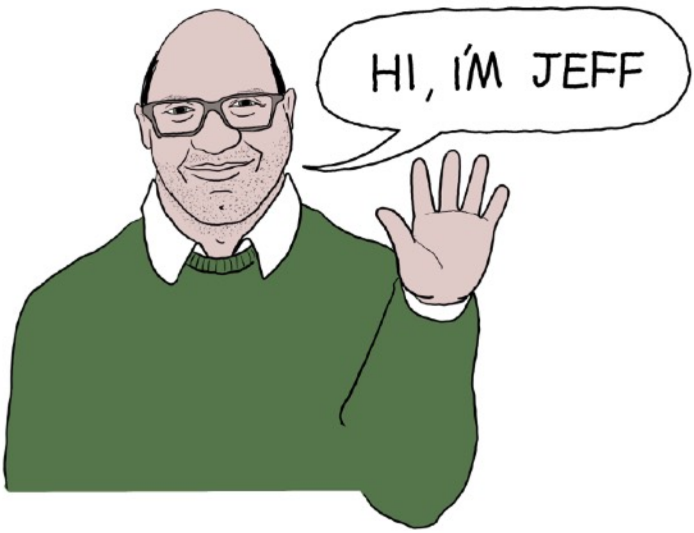


1 INTRODUCTION

I started writing this book in 2016. I am now updating and expanding it in 2020. Much has changed since 2016 - there is a much better understanding by the general public for the need to do something about emissions to halt or preferably reverse climate change. This is in no small measure due to heroines such as the Swedish environmental activist Greta Thunberg and the New Zealand Prime Minister, Jacinda Arden. The youth of today are taking the lead. Changing from a diesel or petrol car to an electric or hybrid undoubtedly reduces emissions but you can reduce them still further as explained in the chapter "Are You Saving the Planet?"

This book tries to explain how you can drive an electric car. Please enjoy the new found freedom of driving an electric car. You do not have to read the book sequentially nor do you have to read everything in a chapter.

If you are reading this book, you have a pioneering spirit. If you drive an electric car you are a pioneer.

2 DRIVING AN ELECTRIC CAR

It takes a while but gradually you realise how archaic a petrol or diesel car is. The first thing you notice in an electric car is that there is no engine to start. You do not have to worry about the car stalling. Unlike a manual gearbox car, you will note there is no clutch and typically only two gears or directions - Drive (forward) and Reverse. For those of you who have a smug face at this point because you are used to driving an automatic, there is even a difference here. An automatic still has multiple gears and you will know when it changes gear because there is a slight change in acceleration and you will see the RPM of the engine change. An electric car usually has only one forward gear. An electric car is capable of going from zero speed to top speed in one gear (in the case of a Tesla it is limited to 155mph).

There are more benefits. The car is extremely quiet. So quiet, indeed, that manufacturers of new electric cars have added a noise at low speeds to warn unwary pedestrians. The car is clean. It is amazing how much smell there is when filling a petrol or diesel car with fuel. Some will be surprised to find that avoiding the need to fill up at a petrol station is a benefit. What about the problem of charging an electric car? There is more detail later but for most people, it is possible to charge effortlessly at home or work while the car is not being used.

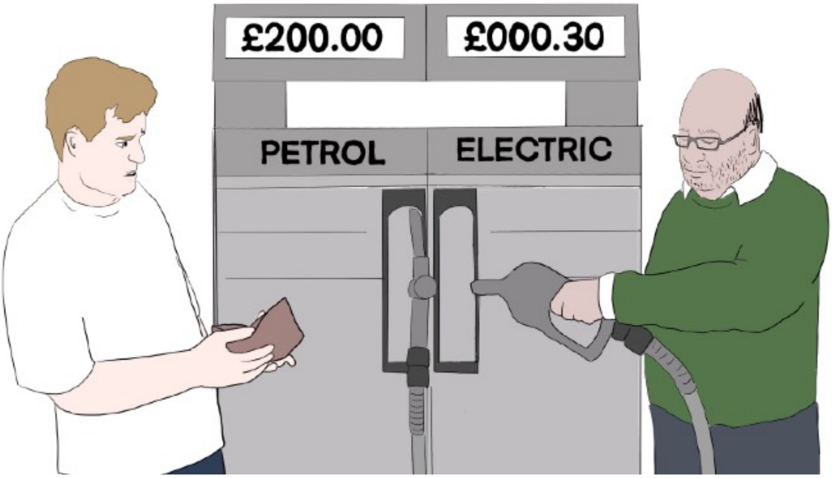
The battery is heavy but placed very low down. This makes an electric car particularly stable when cornering.

When you take your foot off the accelerator, it will slow the car down, like a petrol or diesel car in a low gear. Unlike a petrol or diesel car an electric car also uses the energy needed to slow it down to recharge the battery! When you press the brake even more energy is fed into the battery. This means less wear on the brakes (and therefore lower maintenance costs) and you are saving energy.

So are there any disadvantages? If you have to drive a long distance, then you may need to charge the car partway through the journey. If your electric car has limited range this can increase the journey time significantly but if you have an electric car with a good range, for example a Tesla, this break in driving is likely to be needed in any case to refresh the driver as well as the car.

Most people do not notice that a petrol or diesel car uses more fuel in the winter than the summer. The difference with an electric car is more marked. You may easily have less than 2/3 of the range in winter that you have in summer. As long as you bear this in mind when selecting your electric car, this should not be a problem but it does catch out a number of new drivers of electric cars.

You will not be alone driving an electric car but you will be very much in a minority. There may be over 5 million battery electric-cars world-wide now but there are over a billion cars in total world-wide. That minority will in time become a majority. Electric cars are getting more popular in Britain. Even now, it is difficult to move more than a mile in a large city without spotting an electric car.



3 ECONOMICS

It will surprise many readers of this book to find that running a battery electric car is usually cheaper than running an equivalent petrol or diesel car. You need to take into account all the costs of running a car: Initial cost of car minus final sale price of your car, or leasing cost, fuel costs, vehicle tax cost, Benefit In Kind (BIK) cost (where applicable), insurance cost, servicing cost, MOT cost (where applicable), interest on any loan needed for your car, congestion charge (where applicable), low emission area charge (where applicable). All prices in this book are referenced to August 2020.

Let's consider each in turn, starting with capital or leasing costs. If you buy your car, whether new or used, you need to consider the up-front capital cost. Battery electric cars are generally a higher cost than equivalent petrol or diesel car, however for new battery electric cars, the government offers a "plug-in" grant (see "Getting Further Information" chapter). At the time of writing, the grant will pay for 35% of the purchase price up to a maximum of £3000. There are some caveats, for example the car must cost less than £50,000. You can also get a grant of up to £350 to have a home charger installed and this applies to a new car or a used car {see "Getting Further Information" chapter). Some manufacturers offer to install a home charger as part of the deal of buying an electric car. Battery electric cars used to depreciate appreciably but now it is usual to find that battery electric cars depreciate less than their petrol or diesel car equivalent, so you may find the difference between the price you paid at the beginning of ownership and the sale price at the end is less than for a petrol or diesel car. With regard to leasing costs, these are a little higher for electric cars rather than petrol or diesel but as time goes by, less so.

I would like to give a practical example to demonstrate fuel costs. I drive a Tesla Model S. I have therefore chosen an equivalent petrol car - a Jaguar XF to provide a comparison. My annual mileage is around 10,000 miles. I know that my Tesla consumes 0.361kWh (kilowatt-hour) per mile. My electricity bill shows that I pay £0.185 per kWh. Therefore if I charged my car fully at home, it would cost £10,000*0.361*0.185 = £668. In fact I often charge at Tesla superchargers for long journeys. These are free for me as my Tesla was one of the first and free supercharging was provided for the life of the car! Another factor is that I have solar cells on the roof of my house so in practice, my fuel costs are a fraction of the above amount.

Now consider the equivalent petrol car, a Jaguar XF with a 3 litre engine has a fuel consumption of up to 44 miles per gallon. A litre of petrol costs about £1.10 today and there are 4.6 litres per gallon. Therefore an annual mileage of 10,000 would cost £1150.

With regard to vehicle tax, my Tesla Model S has zero vehicle tax, although it must be taxed every year. A Jaguar XF, if it was a similar age, would be charged £265 per year. Vehicle tax for petrol or electric cars varies according to the type of car but generally the vehicle tax for a battery electric car will either be zero or less than for an equivalent petrol car. Vehicle tax for alternative fuel vehicles including hybrids are not zero after year one but will be less than for petrol/diesel equivalents.

Benefit in Kind (BIK) applies to when a car is provided as part of your work as a benefit. This is the tax which you pay for that benefit. Current company car BIK rates start at 0% for pure-electric cars, 3% for new plug-in hybrid models, 21% for the greenest hybrids and 23% for any car with 100g/km CO2 or more.

Insurance costs are broadly similar for all engine types.

Servicing costs are lower for electric cars because there are fewer moving parts. Despite having driven nearly 70,000 miles in my Tesla, it still has the original brake pads and discs. Interestingly, I used to have my Tesla serviced once per year but when I contacted my Tesla dealer recently, I was told they don't bother with an annual service and instead just fix things when they go wrong!

MOT is the same cost for cars, regardless of engine type.

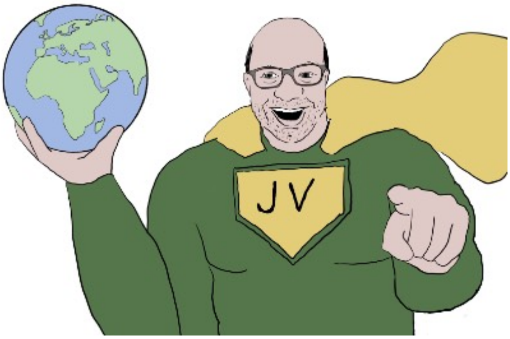
Interest on loans is not affected by the engine type, although it will vary considerably dependent on where you get your loan.

Battery electric cars qualify for a 100% discount from the congestion charge in London but you have to register for that exemption and there is a registration fee of £10 each year. (See "Getting Further Information" chapter).

Charges for the London Ultra Low Emission Zone are complex and changing in 2021 and again in 2025 so although for the moment battery electric cars and vehicles that meet Euro 6 standards (petrol and diesel), that emit no more that 75g/km of CO_2 and have a minimum 20 mile zero emissions capable range (hybrid) will qualify for the 100% cleaner vehicle discount it is advisable to check if you plan to drive in London regularly.

So far the costs I have described are personal costs but there are costs to society associated with driving a car, whether electric, diesel or petrol in terms of effect on climate change, the planet's limited resources and harm to health of the general public. These are covered in the next chapter "Are You Saving the Planet?"

In summary, fuel costs, vehicle tax, BIK, servicing costs, congestion charge London Ultra Low Emission Zone costs are either zero or much lower for a battery electric car than a petrol or diesel car. Capital costs may be higher for a battery electric car but depreciation may be less. Individual cases need to be considered but generally the running costs of a battery electric car should be cheaper than the equivalent petrol or diesel car.



4 ARE YOU SAVING THE PLANET?

If you want to save the planet, don't buy a car, not even an electric car - walk instead. If you need to travel further, use a bicycle (See “Electric Bikes” chapter). If you need to go further still, use a sustainable form of public transport, for example a full or substantially full electric train powered from renewable sources such as wind, hydro or solar. (See “Getting Further Information” chapter).

However, for some, a car is essential, particularly for those with reduced mobility or living in a remote area. Furthermore, many, like selfish me, cannot resist the luxury and enjoyment of a car. Therefore the real question to be asked is “Are you treating the planet better by using an electric car rather than a petrol, diesel or even a hydrogen powered car?” The simple answer is YES, but it is a complex issue which I will try to explain. There are people who will say no but these are all too often people who have a vested interest in exploiting fossil fuels or current automotive technology.

One important point if you live in a city is that you are saving lives by driving an electric car rather than a petrol or diesel car because there are no carcinogenic tail pipe emissions. It is a sobering thought that more than 40,000 people a year die an early death from air pollution in the UK. Contrast this with less than 2000 deaths per year from road accidents in the UK.

Let us get back to the question - “Are You Saving the Planet?”. There are two elements to consider - emissions (especially carbon dioxide), and material resources. It is necessary also to consider the manufacture of the car, the use of the car and the disposal of the car - so called cradle to grave. Let us start with energy.

Energy is needed to extract the raw materials to make any car, namely to transport the raw materials to the factory, to manufacture a car, to transport a car to the dealer, to prepare a car for a new owner, to deliver a car to a new owner. All this energy is needed before an owner of a new car has driven the first mile. This energy is unlikely to be solely from renewable resources and therefore some emissions, especially carbon dioxide but also others will have been produced. How much energy? Does an electric car need more energy for these processes?

Consider the vehicle part manufacturing and assembly process. This is where the majority of the energy to manufacture (and scrap) a car is used. It takes around 9400 kilowatt hours (kWh) of energy to turn raw materials into a finished petrol or diesel car (see “Getting Further Information” chapter). An electric car needs almost 50% more energy due to the manufacturing of the battery - around 14000kWh, but these figures need to be considered in the whole lifecycle. The energy of 14000kWh would be enough to power my electric car 40000 miles. The energy used to run my electric car for a lifetime of 100,000 miles would therefore be just over 2.5 times the energy to manufacture it. In other words the increased energy to manufacture an electric rather than a petrol or diesel car is significant. This means that for an electric car to be better than a petrol car or a diesel car in terms of carbon dioxide emissions, the generation of electricity used to run an electric car must produce less carbon dioxide emission than that produced when running a petrol or diesel car.

The carbon dioxide emissions for an electric car are dependent on the fuel mix of the electricity generation. In Norway, for example, virtually 100% of the electricity is produced from renewable sources - mainly hydro-electric generation, thus close to zero carbon dioxide emissions are produced when driving an electric car in Norway. Due to the high volume of electricity produced from nuclear power in France, train journeys within that country produce little in the way of carbon dioxide emission. At the other extreme, in China, at present, a large percentage of the electricity is produced from coal which produces large quantities of carbon dioxide. In fact, and this is a most significant fact, if your electricity is generated by coal, you will produce less carbon dioxide by driving a petrol or diesel car than an electric car! If you are reading this in China, please consider buying an electric car for two reasons - firstly you will not produce tail pipe emissions which will clog the atmosphere in your city, secondly China is rapidly changing the fuel mix of electricity, reducing the need for coal and increasing the use of renewable fuels to replace dependency on coal. The same can be said at the time of writing for USA, India, Japan and South Korea. The UK mix is improving rapidly too - low carbon sources - renewables and nuclear accounted for more than half the electricity generated on a day in June 2017. As of midnight on 10th June 2020, Britain had no coal-fired power generation on its grid for a full two months - the longest period effectively without coal since the Industrial Revolution. You can find information on the fuel mix for Britain on a daily basis and information on fuel mix for each nation on an annual basis. (See “Getting Further Information” chapter)

Consider this simple calculation. My Tesla has required an average of 354 Watt-hours of electricity per mile in the last six years/ 60,000 miles. As I write, the national grid is producing 176 grammes of carbon dioxide per kilo-Watt hour. Therefore my car will produce 176 multiplied by .354 grammes of carbon dioxide per mile, which is 62 grammes of carbon dioxide per mile if I power it from the national grid. My Tesla is a fast, 2 tonne, comfortable 5 seater car. For comparison, a similar size diesel Jaguar car, a 3 litre turbo charged XJ Luxury produces nearly 300 grammes of carbon dioxide per mile. Note that if it had been a petrol rather than diesel engine it would produce even more carbon dioxide.

Smaller petrol or diesel cars produce less carbon dioxide but equally so do smaller electric cars running on national grid electricity.

In the UK, based on present electricity generation fuel mix, use of an electric car will produce less carbon dioxide and associated emissions than an equivalent petrol or diesel car, providing the car is used for a reasonable lifetime (in excess of around 50,000 miles) before being scrapped.

You can improve the situation further by fitting solar cells to your house roof - my solar cells have produced more energy than I have used in my car. If I ran my car exclusively from the energy produced from my solar cells, the car would release no carbon dioxide.

There are other emissions. Electric cars tend to be heavier than petrol or diesel cars so tyre wear is greater, however the electric brake systems in electric cars means that they produce less brake dust than petrol or diesel cars. The issue of tyre and brake emissions is a serious one for city dwellers in particular. Electric cars are approximately similar to petrol and diesel cars in this area and therefore it can be expected that this remaining significant health problem will need attention, even if we all eliminate tail pipe emissions by changing over to electric cars. (see "Getting Further Information" chapter)

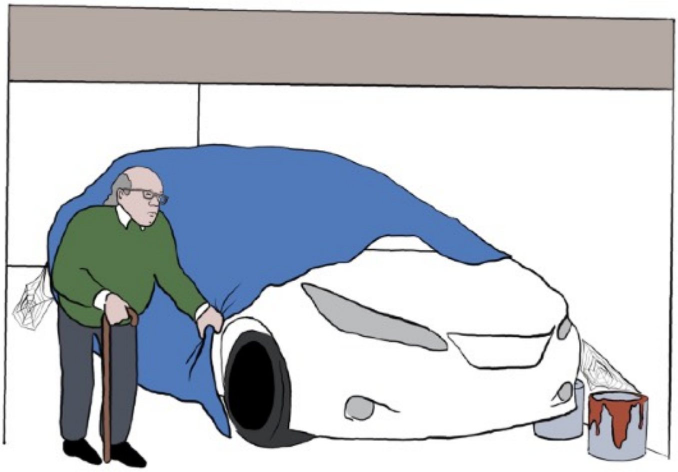
Let us now turn attention to use of material resources. In the early 1950s, a car was predominantly made of steel, with a small amount of aluminium, rubber and Bakelite (an early form of plastic). Cars now, whether petrol, diesel or electric utilise more exotic materials - platinum, for example is used in catalytic converters for petrol cars. More aluminium is used to reduce body weight and plastics abound. The numerous electric motors in a petrol car for heating and ventilation, windscreen wipers, starter motors, electric seats and tailgates utilise other resources such as copper and magnetic materials which an electric car will typically use in even greater quantities for the motors that drive the wheels. This is before the extra resources in batteries are considered. If our planet is not to be denuded by the production and use of cars, then recycling at the end of car life is paramount. Recycling of steel has been dealt with for some time. Recycling of rarer materials is also being resolved, (see "Getting Further Information" chapter). In the UK there is a commitment to recycling which can be found in **https://www.gov.uk/guidance/elv**

Recycling of electric car batteries can begin by electricity companies utilising remaining electric storage capabilities. This needs explaining. When electricity is generated for domestic use, it has to be used at the time of generation because of costs and problems of traditional methods of storage such as pumped water. A used electric car battery will have diminished range for the electric car but may still be used together with other used car batteries by electricity utilities to store solar electricity generated during the day and released from the used car batteries in the hours of darkness when people want to cook, heat and light their homes. A used electric car battery can be given a second life before being taken apart for recycling its constituent parts (see "Getting Further Information" chapter).

At the beginning of the chapter a hydrogen powered car was mentioned. A hydrogen powered car using a fuel cell (which converts hydrogen into electricity) produces no tail pipe emissions, but presently has less than half the efficiency of a battery powered electric car.

There is interest in this technology as a replacement for diesel engines in the area of trucks and railway engines where the reduced efficiency compared to battery electric trucks and railway engines is tolerated due to the short range and high cost of battery electric alternatives. However battery technology is catching up and we are likely to see battery electric trucks soon, just as we see battery electric cars being used successfully now.

In conclusion, in the UK, an electric car will produce less carbon dioxide emissions than an equivalent petrol or diesel car providing it is used for a reasonable lifetime mileage to offset the increased energy needed to produce it. Emissions other than tail pipe emissions (tyre and brake dust) are as much of a problem with electric cars as petrol or diesel cars and remain a health concern. The increased use of more exotic resources than steel in modern car design, particularly electric cars needs particular attention to recycling at the end of life. In other countries the calculation will be different, depending upon the sources of electricity in that country (as per Norway/China, referenced above.)



5 LIFETIME CONSIDERATIONS

The good news is that there is no clutch or gear box to wear out. Furthermore, the electric motors and controlling electric system (power electronics) used in electric cars are considerably more robust than petrol or diesel engines. They are likely to outlive the rest of the car. Brake wear is less than on other types of car too because electric cars have a regenerative brake. This means that (as mentioned previously) the electric motor in an electric car acts like a brake when the foot is taken off the accelerator and also (for some cars) when the foot is placed on the brake. The energy produced is fed into the battery slightly extending the range. This electric braking action means conventional brake pads and discs last longer. My two electric cars show little sign of brake pad or disc wear in over 60,000 miles of use.

The bad news is that the large weight of the battery typically means that electric cars are heavier than an equivalent petrol or diesel equivalent and therefore tyre wear may be more (but not much more).

If anything does go wrong with the motor or battery, replacement can be expensive. The need for replacement is unlikely, unless associated with accident damage. Otherwise the motor is likely to last much longer than the equivalent for a petrol or diesel car. This is because there are fewer moving parts (there are no pistons, crankshafts, gearbox, camshafts, injectors etc.). The only wear in an electric motor is on the bearings, but even this is much less than the wear on the bearings in a petrol or diesel engine. There is no gearbox but there is a reduction drive. The reduction drive, because it is constantly engaged, is not under the same stress as a variable speed gearbox that would be found on a petrol or diesel car. The reduction drive is likely to outlive the rest of the car.

Due to the high level of taxation on petrol and diesel oil, fuel (electricity) costs should be less. This may not be the case if you are dependent on charging stations away from home on a frequent basis if you have to pay a fee to use them. (See “Economics” chapter).

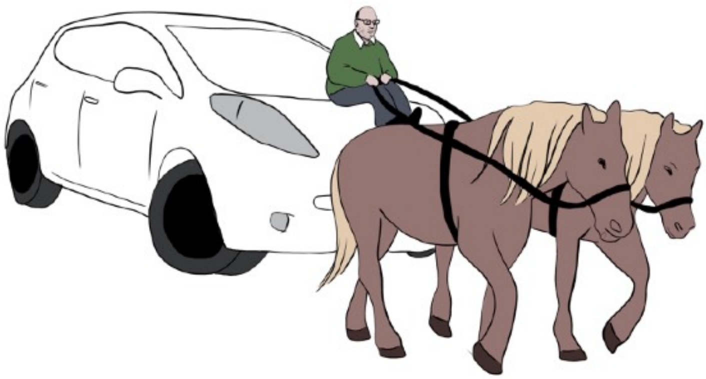
Battery life is difficult to predict. Over a long period of time, batteries deteriorate. As a result, the range reduces, but it is for the car owner to decide when a battery needs replacing - If the owner is willing to tolerate a reduced range then the battery can continue to be used. One driver may feel the need to replace a battery with a reduced range of 90% compared to the range for a new car. Another driver may be willing to allow it to reduce to say 70% before replacement. Eventually a battery will expire, but not without warning of considerably reduced range. Battery life is typically measured in full cycles i.e. charging to 100% and discharging to 0%. One battery manufacturer quotes 500 full cycles. This seems to be an alarmingly small number. However electric car manufacturers typically prevent drivers from discharging to 0% and some prevent charging to 100%. This extends the number of cycles that can be used considerably. There are a number of actions which a driver can take to extend battery life. These include:

(As for any rechargeable battery)
1. Do not leave the car at full charge for any lengthy period. (Most electric cars have a facility to charge it to a particular % - 80% is a good figure to charge it to, if you are leaving it for a while).
2. Charge the car before it has fallen below 20%.
3. Do not leave the battery for extended periods of time in a state of low charge.

and
4. Charge often either at home or work (or both) rather than charging regularly at the higher rate obtainable from high speed chargers. This is because charging regularly at the higher rate will shorten the life of the battery due to the extra stress placed on it while charging at this rate.

However there will be times when you need a full charge and you may find your journey forces you to use the battery until the charge is less than 20%. Occasional use is not a problem.

To give some indication of a typical time period for the life of a battery - Tesla guarantee their batteries for eight years (with unlimited mileage). Nissan currently offer five years or 60,000 miles, whichever comes soonest. A university professor friend wanted a battery for an experiment he was doing and went to a Toyota dealer to buy a Toyota Prius battery. He was told that they had never sold one before and he was amazed at how low the price was. Battery prices fall with time in any case so by the time you need a new battery, say 10 years or more, the price of a replacement battery should be much less than the original cost.



6 HYBRID CARS

A hybrid car has two forms of power. A hybrid car normally has a conventional petrol (or diesel) internal combustion engine and also the components for a pure electric car - a battery and a motor/generator. This allows operation either from the battery like a pure electric car or by means of the petrol (or diesel) engine. They offer long range from the petrol or diesel engine but use the battery and motor/generator to reduce the amount of time the petrol or diesel engine is needed, leading to quiet emission free driving when the car is electrically rather than petrol or diesel engine driven and an overall decreased fuel consumption compared to a conventional car with just a petrol/diesel engine. The additional components in a hybrid make it more expensive and heavier than a conventional petrol or diesel car.

The battery of a hybrid is typically charged when the car is braked, but also by the petrol or diesel engine when the petrol or diesel engine is being used to drive the car. Most recently built hybrid cars allow you to charge the battery from charge points at home, at work or at public charge points, if you wish to. This is only to ensure you have a charged battery before you set off and is not essential to drive the car, but does increase the opportunity to drive the car under electric power.

When I first started writing this book, I was in two minds as to whether to include a chapter on hybrid cars as they are not pure electric cars. However I can see they are more likely to be acceptable to current drivers of petrol or diesel cars than pure electric cars, not least because you are not wholly dependent on the battery being charged to travel long distances. Indeed you could drive a hybrid car without even being aware that it has an electric capability as most hybrid cars will automatically switch between electric or petrol/diesel. They are a good route towards reducing dependency on fossil fuels. I foresee that these cars will become ever more popular. Volvo, for example (as of 2019) only manufacture hybrid or pure electric cars. Other manufacturers are giving similar undertakings.

There are several different categories of hybrid cars ranging from micro to full hybrid. A micro hybrid car will simply switch off the engine if you are stationary at traffic lights and switch the engine on when you want to move off. There is no capability to drive with the electric motor alone but it does decrease fuel consumption and reduces emissions when in stationary traffic. A large number of modern cars have this facility and most drivers of such cars are not even aware that they are driving a micro hybrid car. This is often referred to as stop-start technology. At the other end of the spectrum, a full hybrid car is capable of being driven by the electric motor alone, typically when setting off, reversing and in town for short journeys. Providing the battery has been charged sufficiently, full hybrid cars will start off on the electric motor and automatically switch to petrol or diesel when the battery is no longer sufficiently charged. Some early hybrids did not have a facility to charge the battery at charge points. The more recently built hybrids have this facility and are known as “plug in” hybrids. Some manufacturers have controversially used the lack of a plug in facility as a selling point! They have been branded as “self charging”.

One of the most popular hybrid cars is the ubiquitous Toyota Prius.

A pair of Toyota Prius cars

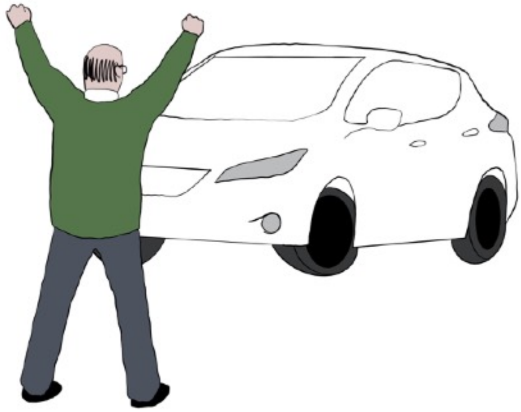
The Toyota Prius is much favoured by taxi drivers in cities for its low fuel consumption. It is also popular in London as it has been exempt from the congestion charge. The early Toyota Prius was without a plug in capability but more recently built ones have that capability.

The following is a list of other manufacturers of popular full hybrid cars:

Volvo, Audi, Kia, Hyundai, Honda, Infiniti, Toyota, Skoda, Ford, Vauxhall, BMW, VW, Lexus, Mitsubishi, Mercedes, Mini, Renault.

There are many other manufacturers. More exotic examples include Ferrari and Porsche.

To conclude - A hybrid, even a micro hybrid, reduces emissions and reduces fuel consumption when compared to a conventional petrol or diesel car. A hybrid is typically more expensive and heavier than a conventional petrol or diesel car. A hybrid is not dependent on its battery being charged for long journeys so it has that advantage over pure electric cars. However a pure electric car has no exhaust emissions which a hybrid car does have when the petrol or diesel engine is being used.



7 BUYING OR LEASING A NEW CAR

The advantage of buying or leasing a new electric car rather than a used electric car is that you will benefit from the latest technology. This can be important as the technology is changing fast, particularly the available range and driver automation.

The question most often put to drivers of electric cars is “What is the range?”. The time is coming when that question will not need to be asked. It is rarely asked about a petrol or diesel car and it is a difficult question to answer. There are various standards which car manufacturers quote - EPA (The U.S. Environmental Protection Agency) is an example, NEDC (The New European Driving Cycle) is another. Such standards are useful to compare one car manufacturer with another but are not always indicative of the type of range you might achieve practically. A more recent standard WLTP (Worldwide harmonised Light vehicle Test Procedure) is supposed to reflect more realistic ranges. Unfortunately, some car manufacturers are getting wise to these standards and there have been reports of some dubious values being quoted by manufacturers.

Range is dependent on temperature, speed, type of use and will therefore vary from driver to driver and time of year. I know exactly what the range of my used Nissan Leaf is for specific conditions (under good conditions in the summer at a steady speed of 70mph - about 80 miles) but I have only a rough idea of the range of my Tesla as I never need to use the full range (which under the same conditions is probably around 250 miles). Just to show how meaningless the standards are for practical range, consider that with the EPA standard a range of 250 miles might be shown and for the same car a range of 310 may be given for the NEDC standard. Nevertheless if you use just one standard, you can compare the relative ranges of two cars. Interestingly the EPA range for my Tesla is about right for a summer day driving at 70mph. This does not mean the EPA range is accurate - it is intended to cover combined city and highway. The NEDC range is hopelessly optimistic for real life driving.

The effect of temperature is considerable. People who buy electric cars are often disappointed at the very noticeable reduction in range when the weather gets cold. It is not unusual to experience a 30% reduction in range in freezing temperatures compared to a summer's day. There are several reasons for this - the battery is less efficient in cold temperatures and there is typically the extra burden of heating which can be a drain on the battery.

Ideally most owners would like to buy an electric car which can be charged when not being used, typically overnight at home and have sufficient range to complete all the driving required during the day or even better for several days. If this can be achieved, this is better than a diesel or petrol car as you will not have the inconvenience and the expense of filling up at a fuel service station. If you have a long commute for example, it may be useful to also charge at work. Increasingly, workplaces provide the means to charge during work time. If you have a very long commute, say in excess of 100 miles, you may charge on the way at a high speed public charging point. This could take 30 minutes but may provide a useful break to driving, particularly as these are typically located at service stations or other similar amenities.

The best way to find out what is involved in living with a particular new car is to try it out for a day, preferably a few days to see what is involved. If it is your first electric car you may not have a home charging facility, it may be possible to charge it slowly from a domestic socket or remember to get the dealer to charge it fully before handing it over.

The best time to try it out is in winter as range decreases significantly in cold weather. If the range is sufficient for you in cold weather it will be more than sufficient in the warm weather. If you can only try it in the summer, then as a rough guide assume your range may be a third less in the winter.

Another point to consider with range is that even if the car will suit your everyday needs, you will also have to consider its use for occasional longer journeys. If you want to go for a very long drive and charge on the way at a public charging point, you may need to prepare an app or apply for a charge card in advance or borrow one from the dealer (see the “Driving Long Distances” chapter). The reason for this is that few public charge points accept credit cards at present, although this is changing. Your journey time will be extended compared to a petrol or diesel car if you need to charge on a longer journey. Even if you rarely travel on a long journey, it is worth trying out a long journey on your trial.

There is now a wide variety of electric cars available. Virtually every car manufacturer has an electric car. For up to date information on new electric and hybrid cars as they emerge try reading Autovolt magazine (See the “Getting Further Information” chapter).

The following give some idea of the range of new electric cars you can buy or lease. Very roughly, they are listed in terms of physical size and cost. The smallest you might consider is a Renault Twizy. This is a fun two seater which may be OK in the summer for very short journeys if you want to be noticed but is not particularly practical. A more practical two seater city car is the Smart car.

Renault Twizy

Smart Car

If you prefer a smaller SUV style car there is the MG ZS and the Kia E-Niro.

MG ZS

KIA e-Niro

The Renault Zöe has been a popular small hatchback car for some time

Renault Zöe

Tesla do not advertise but provide the lion's share of electric cars. The company has now progressed beyond its millionth car. At the bottom end (although more expensive than most other makes of electric cars), there is the Model 3. This provides great value for money compared to the other models of Tesla cars (and other makes of electric car) as it has similar range to the more expensive models and the same level of automation. It is about the same size as a BMW 3 series and is a conventional saloon, not a hatchback.

Tesla Model 3

The Tesla Model Y is a SUV style car of similar size to the Model 3.

The Model S is a luxury, very large hatchback. The Tesla Model X is a very large SUV. This can be configured to fit seven adults comfortably.

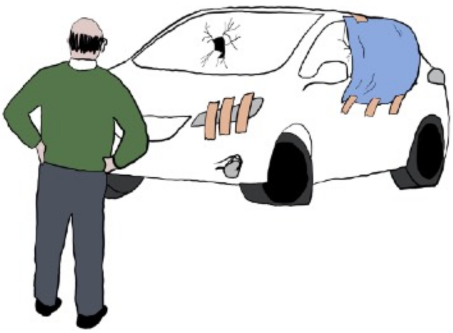
Tesla Model S **Tesla Model X**

If you are considering buying a new Tesla, you may want to use my referral code (http://ts.la/drjeff3933) which will give you a benefit, for example free charging for a fixed distance, see the referral code above for further details of the current benefit.

If you want an even larger electric car, a US style pickup, the following are expected to be available soon: the Tesla Cybertruck, the GMC Hummer and the Rivian R1T.

As referenced before, cars are eligible for a government backed “plug-in grant (see “Getting Further Information” chapter).

The disadvantage of buying or leasing a new car compared to a used car is depreciation. Furthermore, at present new electric cars are more expensive than equivalent petrol or diesel cars.



8 BUYING A USED CAR

Just because you are buying a used car, there is no need to buy a wreck. Although electric cars, in modern form are still relatively new, enough years have passed since their introduction for used car sales to be well established now.

Buying your used car from a dealer will usually cost you more than a private purchase, but in return you get a warranty and dealer attention. There are dealers who sell a variety of different makes of car including petrol and diesel cars. There are also specialists who sell used electric cars (with expertise in a single make or a variety of makes).

Finally it is possible to strike a bargain by buying privately. In this last category you need to be aware of the Latin saying “Caveat Emptor”. This translates to “Be careful what you buy, there is no going back” - those Romans were very succinct. See “Getting Further Information” chapter for examples of each type of vendor.

Electric cars depreciate, like any other car, so one advantage of buying a used electric car is that the price is lower than a new one.

Historically the reason for the large depreciation of most used electric cars is that there has been only a small demand for second hand electric cars as potential buyers have been nervous about how long the battery will last. Some manufacturers have attempted to counter this perceived problem by leasing the batteries. This has itself led to a further problem as buyers of a new car are more willing to pay the price to hire a battery than buyers of a used car. If you see a newer car for the same cost as an otherwise similar older one, it is likely that the newer one has a leased battery rather than one that has been fully purchased from new. If you go for the newer car with a leased battery, you will have leasing costs to deal with throughout ownership. Fewer leased batteries are available now that the general public are realising the batteries last a long time. The life of the battery is covered in more detail in the “Lifetime Considerations” chapter. Suffice to say that battery life has proved to be far longer than most people would expect. Batteries can fail in rare cases and they can prematurely age - in Arizona there have been a few problems with older battery technologies. However most batteries gracefully degrade - their range reduces by a small amount each year. It is usually a matter for the owner to decide when it needs replacing. There is one advantage in buying a used car with a lease battery - you can upgrade the battery and end up with the newer technology for a fraction of the cost of a new car.

A word of warning about buying too cheaply. The G-Wiz was a pioneering electric car in its day. It was very popular in London and there are examples still around but they are small, have short range, especially the lead acid battery variety and more significantly they are made of fibreglass to reduce weight, hence they are not robust in an accident.

G-Wiz

There are a number of bargains to be had dating back as far as 2009. For a car this old, the range will be less than when new and you should be aware that older cars, even when they were new, had a shorter range than new cars available now. One of the cheapest and oldest 4 seater modern electric cars available is the Mitsubishi I-MiEV or its lookalike Citroen C-Zero or Peugeot iOn. These are still being made.

Mitsubishi I-MiEV

For a little more money, a 2011 onwards Nissan Leaf can be found. There are a number of alternatives if you can afford more. For example, the BMW i3 is more expensive but still much less than the price of a new one.

BMW i3

An even more expensive but long range luxury car option can be found in a Tesla. If you are buying a used Tesla Model S or Model X There are other benefits - From April 2017, new Teslas costing more than £40,000 require payment of vehicle tax, whereas earlier ones do not (at this time). Furthermore an older Tesla can make use of free charging from the Tesla network of chargers for travelling long distances, whereas owners of new Teslas need to pay for use of the chargers.

It is important to try to find out what it is like to live with a car of the type you are planning to purchase. If you are buying from a dealer, you may be able to try it for a while, in which case the information in the previous chapter about trialling a new car applies. However if you are planning to buy privately, this is unlikely to be possible. I would suggest that in this case you try to rent one for at least a day or two to find out what it is like. See “Getting Further Information” chapter. Failing this try to find out what the experience of other drivers is by looking at owner group forums. Most makes have one. Again, see “Getting Further Information” chapter.

Before buying a used electric car it pays to try to establish how well the car has been treated. A good service history, recording regular servicing carried out in accordance with the manufacturer’s recommendations is always a help.

However it is useful (but unfortunately normally very difficult) to find out the following:
1. Is the car frequently charged to 100%? (Usually not good)
2. Is it charged often either at home or work (or both) rather than being charged regularly at the higher rate obtainable from high speed chargers? (A good thing),
3. Is it often driven until the battery is flat/close to 0% (Not good),
4. Is it often left in a state of low charge? (Not good),
5. Is it frequently charged when nearly full? (Not usually good),
6. Is it left fully charged and not used for a while? (Not good)
7. Does it have a high mileage (more than 25,000 miles a year)? (Not usually good),
8. Does it have a low mileage (less than 4000 miles a year)? (Not usually good).

All of these factors affect the battery quality. Some cars such as the Nissan Leaf, have a means of indicating the quality of the battery (this is not the state of charge or percentage charged). On the Nissan Leaf dashboard, where it indicates state of charge (percent charged) and current range in miles, around the outside is a number of illuminated graduations. There are 12 when new and in the figure below, a 3 year old 50,000 mile example is shown to have 11. The battery has degraded to the point where it has lost one graduation. With that mileage and age that is a reasonable degradation and does not affect the range very much but if the same car had say only 8 or 9, it would indicate a harshly treated car.

Nissan Leaf with a battery state of 11 out of 12 graduations

Some service records will indicate how good the battery was at the last service. If not, it might be worth phoning the place where it was last serviced to find out if more information on the battery status is available.

The figure above demonstrates another point. The range for a full battery is shown as 53 miles. This photo was taken at winter when most recent journeys had been short. In summer with recent long journeys, for the same car this would go up to 86 miles.

Lastly, one disadvantage of buying a used car is that the technology is changing fast and one factor which is changing in particular is the energy storage which is linked strongly to the range available. For example, a top of the range Tesla bought new a few years year ago, might have 85% of the energy storage capability of one bought now.

9 CHARGING AT HOME

There is no need to bring the car inside your house to charge it. Indeed, it is wise not to do so for all sorts of reasons, not least tyre marks on the carpets. Nevertheless, home charging is remarkably easy to carry out in most circumstances. In many ways it is easier than charging a mobile phone. For one thing, the cable connectors are bigger and easier to fit into the sockets.

Typically, charging at home is carried out overnight, so that the car has maybe a full charge but certainly a higher charge the next day. It obviates the need to fill up at a garage and even if your mileage means you need to charge every night, this is still less bother than filling up a petrol or diesel car.

A typical charging scenario is as follows - A button is pressed or a lever pulled in the car to open a flap revealing a connector. This may be at the front, at the side, or at the back of the car, depending on the car manufacturer. There may be a need to open a further flap as in the case of a Nissan Leaf, for example. The charging lead from an installed charger is then simply plugged into the connector on the car. Charging then happens automatically. The following diagrams show how this happens for two different cars - a Nissan Leaf and a Tesla. There are a few variations to this procedure which can be identified in the manual for your particular car.

Pull lever to open flap (Nissan) **Open further flap (Nissan)**

Connector open (Nissan) **Plug in lead (Nissan)**

You can safely connect your charging lead, even in the rain. Every type of charger is designed to ensure that no power can flow until everything is safely connected. The chargers are also designed to cut the power if a dangerous situation is identified.

Press button to open flap (Tesla) **Connector open (Tesla)**

Plug in charging lead (Tesla)

Unplugging is even more straightforward but you need to check the manual for your car to find out the steps to unplug the car.

Some cars or apps for the car allow you to specify times to charge, levels to charge to (for example to 80% of a full battery, rather than to 100%) and times to heat or cool the car. The latter is very useful to prepare the car for safety and comfort before you get into it. It may also help with the range by ensuring the battery is at a suitable temperature for highest efficiency. If you heat or cool the car while it is plugged in for charging then you will get a much better range than if you set off and heat or cool the car after you have set off. Setting different charge levels, for example to 80% rather than 100% is for extending the life of your battery. This is covered in detail in the “Lifetime Considerations” chapter. Typically an 80% charge would be used for short journeys or occasional use while 100% would be used only for longer journeys. Some cars allow you to choose the end time for the charging. If you use this facility to coincide with the time when you need to drive the car, it will warm the battery, making the car ready for efficient use. The instruction manual for your car will show you if any of these facilities are available and how to use them.

To charge your car at home, you need three elements - the car, a charger and somewhere - a drive, a garage or increasingly for flats, a designated car parking space - where the charging lead can be run from the charger to the car.

Dedicated charging car park space at flats

This is a potential problem if you live in a flat without the above facilities or where there is no off-street parking. There are a few ingenious solutions including running a cable out of a window. Some enterprising Local Authorities are providing chargers in lamp posts. See the “Getting Further Information” chapter if you think this arrangement would help you. If home charging is not practical then it becomes necessary to either use public chargers or charge at work. Public chargers are illustrated and covered in the next chapter “Travelling Long Distances”. To all intents and purposes, charging at work is similar to charging at home. Indeed the chargers are the same as those available for charging at home. The difference being that it is done during the day so that the car has increased its charge by the time you are ready to go home. Public chargers are discussed and illustrated in some detail in the “Travelling Long Distances” chapter.

The most robust means of charging at home is to use an installed charger, usually wall mounted. You need a qualified electrical fitter to fit one of these and depending on the power rating, you may need modifications to your domestic supply which a fitter can advise about. There are Government grants available for these chargers and for chargers at work if you want to convince your employer to fit one or more chargers. See “Getting Further Information” chapter for details of how to find these. There are also details on government approved companies which can supply and install both home chargers and workplace chargers.

You can mount your home charger on an outside wall or, if you have a garage, on the inside wall of the garage.

Two examples of chargers are shown in the diagrams below.

Two different makes of installed charger

I prefer to have a “tethered” charging lead. This means the charging lead is permanently attached (tethered) to the charger and therefore always available for use. Some people prefer an “untethered” charger. This has a socket on the charger and a separate charging lead which is either kept in the house or in the car which needs to be brought out and connected for each charging session. An untethered lead will allow for different plugs that fit in the car so if you have two cars with different plugs this might be a better option than a tethered lead.

The charging lead needs to be compatible with the socket on your car and that is why I have two - one for my Nissan Leaf and another for my Tesla - since, as shown previously, these two cars have a different design of plug that fits in the socket in the cart. Your fitter can advise you on the charging lead connector to ensure it is compatible with your car.

One of the main things you will have to decide is what power you want for your charger. The more powerful the charger, the shorter the charging time. People often choose a higher power charger than they really need. The standard ratings are 3.7kW, 7kW, 11kW and 22kW. The most popular at present are 3.7kW and 7kW. These are the ratings for which you can get a government grant.

You will need to check how quickly your car will charge at each of these power levels and judge for yourself if this will be adequate. It does depend on how big your battery is and how long you will be at home, not needing to use the car. For example I manage to charge overnight using a 3.7kW charger for my Nissan Leaf and a 7kW charger for my Tesla, (which has a much bigger battery). You should not need to alter your house wiring significantly for a 3.7kW or 7kW charger but if you really feel you need an 11kW or 22kW charger, you will need a 3 phase supply. You also need to check if your car can make use of the power if you go for a higher powered charger. For example, my Nissan Leaf which is over six years old, cannot charge from a home charger at a higher rate than 3.7kW. Again your fitter will be able to advise you.

You can now get cordless chargers whereby a unit is installed under your drive or under the floor of your garage and you simply park the car over it. The advantage of these is that they do not need connecting as above and are not visible.

A very simple form of “untethered” charger is a portable charger. It is a unit with a charging lead and connector which is portable and can be carried in your car. It is typically supplied with the car. This may be connected to an external domestic socket or a more powerful arrangement using a special socket called a commando socket as shown below in the diagrams. This arrangement is mainly intended for emergencies where there are no nearby public chargers and you are away from home. You also need to be careful about protection from water ingress when it is raining, although they are usually resistant to water to an extent. People who prefer not to install a permanent charger charge their cars at home using this arrangement.

Portable charger using domestic socket   Commando socket

10 DRIVING LONG DISTANCES

Your journey may normally be such that you can drive ‘there and back’ without charging, or charge at your destination, for example when staying at a hotel which has something similar to a home charger.

However if you do want to travel beyond the range of your car, you will have to charge part of the way along your journey in much the same way as you would need to refuel in a petrol or diesel car if your fuel was insufficient to get you to your destination and back. This requires a little planning.

In the UK there are a number of high speed chargers, often at motorway service stations suitable for charging reasonably quickly. Typically a substantial recharge, (up to 80% of the battery capacity) might take 30 minutes which is a good time to have a coffee, have a nap or refresh yourself. The most popular type of high speed charge point is a CHAdeMO type. This is a technical term which comes from the Japanese meaning “Have a cup of tea” - a good piece of advice.

The planning you can do is to check what chargers are available on your route and whether they are working or not. There are a number of apps available for a mobile phone. Zap map is one I use. See the “Getting Further Information” chapter for suitable phone or computer apps for planning. Equally your sat nav may be able to let you plan your route and tell you where you can charge en route. The Tesla sat nav tells you as you travel how many bays are in use and how many are free at Tesla Super Charging sites. Some new cars now have a built in app with charger locations.

When my son and I drove from Land’s End to John o’Groats and back, gaining a Guinness World record for charging time, we did the bare minimum of planning. In fact when we got to John o’Groats we found a high speed charger we did not know existed. I am sure that most people who drive in a petrol or diesel car do not check what garages are available en route to fill up. The network of charging stations is so good these days it is not absolutely necessary to plan with an electric car. However, if you do not check availability, it is advisable to charge when you can in case the next charging site is faulty.

Although the charging network is well developed, the means to pay is not. Some charge points require you to obtain a charge card prior to use, some use a phone app, which it is preferable to set up before you leave. Very few allow a credit card to be used at the charge point. At the time of writing there is a substantial network of fast chargers in England operated by Ecotricity and their phone app will get you access to any of their charge points. In Scotland, Charge Your Car, CYC operate a large number of charge points and give access to a number in England and Wales too. CYC operate through their charge card, which you can apply for, or a phone app which you need to register. There are other suppliers too. See the “Getting Further Information” chapter for further details. A couple of useful cards are shown below.

Charge cards

It is worth researching charging accounts to get the right one for you. Some charge a monthly fee and are particularly useful for people who frequently charge their car on a journey. However others charge more per charge but with no monthly fee. I tend to have accounts which do not have a monthly fee. In fact the chargers I use most frequently en route (apart from Tesla superchargers which are free for my Tesla) are Ecotricity ones. If you have Ecotricity electricity at home you can get a discount on each charging session.

When you need to use a high speed charge point, you need to find it first. You may find your sat nav can do this for you and may suggest when you need to charge. If not there are phone apps such as Zap Map, which can tell you where there are nearby charge points. See the “Getting Further Information” chapter for details of Zap Map and other similar apps.

Having found the charge point, you need to park your car so that the charge point is close to where you plug in a charger cable on your car. Each high speed charge point has its own cable so you don’t have to be very close and importantly you will not need your own cable.

Taking the Ecotricity charge points as an example, get out of the car and approach the charge point. As you can see in the photo below, the charge point has a prominent square computer code

which is read by the Electric Highway app when you point your phone at the code. When the phone has successfully read the code, the phone will prompt you to check if it has identified the correct charge point, for example with the name of the motorway services where the charge point is located. The phone app will then request
your credit card security code and direct you to the screen which can be seen in the photo below. The CYC charge points are similar but you need to place your card next to the card reader on the charge point or use their phone app in a similar way to the Ecotricity one.

Ecotricity charge point

The screen will prompt you to press buttons to indicate which type of charging you need - DC CCS for e.g. BMW i3, AC for e.g. Renault Zoë and DC for e.g. Nissan Leaf. It shows you a diagram of the connectors. The connector on the left in the photo above is for AC. The connector on the right is for DC. The screen on the charge point will then prompt you to connect your car, using the cable provided.

Open the flap on your car to reveal the place where you connect cables to charge the car. This is described in some detail in the “Charging at Home” chapter. As you can see on my Nissan Leaf, which uses DC, there is a large connector on the left in the photo below. The photo next to it shows the cover to the connector open. You then insert the cable plug as shown in the third photo below. This is a modern plug which you can tell from an (orange) button which is used to release it. Charge points with older plugs have a trigger action.

Connectors revealed

Cover open

Cable plug inserted

Once the cable is connected, return to the screen on the charge point and press the button to confirm everything is connected. There is a delay while tests are carried out and then your car will be charging. You can view how long you have charged for on the app, while you enjoy your tea break.

You will finish charging, either because the app has timed you out (currently 45 minutes on Ecotricity) or because you select stop charging on the app. You then need to disconnect the cable by pressing the orange button on the plug in the photo above. The older trigger grip plug has a black button which needs to be pressed to release the trigger handle. Remove the cable. Close the cover and flap on the car. Return the cable plug to its holder on the charge point and you can drive away with the car charged and hopefully the driver refreshed. Note it is really bad form to park at a charge point if you are not charging.

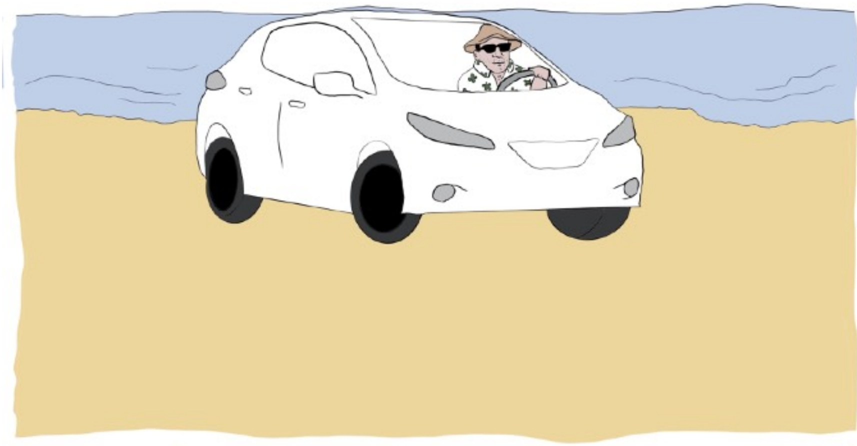
Tesla Super Chargers are even easier to use. Simply connect the cable by plugging into the socket you use for charging at home. When you have finished, press stop charging on the screen.

The Supercharger on the next page is the most northerly in the World, several hundred miles inside the Arctic Circle.
If you have a Tesla and visit a remote part of the world like Wales, where there are few superchargers, you may find it useful to get a CHAdeMO adaptor from your friendly Tesla store so you can use it at public charge points.

Tesla Super Charger

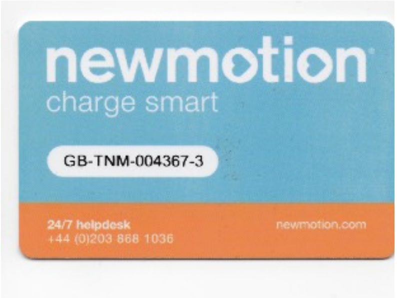
Do not use a Tesla Super Charger if you are not driving a Tesla. The plug may look like the same type as you use to charge your non Tesla electric car but it is a different system and will not work.

If you do have a problem with a high speed charger, telephone the number on the charger. If you find yourself some distance from a high speed charger, for example due to a faulty site, do not panic. Look for an alternative, possibly a lower power charger, if necessary using an app such as Zap Map. Drive slowly and you will conserve range. It is highly unlikely you will not find somewhere to charge but if you do run out, you will have to call a recovery service such as the AA.



11 DRIVING ABROAD

Driving abroad is similar to driving long distances in the UK. The big difference is you will need cards or apps to operate the public chargers, which are typically different from the cards and apps you use in the UK. You will need to organise these cards and apps before you go abroad. Otherwise, the instructions in the chapter "Driving Long Distances" chapter apply. The figures below show examples of two cards.



European charge cards

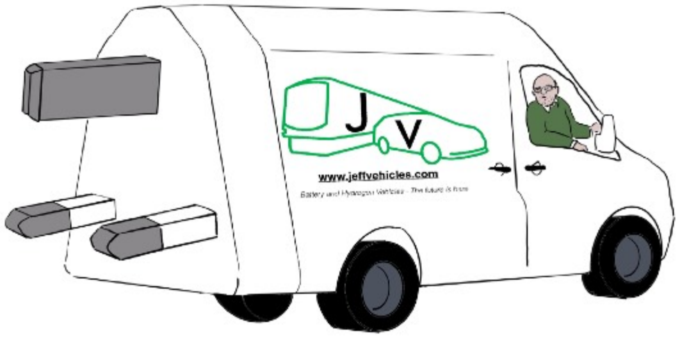
One is a New Motion card. This covers quite a large part of Europe including the UK so you will have the chance to try it out before you go abroad. The other card is an IBIL card which works in Spain. This is a card that you have to load with prepaid cash to use. I found the application form a little confusing, not least because it was in Spanish. It asks for your identification number - (I suggest you use your passport number) and it will ask for your second surname as well as your first and it is a mandatory field on the web based form - good luck with that! I used my mother's maiden name. The "Getting Further Information" chapter has some information on companies which provide public chargers en route in other countries.

When you arrive at your destination you may want to charge from a domestic socket using your portable UK charger which typically is supplied with the car. (See "Home Charging" chapter). If this is the case you will need to use an adaptor. Make sure that the adaptor is robust enough to do the job and the domestic socket is modern as otherwise you may find you plunge the place you are staying at into darkness. A typical adaptor you can buy at an airport is rarely adequate. The "Getting Further Information" chapter shows how you can obtain more robust adaptors such as the one below, which has a European style plug at one end and a UK domestic style socket at the other end.

European plug to UK socket adaptor

If you own a Tesla, life is much simpler; you just use Superchargers as you would in the UK and if necessary, Tesla destination chargers.

Irrespective of whether you are travelling in an electric car, certain regulations apply which do not in the UK. For example if you wear glasses or contact lenses you need a spare pair of glasses in Spain which must be kept in easy reach of the driver's seat. (See "Getting Further Information" chapter).



12 ELECTRIC VANS

The Nissan eV200 electric van is shown below.

Nissan eV200
This one has a refrigerator on the roof. Presumably the van is used to distribute fresh food goods locally. Electric vans are widely used for what is known as last mile deliveries. They have a number of advantages over diesel or petrol vans for this application. They are quiet, emission free, low cost to run and increasingly important, are not subject to emission taxes in cities.

The eV200 was one of the first to arrive on the scene but since then offerings including from Citreon, Fiat, Ford, Peugeot, Renault, Mercedes Vauxhall and Volkswagen have appeared. The Maxus is offered by the Chinese company SAIC. A Maxus van is shown below, again being used in a last mile delivery mode.

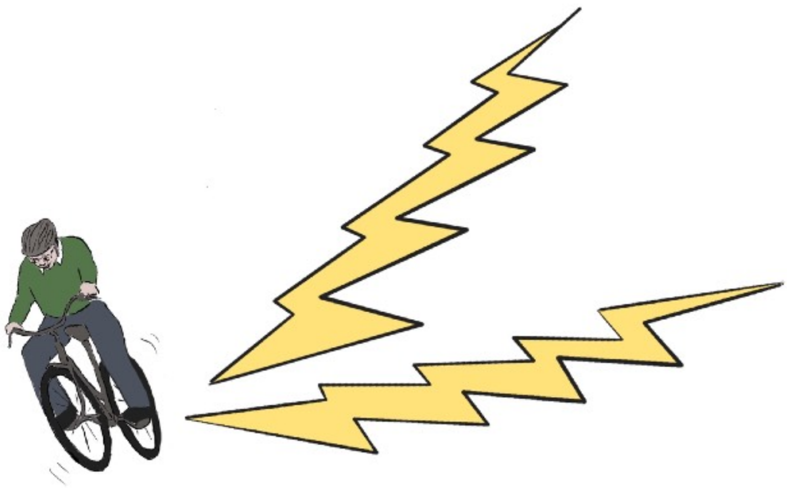
Maxus Van

There are therefore a number of different manufacturers of vans to choose from. Some used vans are now available for purchase as well as new ones.

A number of chapters in this book apply equally to vans as they do to cars:

Driving an Electric Car, Economics, Are You Saving the Planet?, Lifetime Considerations, Hybrid Cars, Buying or Leasing a New Car, Buying a Used Car, Charging at Home, Driving Long Distances and Driving Abroad.

The best advice that can be given if you are considering leasing or buying a new or used van is to try it, preferably in winter, when range tends to be at its lowest.



13 ELECTRIC BIKES

An electric bike (or e-bike) is similar to a conventional bicycle but with a battery and motor to augment the effort you provide on the pedals. If it is many years since you have ridden a bicycle, you may be wary, but please read on. Electric bikes allow you to get some exercise as you would on a conventional bicycle but they make it easier by allowing you to choose how much support you get from the battery and motor. In any case, even if you choose the minimum support you will find going uphill is virtually effortless. This means that you can easily double the distance you would feel comfortable cycling. For most people that would mean that in theory you could get rid of your car!

Electric bikes are easy to use - modern ones simply add to your effort automatically as the control system recognises the speed at which you are turning the pedals and applies additional energy to help you accordingly. Typically, there are different settings you can apply, depending on how much help you want. I usually select the minimum (eco) setting which on my bicycle provides up to the same amount of energy as I apply to the pedals, but I could select the highest (turbo) setting and find that I get three times more energy than I apply to the pedals. On this setting, you would not even realise you were going up hill. Electric bikes are considerably better for the environment than cars, buses or trains. For example, my electric bike shown below has a battery range considerably better than my Nissan Leaf car but has a battery size one thirtieth of the car.

The author's e-bike

If you have not ridden an electric bike before, try one. Most bicycle shops will let you try one for no payment. If you are thinking of buying one, my recommendation would be for one with a motor near the pedals rather than in either the front or back wheel. This is because you gain the benefit of the gears on your e-bike. My e-bike even has an indicator to tell you when to change gear to make it easy to pedal at all times. However you should try a few to see which one suits you. One point to note is that by law, the electric assistance is stopped above 15.5 mph. As an electric bike is typically heavier than a conventional bike, you will find you have to pedal harder than you would on a conventional bike, above this speed. I used to use a conventional bicycle regularly but since I have bought an electric bicycle, I have not gone back. I confess I use my e-bike more than either of my electric cars.

14 HYDROGEN CARS

A car which runs on water? Not quite. Few people realise that the Apollo moon missions could not have taken place without hydrogen providing the electricity needed in the space capsules to support the human crew. Battery technology at the time was too bulky and heavy. Instead a hydrogen fuel cell was used to produce electricity from hydrogen and oxygen carried onboard. The subsequent space shuttles also used hydrogen.

The same technology can be used in a car. Refuelling is actually quicker than recharging a battery. It takes about the same time as a petrol or diesel car to refuel. Like battery cars, there are no toxic emissions (only water vapour) and the range is typically better than most battery cars. This looks like the ideal alternative to a petrol or diesel car and yet, Elon Musk, the driving genius behind the most mass produced electric cars has publicly referred to fuel cells as fool cells. We are not all driving hydrogen cars so what is preventing us from doing so? Let's start by looking at the positive practicalities before examining the draw-backs.

A Toyota Mirai hydrogen car

As can be seen above, a hydrogen car looks much like a petrol car. This one seats five people with plenty of space in the boot. It can be filled up at a hydrogen refuelling station as below.

A Shell hydrogen refuelling station

The nozzle and hose on the left hand side of what looks like a large petrol pump deliver compressed hydrogen gas at a high pressure to the car. The hydrogen is produced on site from water and (preferably sustainable) electricity

The photo below, shows the receptacle for the hydrogen tank on a hydrogen car which is very similar to a petrol car. Refuelling will be familiar to anyone who has filled a diesel or petrol car.

Filler cover closed.

Filler cover open

Cap over receptacle removed

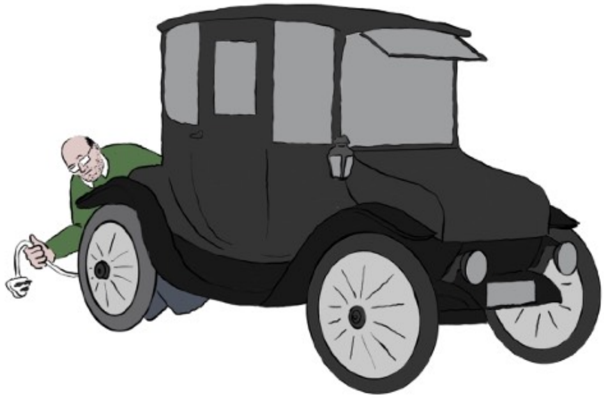
So why are there over 300,000 battery electric cars in the UK since they started to become popular in 2009 and only 160 hydrogen cars even though billions of euros have been spent on developing hydrogen cars over the last 20 years?

The answers are as follows:

1) Lack of refuelling infrastructure - actually there are a number of Shell garages with such infrastructure at strategic locations in the UK and the number is increasing.
2) Cost - the cost is similar to a Tesla Model S but the two main manufacturers - Toyota and Hyundai tend to lease their cars, partly to ensure that safety critical maintenance is carried out.
3) Perceived safety issues - there is a great video on Youtube (see “Getting Further Information” chapter) where a hydrogen car and a petrol car are both set alight and left to burn out. There is nothing but the burnt metal body left of the petrol car but the hydrogen car looks in showroom condition. Hydrogen is lighter than air and the flames flow into the sky away from the car.
4) Efficiency - a fuel cell is only 50% efficient and there is further loss in producing hydrogen. However if the hydrogen is produced locally from sustainable sources, this is less of an issue.
5) Public enthusiasm - battery electric cars have attracted a large number of enthusiasts. Hydrogen cars have not.
6) Battery cars can be charged at home at a fraction of the cost of the equivalent hydrogen or petrol (the cost of hydrogen is similar to petrol at service stations)

There is a potential future for hydrogen cars as well as battery electric cars, especially where refuelling a large number of cars is needed such as motorway services.

Whereas a battery electric car can be built with a 300 mile range, seating 5 or more adults and with a good performance, the resources, volume and weight needed for battery trucks, battery trains and battery marine applications together with limited need for infrastructure makes hydrogen alternatives much more attractive even with the lower efficiency. I am currently working with Porterbrook and the University of Birmingham on the UK’s first hydrogen train.



15 HISTORY

Most people will be astonished to read that electric cars were invented before petrol cars and well before diesel cars. First prototypes of electric cars appeared in the 1830s. The invention of the lead acid battery in 1859 with further improvements to battery technology enabled more practical examples. An early UK electric car was built, in 1880, by inventor Magnus Volk and is illustrated below.

Magnus Volk in his electric dog cart

Magnus Volk is pictured outside his railway offices. He was the inventor of the first electric railway in the world. It actually ran on tracks near the sea at Brighton. His electric railway is still in use today and runs along the sea front. Recently, another of his inventions has been restored - a gold globe on the clock tower in the centre of Brighton which rises and falls every hour. (see “Getting Further Information” chapter).

The first golden age for electric cars was between the 1890s and the early 1910s. The world land speed was held by electric cars until 1902 when the 65.8 mile an hour record was broken by a steam car. Electric taxis were on the streets of London during this time. Electric cars were popular as they were more attractive than petrol or steam cars. They were easy and quick to start, clean, and easy to drive. The main problem was range although they proved popular for city use.

Electric cars declined by the 1920s when petrol cars became cheaper through mass production. At the same time petrol cars began to be fitted with electric starter motors, overcoming another obstacle in their use. Development of good roads allowed more comfortable long distance travelling and increased the need for more range than electric cars could offer at that time.

Electric vehicles continued in niche areas, the ubiquitous milk float being a good example. Milk was delivered early in the morning and the frequent stop-start and necessity to be quiet to avoid waking customers combined with a requirement for only a short range made the technology highly suitable. Large numbers of lead acid batteries were used.

Interest in electric cars was revived in the early 1970s due to the energy crisis. The 1972 Leyland Compton prototype shown below was typical of the period.

1972 Leyland Compton prototype

These were heavy and impractical, relying on lead acid batteries. The Leyland Compton used Mini parts but despite being small, it was one third heavier than a Mini. It had a top speed of 33 mph and a range of only 40 miles. Mass production of these types of cars never happened.

Under pressure from the state of California in the USA, a number of electric cars were produced by mainstream car manufacturers, such as Ford, General Motors and Honda in the 1990s. The cars were typically leased and were highly popular with the people leasing them but the manufacturers appeared to have another agenda exemplified in the documentary film “Who killed the Electric Car?”(see “Getting Further information chapter”). GM, much to the disgust of a number of people leasing their EV1 cars repossessed the cars at the end of the lease period, refusing to sell them and subsequently destroying most of them.

The real breakthrough for electric cars came through the development of the lithium ion battery. In the early 2000s, a number of short range but normal speed electric cars were developed culminating in the launch of the Mitsubishi I-MiEV in

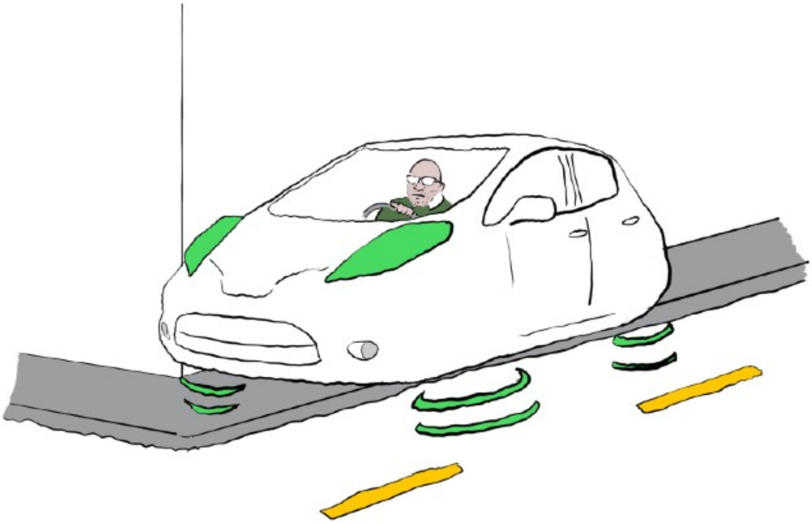
2009, an electric car owned by the author and, a year later, the Nissan Leaf, also owned by the author.

Perhaps the most remarkable car of the time was the Tesla Roadster which was first sold in 2008. This had an amazing range and performance compared to all other electric cars. The sales of the Roadster funded the Tesla Model S which again was a game changer as it is a large 5 seater capable of being driven hundreds of miles at 70mph. This was launched in 2012. It is the author's favourite car!

Hybrid cars have a long history too. Dr. Ferdinand Porsche built the first car to combine an internal combustion engine with electric motors, albeit without a battery. There was some interest in hybrid vehicles after this time.

The photo below shows the 1927 Lanchester hybrid which did include a battery. However by the 1930s all interest in hybrids had disappeared until Toyota introduced their Prius in 2000 so we are now celebrating two decades of modern hybrid cars.

1927 Lanchester hybrid



16 FUTURE TRENDS

The general trend with batteries and charging infrastructure is for range to increase, cost of batteries to fall and charging time to decrease. All of these factors are likely to accelerate the switch to electric cars because perceived barriers to use are broken down.

Other technologies, such as super capacitors are being developed with even shorter charging times, however at present the problem is cost and weight. (See “Getting Further Information” chapter)

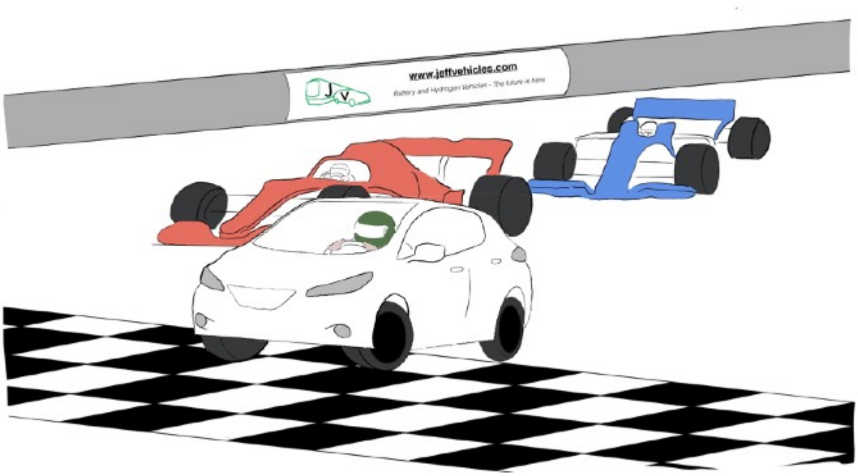
There is an interesting trend in the UK, particularly in cities for a smaller number of young people to learn to drive. There are several reasons for this - improved public transport, lower cost of taxis and higher cost of car ownership, especially insurance; also a greater concern for the environment.

A typical car, whether electric or not, is used for a small proportion of a day and therefore it is not cost efficient. Improving automation leading towards fully autonomous driving is likely to result in less of a need for full ownership and more car sharing. In London, recent technology has made it relatively easy to rent a car without the need to book in advance and without the need for the user to deal with human sales staff. Typically the car can be collected from one place, used and then left at a different location. (See "Getting Further Information" chapter)

A potential use for electric cars when they are not being driven is to stabilise electricity supplies. Solar cells which are increasingly being installed on household roofs generate during daylight hours when electricity is not at a high demand. At peak usage of electricity at night, the solar cells are not able to provide a supply. One answer is to use the battery in an electric car as a store. The solar cells can charge the battery during the day and at peak times, electricity can be extracted from the battery. (Discussed in "Buying or Leasing a New Car" chapter.) This does require a modification to the electric car but such systems are now available. This will help to resolve a problem of capacity of the electricity supply as more and more people switch to electric cars from petrol or diesel cars. (See "Getting Further Information" chapter)

Fully autonomous vehicles will obviate the need to drive at all, resulting in a true transport revolution. There are a few examples under development which demonstrate this potential technology. (See "Getting Further Information" chapter)

Whether the science fiction of hover cars will ever become reality, there is now considerable effort being put into the development of flying cars, often designed around scaled up drones. (See "Getting Further Information" chapter)



17 SPRINTS HILLCLIMBS SPEED TRIALS AND DRAG RACING

This may seem to be a strange chapter but drag racing is popular with more powerful electric cars and I have successfully participated in amateur motor sport in the form of sprints, hillclimbs and speed trials. I am keen to have more competition. Unfortunately, no sprints, hillclimbs or speed trials took place in the UK since the end of the 2017 season due to the difficulty event organisers found in meeting the MotorSport UK's new safety requirements for events which include electric cars. In the 2021 season one hill climb at Shelsley Walsh took place and it is hoped that this marks the return of competition using electric cars.

The aim of a sprint, hillclimb, or speed trial is to complete the course from a standing start in the shortest time possible. Each car is timed and competes without other cars nearby. The car with the shortest time in their class wins. A hillclimb, as the name suggests, is typically a road with smooth tarmac (and of course no traffic) up a hill with bends to make the racing more exciting. A sprint takes place at a motor race course, such as Silverstone or Brands Hatch and typically consists of a lap of the course, or, occasionally two laps. A speed trial is a straight course typically 1/4 mile long. Drag racing is similar but with two cars running in parallel.

The advantage of sprints, hillclimbs and speed trials over more conventional motor racing is that you are not on track with other cars which could hit yours, you can use a conventional road car and the courses are short so the car is not unduly stressed.

You need safety equipment - a fireproof suit, a racing helmet and gloves and it is advisable to use fireproof shoes too. Very little is needed on the car; in essence, a timing strut to break a light beam at the start and finish, some numbers on the side of the car and tow hooks on back and front. You need to obtain a passport for your car from Motor Sport UK. Also an electricity symbol is needed to indicate that it is not a conventional petrol/diesel car. (See “Getting Further Information” chapter).

Electric cars are well suited for these types of events. Initial acceleration is typically better than petrol car equivalents and the battery is low and heavy resulting in a low centre of gravity which is good for road handling.

At the beginning of an event you have to register, producing your race licence. This is then followed by scrutineering where officials working for the event will check the safety of your car. The event starts with all cars completing two practice runs, one at a time; this is followed by two timed runs and an awards ceremony. It’s an early start to the day but a finish which is around early evening. There is a lot of waiting between runs as it is not unusual to have around 100 cars competing. It is an excellent way of learning the full capabilities of your car.

Preparing to be scrutineered

Competing in a Mitsubishi I-MiEV

18 GETTING FURTHER INFORMATION

3 Economics

https://www.gov.uk/plug-in-car-van-grants

This website contains details of grants available for the purchase of a new electric or hybrid vehicle.

https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles

This website contains details on how to apply for a grant for a home charger including eligible vehicles. It also provides a list of approved installers.

https://tfl.gov.uk/modes/driving/congestion-charge

This website shows how to get a discount for a battery electric car on the London congestion charge.

4 Are You Saving the Planet?

https://www.withouthotair.com

This website gives access to the late Professor Sir David MacKay's free book "Sustainable Energy - without the hot air" which explains the carbon dioxide emissions for different forms of transport.

https://greet.es.anl.gov

This website contains a detailed mathematical model produced by the US department of energy to calculate the energy used in car manufacturing - conventional petrol/diesel and battery electric.

http://electricityinfo.org/real-time-british-electricity-supply/

This website shows the current source of electricity generation in Britain so you can see how much is from renewable sources.

http://2050-calculator-tool.decc.gov.uk/#/home

This website gives access to a tool whereby you can see the effects for Britain of changing electricity supply from coal to renewable energy, changing demand for transportation and the effect of changing over to a zero carbon transport system. It was developed at the Department for Energy and Climate Change (DECC) by Professor Sir David Mackay's team when he was chief scientific adviser to the government at DECC.

https://www.bp.com/en/global/corporate/energy-economics.html

This website includes a report which contains a breakdown of electricity sources by country.

http://www.greencarcongress.com/2012/06/harrison-20120611.html

This website describes the continuing health problem with cars due to tyre wear and brake dust, even when exhaust emissions are eliminated

https://www.electrive.com/2020/11/22/project-recovas-to-commercialise-battery-reuse-in-uk/

This website describes battery recycling processes for car batteries.

http://nissaninsider.co.uk/powering-ahead-with-second-life-battery-system/

This website explains how used electric car batteries can be used for a second life after they are no longer of use in an electric car.

7 Buying or Leasing a New Car

https://www.autovolt-magazine.com

This website shows how you can subscribe to Autovolt magazine. Autovolt magazine reviews new battery electric and hybrid cars as well as providing useful features on these cars and their development.

https://www.gov.uk/plug-in-car-van-grants

This website contains details of grants available for the purchase of a new electric or hybrid vehicle.

8 Buying a Used Car

https://www.tesla.com/en_GB/preowned

This website shows used Teslas for sale from the Tesla company.

https://usedcars.nissan.co.uk/en/nissan/leaf

This website shows used Nissan Leafs for sale from the Nissan company

http://eco-cars.net

This website specialises in selling used electric cars. It is one of the most established around.

http://www.autotrader.co.uk/used-cars/nissan/leaf

This website advertises used cars from dealers and private individuals.

https://greenmotion.co.uk/fleet

This website allows you to hire Nissan Leaf electric cars

https://www.evrent.co.uk

This website allows you to hire a Tesla model S, a model 3 or a model X and other makes of electric cars

https://www.mynissanleaf.com

This is a forum about Nissan Leafs.

https://forums.tesla.com

This is a forum about Teslas.

http://www.mybmwi3.com

This is a forum about BMW i3s.

9 Charging at Home

https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles

This website contains details on how to apply for a grant for a home charger including eligible vehicles. It also provides a list of approved installers.

https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles

This website contains details of how to apply for a grant for workplace chargers including eligibility and provides a list of approved installers.

https://www.ubitricity.com/en/

This website has details of street light chargers.

10 Travelling Long Distances

https://www.zap-map.com/live/

This website allows you to find and check the status of public chargers. You can get a phone app too.

https://www.plugshare.com

This website allows you to find and check the status of public chargers. You can get a phone app too.

http://www.chargeyourcar.org.uk

This website allows you to register for a charge card for CYC chargers, which are available extensively in Scotland and many places in England. There is also a phone app which you can register for too.

https://www.ecotricity.co.uk/for-the-road

This website allows you to register a phone app for Ecotricity chargers, which are available extensively at English and Welsh motorway services and increasingly in Scotland too.

https://pod-point.com/open-charge

This website allows you to register a phone app for Podpoint chargers, which are available in the UK, particularly in towns and cities. Many of these are slower chargers but useful all the same.

11 Driving Abroad

https://my.newmotion.com

This website allows you to register for a New Motion card or app enabling you to use charging points in the UK - England, Wales, Scotland, Northern Ireland as well as: France, Germany, Belgium, Netherlands, Switzerland, Austria, Italy, Croatia, Czechia, Slovakia, Sweden, Norway, Albania, Macedonia, Romania and Russia. Please check carefully before you go that you have sufficient charge points on your route - Some countries only have a few charge points

https://www.esb.ie/our-businesses/ecars/charge-point-map

This website allows you to download a phone app to gain access to charge points in Ireland

https://www.ibil.es/

This website enables you to apply for a card giving access to Spanish charge points. (note the comments in the chapter “Driving Abroad” re. completing the form).

https://www.amazon.co.uk or https://www.ebay.co.uk

Either of these two websites should enable you to buy a suitable adaptor to convert a European style domestic socket to a UK style plug. Search for “European plug to UK socket 13 amps”. Ensure it has a European plug at one end, a cable, one or more UK sockets and most importantly, it is definitely rated at 13 amps.

https://www.theaa.com/european-breakdown-cover/driving-in-europe/what-do-i-need

This website gives information on what you need when driving in mainland Europe, over and above what is required in the UK.

13 Hydrogen Cars

https://www.youtube.com/watch?v=lknzEAs34r0&t=1s

This video shows two cars being set alight - one a hydrogen car and the other a petrol car.

14 History

https://brightonmuseums.org.uk/brighton/

This website gives further information on the Brighton Museum and Art Gallery which has all manner of objects and information associated with Brighton, not least photographs of Magnus Volk and his inventions.

http://www.whokilledtheelectriccar.com

This website gives details of the documentary produced by Chris Paine. The DVD is available from **www.amazon.co.uk** or iTunes.

15 Future Trends

https://www.fleeteurope.com/en/mobility/europe/features/battery-breakthrough-could-boost-ev-range-and-slash-charge-time

This website has a short article on the possible future of supercapacitors.

https://www2.zipcar.com

This website describes a means of hiring a car in London simply by tapping a card on a reader on the windscreen of the hire car.

https://www.forbes.com/sites/constancedouris/2017/12/18/electric-vehicle-to-grid-services-can-feed-stabilize-power-supply/#c519a9863df1

This website has an article on vehicle to grid technology whereby electric cars are used to stabilise an electricity network.

https://www.techemergence.com/self-driving-car-timeline-themselves-top-11-automakers/

This website describes the progression of autonomous cars from the perspective of car manufacturers.

https://www.techradar.com/news/flying-car-watch-as-this-drone-flies-around-with-passengers-inside

This website includes a video of a drone based flying car.

16 Sprints, Hillclimbs, Speed Trials and Drag racing

https://www.motorsportuk.org

This website gives information on Motorsport UK which is the governing body for amateur motor sports in the UK. It is where to apply for a race licence and passport. It also has information about safety equipment needed.

ABOUT THE AUTHOR AND ILLUSTRATOR

Jeff Allan

Dr. Jeff Allan is an award winning chartered engineer who runs Jeff Vehicles Ltd., promoting electric and hydrogen solutions for road and rail vehicles. (**www.jeffvehicles.com**). He competes in amateur motorsport - speed trials, sprints and hillclimbs in electric cars. He has won the Brighton national speed trials, electric car class twice. He jointly holds two Guinness World records with his son for shortest charging time of an electric car from John o'Groats to Land's End and shortest charging time for an electric car across Europe (Nordkapp, Norway to Tarifa, Spain). He is on his fourth electric car, having started using one in 2010.

He was born in New York and lives in Birmingham. His Ph.D., completed in 1981 was concerned with regenerative braking and he has 40 years of experience working on electric railways. He is a consultant on innovation in railways. He helped design the first hydrogen powered train in the U.K. He has had a lifelong interest in cars. He built one when he was 17 years old.

Maddie Cottam-Allan

Maddie Cottam-Allan is the artist who is the mastermind behind the satirical comic 'Terrible Sex Partners'' which can be found at www.vice.com. She also works as a photographer while regularly posting her comics and illustrations to her Instagram @**maddiecottamallancomics**. She studied at the Birmingham School of Art.