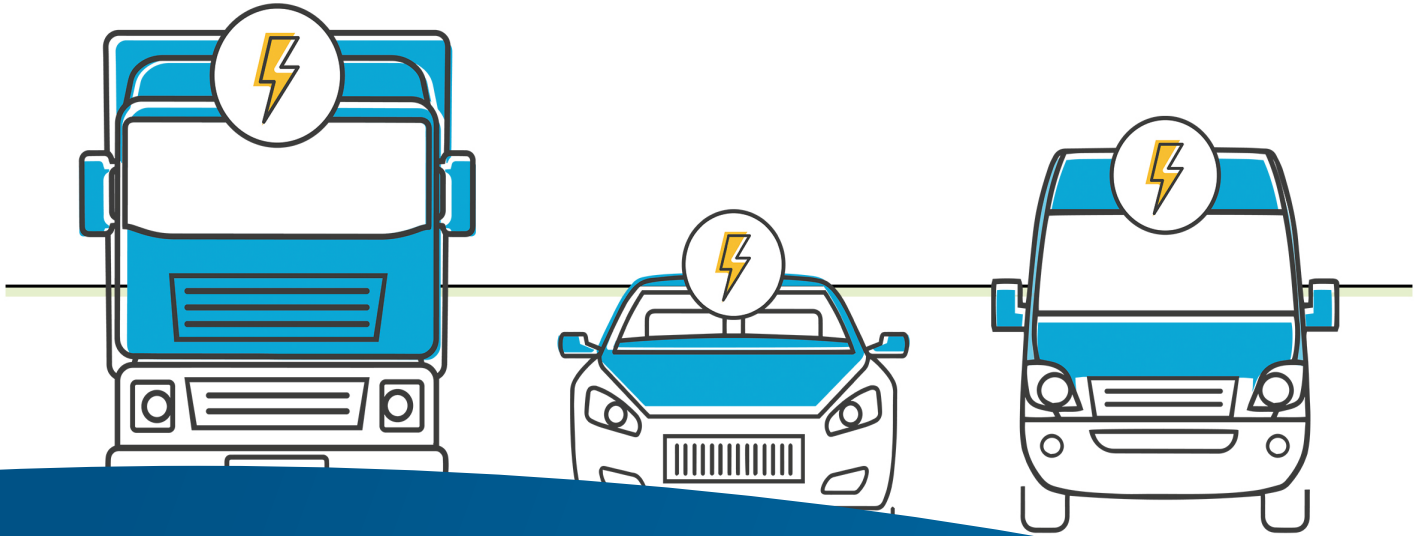




Lowering your emissions
through innovation in transport
and energy infrastructure



An Introduction to Battery Electric Vehicles

Cenex Insight - May 2021



Battery Electric Vehicles

The first electric passenger vehicle was invented around 200 years ago, predating the combustion engine, with mass produced electric cars manufactured in the late-1800s, however it was quickly superseded by petrol power by the 1930s.

Today more and more vehicle manufacturers are launching new electric models in line with targets to end the sales of new petrol and diesel vehicles, with more than 130 electric vehicles available in the UK.

An electric vehicle (EV) is powered by electricity, via an electrically charged battery pack that powers the motor to turn the wheels, unlike petrol or diesel-powered vehicles, which run off a traditional internal combustion engine (ICE).

Electric vehicles are recharged using a dedicated charging unit, where the car's charge port is connected to a source of electricity and the vehicle receives and stores that electrical energy in the battery.

A Battery Electric Vehicle (BEV) runs purely on electric power, stored in an on-board battery that is charged from mains electricity (typically at a dedicated chargepoint).

Battery electric vehicles do not have tailpipes (exhausts), and therefore produce no tailpipe emissions. They are more environmentally friendly than ICE powered vehicles and are often chosen by eco-conscious drivers.

While the vehicle may be zero emission when driving, it is important to note that there are emissions involved along the whole life of a vehicle: from the extraction of raw materials, manufacturing, vehicle use, to recycling and disposal of the vehicle.

While EVs are cheaper to run than a petrol or diesel vehicle, their up-front cost is approximately 25% higher than the equivalent ICE vehicle, but they are expected to achieve cost parity with ICE vehicles by 2025.



A Nissan Leaf, one of the first modern battery electric vehicle models

Benefits of Electric Vehicles



There are several benefits to owning and operating an electric vehicle, from reduced environmental pollution to reduced fuel costs. The main benefits have been outlined below:

Environmental

Research shows that EVs are better for the environment, emitting fewer greenhouse gases and air pollutants over their life than a petrol or diesel car. This is true even after we consider the production of the vehicle (including battery pack) and the generation of the electricity to fuel them.

Cost

EVs are also cheaper to run when compared to petrol or diesel. Typically, an electric car costs less than £3 to drive 100 miles, while the average petrol equivalent, to drive the same miles, would cost around £10.

With fewer moving parts, EVs need less maintenance and servicing is much simpler. This means that you

could save on the cost of service and maintenance.

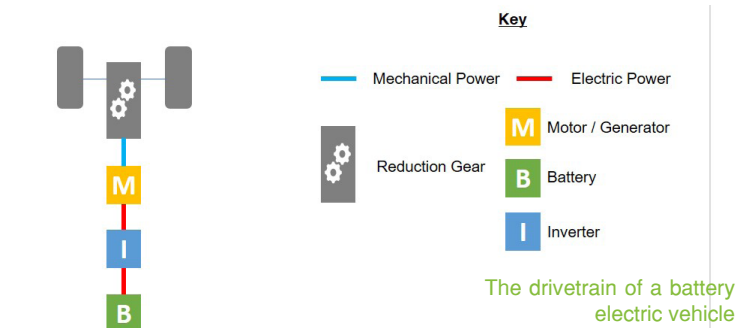
Driving experience

Instant torque from the electric motor gives high and responsive acceleration and regenerative braking feeds energy back into the battery adding to the overall vehicle efficiency.

Also, the weight and distribution of the batteries and low centre of gravity benefits handling, comfort, and safety. When driving an electric car, you are less likely to be seriously injured.

EVs are also significantly quieter than conventionally powered vehicles, only producing loud noises when they travel at moderate to high speeds, due to wind or tyre resistance. Some EV models also produce artificial sounds when travelling at very low speeds (when they are the quietest) for the safety of pedestrians.

Drivetrain



One of the advantages of a BEV is the reduced number of moving parts, and therefore fewer components that can wear out. The core components of a battery electric vehicle are:

Battery

This is where the energy is stored. There are a range of battery chemistries, but most current EVs utilise lithium ion or lithium polymer batteries due to the high energy density that can be achieved

Inverter

An inverter is used to convert the direct current (DC)

electricity in the battery to alternate current (AC) required for the motor.

Motor

While energy can flow electrically between the battery and inverter, it needs to be converted into mechanical power in order to turn the wheels. This is the role of the motor.

Reduction gear

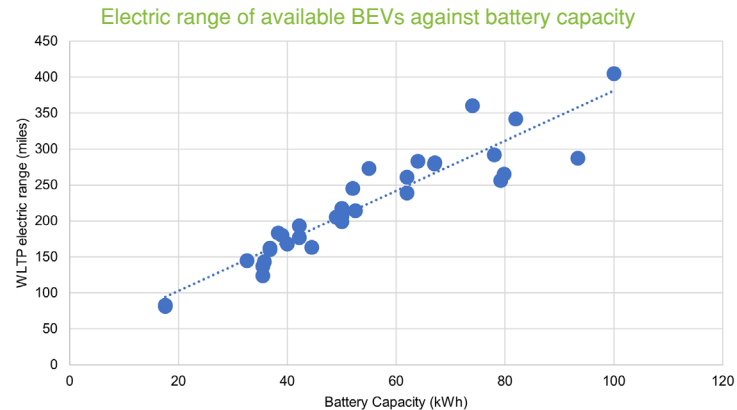
While electric vehicles tend to have a single gear and therefore do not have a transmission/gearbox, a reduction gear is still required between the motor and the axle/wheels. Electric vehicles are able to avoid having multiple gears because electric motors revolve (rev) to a significantly higher rate than internal-combustion engines, meaning that you can achieve the same acceleration without the need for changing gears. From a manufacturing perspective, having a single gear provides two key benefits: simplicity and lower cost. Utilising a system with multiple gears immediately adds cost and complexity.

Driving Range



The first generation of BEVs had a range between charges of around 80 miles but improvements in battery energy storage capacities now allow for much longer ranges from more compact battery packs.

Now, larger passenger cars are able to accommodate larger battery packs to deliver ranges of over 250 miles. This is shown in the chart below, which shows the average range of a BEV is around 180 miles.



Each dot on the chart is a BEV model currently available in the UK. To put this in context, the average individual journey length in the UK is around 8.6 miles and in total around 25 miles a day.

The actual range of an EV will depend on how you drive and the conditions in which you drive. The electric range with an aggressive driving style, lots of acceleration and braking, will be shorter than with a smooth driving style.

Weather conditions also have an important impact on range as batteries tend to be less efficient in cold temperatures. This means that an EV with a smaller battery capacity may meet the needs of the driver in the summer, but struggle with longer journeys in the winter months.

Parking and Charging



The parking location and length of time parked are key factors in determining when charging will be possible and different locations can suit different types of charging (speed and power of charging).

Where regular access to charging is possible, shorter range EVs can be used. As batteries are a major contributor to the cost of EVs, there will be cost savings for a shorter range EV. The plug-in time needs to be sufficient to ensure the EV can refill the battery with the electric energy needed for the next day of operation. Otherwise, regular top-ups may be needed.

It is important to note that the charging speed of an electric vehicle will be limited by the type and power of the charger fitted in the vehicle.

Many early EV's came with AC charging systems only, limiting charging speeds. So, even if you were able to plug into a higher power charger, the speed at which the charge was delivered would be

limited by the vehicle. Higher charging rates are typically delivered using DC charging systems and it is becoming common for newer EV's to have DC charging ports as well as the standard AC port.

There are two main DC connector types, so drivers will need to ensure that their vehicle is compatible with the charging system. Thankfully, standardisation is gradually removing many of these challenges from the vehicle side, so EVs released from 2021 onwards will largely avoid these issues.



Commercial Electric Vehicles



Businesses running larger vehicles like vans and trucks will need to assess their business operation in detail before deciding on switching to electric.

Most electric vans have shorter ranges than electric cars, with most on the market delivering up to 200 miles range between charges. Van purchases are business led, therefore are more sensitive to the vehicle capital cost and payload impact of large battery packs. The range of the van will be affected by factors such as the weight of load carried which can have a negative impact on the range of an electric vehicle; you will need more power to accelerate, also reducing the vehicle range.

In many urban delivery applications, the daily mileage of a van is within this range, and volume rather than weight is the critical metric, however this is not always true and vehicles working in more rural locations or carrying out inter-city deliveries are likely to find the limited range of an electric van more challenging.

Vans

While the initial cost of an electric van is higher than an equivalent diesel version, there are major savings to be made in running costs. As a result, most electric van makers are keen to concentrate on the total cost of ownership (TCO) to help focus on the benefits of electrification.

The target of most electric vans is the so-called ‘last-mile’ delivery sector where daily ranges are relatively low.

Last-mile deliveries have seen an explosion in recent years as people increasingly switch to internet-based shopping, meaning that businesses need a courier to deliver orders. An electric van is generally a good fit for this kind of job because it often entails multiple stops on short, urban routes, sometimes with the van entering low or zero-emissions zones that may involve charges for petrol/diesel vehicles (such as the congestion charge in London). These charges can be avoided by driving an electric vehicle.

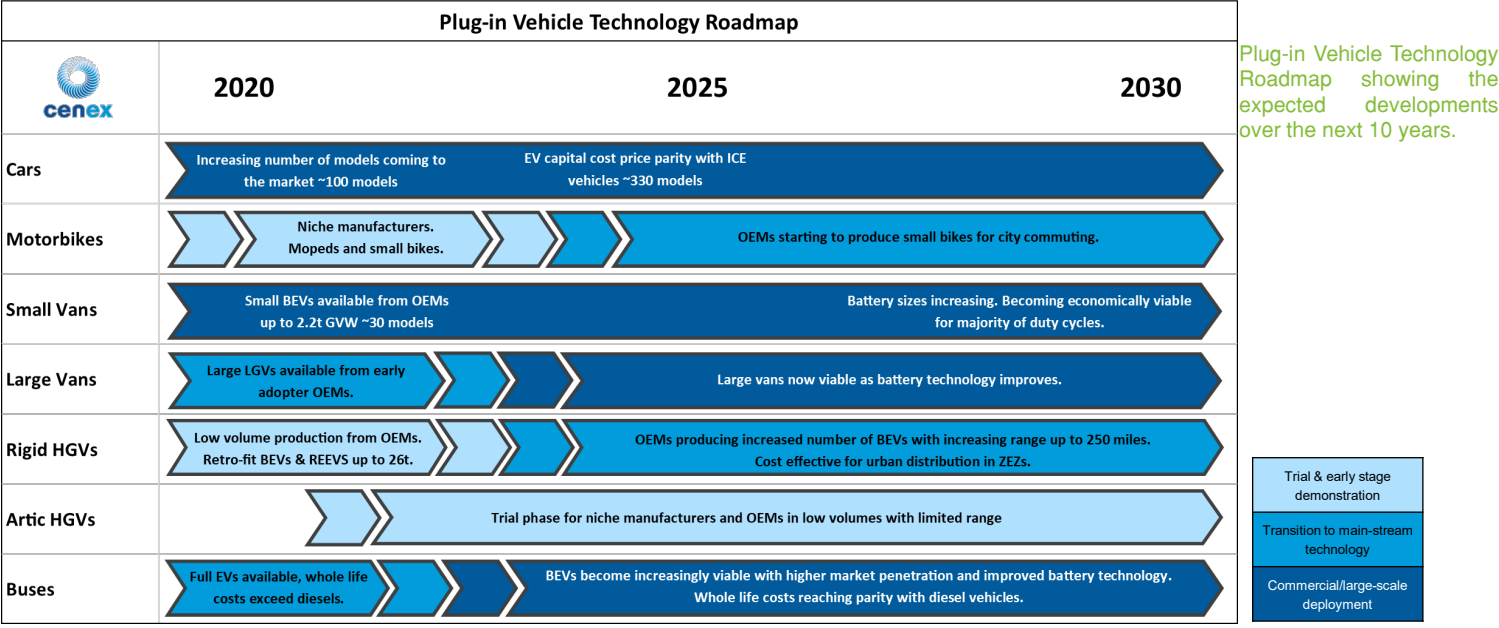
Commercial Electric Vehicles



Trucks/Heavy Goods Vehicles

It is still expected to take a number of years before electric trucks and HGVs are fully viable as cost and charging infrastructure remain big challenges at this scale.

Diesel vehicles are still seen by many as the most cost efficient. However, as battery costs are coming down and diesel prices increasing, we are close to a point where electric trucks offer an efficient business model for many applications.



Hybrid Electric Vehicles



Hybrid vehicles use a combination of a battery and internal combustion engine (either diesel or petrol) to reduce the overall emissions of the vehicle and, in the case of plug-in versions, enable some degree of zero emission driving.

However, the environmental impact of hybrids can be significantly undermined if used incorrectly. If vehicles are left with batteries uncharged then this can result in higher emissions than the equivalent ICE as the vehicle must carry the extra weight from the battery and electric motor.

Plug-in hybrid EV (PHEV)

A vehicle with an ICE and a small rechargeable battery, allowing for either pure electric-powered driving for about 30 miles, after which the combustion engine will take over. They tend to have a combined fuel efficiency of 100 – 200 miles per gallon (mpg) and produce tailpipe carbon emissions of around 30 g/km, pushing these into the UK category of 'Ultra-Low Emission Vehicles'.

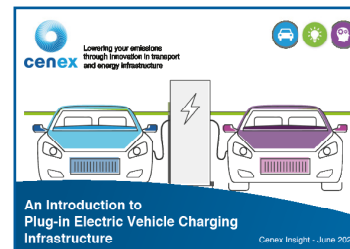
Range-extended EV (REEV)

A vehicle that has an electric drivetrain, with a small petrol generator to charge the battery when range is depleted for longer trips. The drivetrain of a REEV means that it will always use the electric motor, only using the ICE to top up the charge on the battery for longer journeys. Most REEVs are able to operate in electric only mode for 50 – 100 miles for a combined fuel efficiency of 200 – 500 mpg and produce tailpipe carbon emissions of around 15 g/km, meaning they are also classified as 'Ultra-Low Emission Vehicles' in the UK.

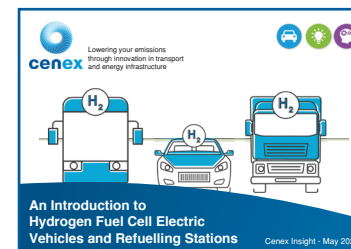
'Self-charging' Hybrid

A vehicle powered by an ICE as well as an electric motor, powered by a small battery. The battery cannot be charged from a plug, but is charged through regenerative braking and by the ICE to increase the efficiency of a vehicle. Standard hybrid vehicles tend to have a fuel economy of around 90 mpg and produce tailpipe carbon emissions of around 90 g/km.

Further Reading



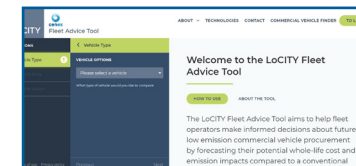
An Introduction to Plug-in Electric Vehicle Charging Infrastructure
<https://www.cenex.co.uk/resources/an-introduction-to-plug-in-ev-charging-infrastructure/>



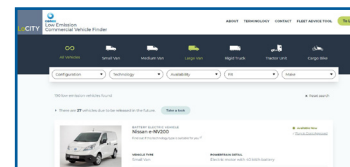
An Introduction to Hydrogen Fuel Cell Electric Vehicles and Refuelling Stations
<https://www.cenex.co.uk/resources/an-introduction-to-hydrogen-vehicles/>



Introduction to Low Emission Road Transport - Future Learn Course
<https://www.futurelearn.com/courses/introduction-to-low-emission-road-transport>



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