LowCVP
Low Carbon Vehicle Partnership

The Journey of the Green Bus

A revolution in the introduction of greener, cleaner buses in the UK is helping deliver on climate and air quality objectives

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Maintaining our ability to move around in ever more congested towns and cities is more critical today than ever before. While a wide range of transport options now exist, there's no doubt that an effective bus operation can deliver one of the best solutions to the challenges of air quality, climate change, congestion, convenience and, of course, cost. Bus travel has evolved with the development of the green buses of today. *The Journey of the Green Bus* explains how the last 20 years have transformed the emissions, efficiency and experience of buses. It will, hopefully, help to dispel some of the outdated perceptions of this essential travel option.

With road transport responsible for around a quarter of the UK's greenhouse gas emissions and up to 60% of roadside NOx pollution in many cities around the UK, the introduction of cleaner, low emission buses is a vital component of a low emission transport future.

DID YOU KNOW...

The emissions tests for UK buses are the only tests in the world that measure the full well-to-wheel greenhouse gas impacts, taking both the fuel and vehicle emissions into account.

Where it all started

For 20 years the UK bus industry has been driving innovation in the quest for lower emissions and greater efficiency. The last decade, in particular, has witnessed a revolution in the UK bus market and, today, approaching 3,500 buses certified to the LCEB (Low Carbon Emission Bus) standard are now in operation on UK roads.

It all began around 1996 when London Transport Buses was desperate to help reduce the pollution along a major street in central London where there were high levels of particulates from the exhaust pipes of vehicles, including the old Routemaster buses.

But traditional catalysts (developed for trucks) just wouldn't work in the congested stop–start conditions of London's streets. The route to a solution was via the first 'real world' emissions test cycle for buses.

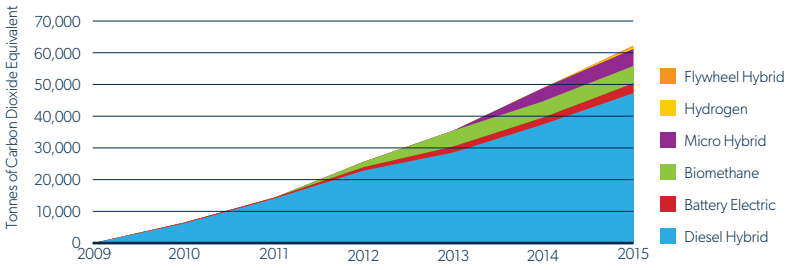
Developed by recording Route 159 running right through the centre of London, the Millbrook London Transport Bus (MLTB) cycle became the standard for every bus manufacturer selling vehicles in the UK and has formed the backbone of all government support to bring even greener buses into operation. The particulates from those early buses were reduced by over 75% through developing catalysts specifically to work on a bus cycle – real world testing had begun!

DID YOU KNOW...

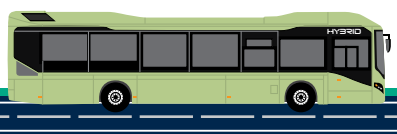
A Low Carbon Emission Bus produces 30% less well-to-wheel greenhouse gas (GHG) emissions than a normal Euro III diesel bus.

*Reduction in CO_2 emissions from Low Carbon Emission Bus technologies**

Tonnes of CO_2e saved (estimated)



** Compared with their standard diesel equivalents*



1996
Real world bus cycle developed on Route 159

1998
Oxidation catalysts fitted to Routemaster buses – 90% reduction in PM

The carbon challenge

Buses lead the journey of greenhouse gas reduction.

With the introduction of the Climate Change Act in 2008, the UK became one of the leading nations taking international action on climate change. In Europe the car industry had recently introduced mandatory legislation for CO_2 emissions with challenging targets for future years, but the structure of the heavy duty vehicle market (buses and trucks) left policy makers challenged over how to measure – and manage – carbon emissions. A challenge that is still being tackled to this day.

For the UK bus operators the picture has become clearer. After 10 years of testing a wide range of vehicles, a picture of the carbon impact of buses had emerged and testing and assessment processes were fully established.

Buses are playing a vital role in decarbonising road transport by significantly reducing their own emissions and through modal shift, replacing car journeys.

In fact, so advanced was the UK bus market on this critical path, that it leapfrogged EU legislation, introducing a comprehensive assessment which covered the whole well-to-wheel carbon impact of the buses in test. Every impact on climate change was considered; the real effects of methane and nitrous oxide were incorporated into the definition. For the green bus there was no hiding place where exhaust emissions could lurk unchallenged or 'fall outside the measurement'.

IN FACTS

60% of the buses sold in the UK are built by the three UK manufacturers: Alexander Dennis; Optare; and Wrightbus.

At the landmark Paris Climate Conference (COP21) nearly 200 governments – including all the world's leading countries – agreed a deal to cap global warming at 'well below' two degrees above pre-industrial levels, with an aspiration to achieve a lower, long-term 1.5 degree target. Tackling climate change is now truly an international endeavour.

IN FACTS

The UK Climate Change Act, 2008: the world's first long-term, legally binding framework to tackle climate change.

By 2050, greenhouse gases are required to be cut by 80% compared with 1990 levels.

BACKGROUND

What is an LCEB

In 2008, the LowCVP devised a definition of a Low Carbon Emission Bus as one producing 30% less well-to-wheel greenhouse gases (GHGs) emissions than a normal Euro III diesel bus.

The greenhouse gas emissions covered were methane, carbon dioxide and nitrous oxide. This served as a performance target for different low carbon bus technologies and fuels and as the bar for qualification for the Government's fiscal incentives.

Recognising the need to balance air quality and climate change objectives, the definition of a LCEB has now been superseded by new Low Emission Bus (LEB) criteria (see page 11).

1999
First CNG powered buses in UK fleet

2002
LowCVP formed. Target of 600 low carbon buses p.a. by 2012

Tackling air quality

Road transport is the main source of many air pollutants which impact local air quality in the UK. Pollutants of current concern include nitrogen oxides (NOx) and particulates ($PM_{10}/_{2.5}$).

Air pollution has a negative effect on public health, both short and long-term. Fine particulate matter and nitrogen dioxide have been identified as having particularly detrimental impacts to people, adding to the risk of heart and lung disease and lowering life expectancy. Exposure to small particulate matter ($PM_{2.5}$) was implicated in 29,000 early deaths around the UK according to research by the Committee on the Medical Effects of Air Pollutants (COMEAP) in 2010[1].

Air quality regulations have been set in Europe for various air pollutants to protect human health. Though much has been achieved to date, 38 of the 43 UK air quality zones still exceed targets for air pollution with at least five zones facing a major challenge in meeting them by the legal deadlines.

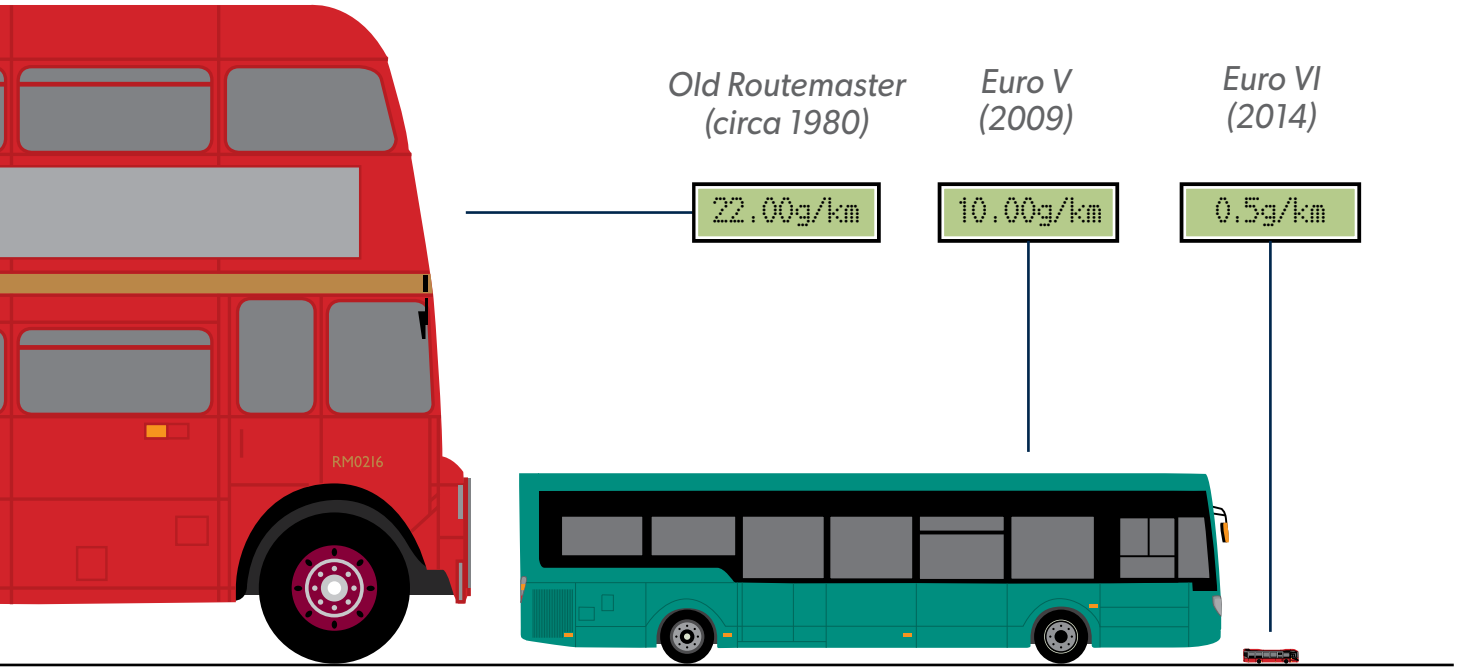
DID YOU KNOW...

Road transport contributes around 60% of NOx emissions at the roadside where air quality is poor.

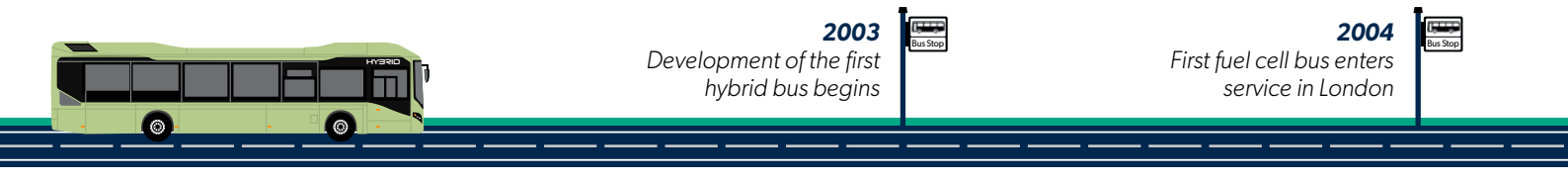
Automotive manufacturers are required to comply with European legislation to control air pollution from new vehicles, commonly referred to as European Emission Standards. The latest – Euro VI – standard for buses was introduced in 2014. It encourages the use of advanced new technologies such as selective catalytic reduction (SCR) and diesel particulate filters (DPFs) which are already delivering real benefits in fuel efficiency and emissions for fleets across the UK. The latest Euro VI buses deliver a 95% reduction in NOx compared with Euro V.

1. Defra 2010 via COMEAP.

A Euro VI bus emits 95% less NOx than a Euro V ... and a fraction of that of an old Routemaster



Source: SMMT: www.smmt.co.uk/2015/02/support-low-emission-diesel-cv-uptake-clean-britains-air-smmt-urges-policy-makers/



2003
Development of the first hybrid bus begins

2004
First fuel cell bus enters service in London

HYBRIDS

A hybrid bus combines a conventional diesel engine and an electric motor. The hybrid system enables energy to be recovered during braking and then releases it to accelerate the vehicle. This improves fuel efficiency, reducing emissions and cutting fuel costs. There are a variety of hybrid buses from 'mild' to 'full' and now 'plug-in hybrid'. The method of energy storage can also vary from a battery to a flywheel to supercapacitors.

PLUG-IN HYBRIDS

The latest innovation in hybrid bus technology, serving as a bridge to full electrification, is the plug-in hybrid (PHEV) and Range Extended Electric Vehicle (REEV). These typically operate in a similar fashion to the conventional hybrid bus but are fitted with a larger electric battery enabling longer electric-only range. They offer excellent opportunities to improve air quality and cut greehouse gas emissions. GPS devices can be fitted to ensure zero emission operation in areas of poor air quality such as Low Emission Zones, switching to hybrid operation after leaving the zone. Alexander Dennis's Virtual Electric was the first type of REEV bus to be operated in the UK, and a Volvo plug-in (PHEV) is expected to be available in the UK in 2016.

DIESEL HYBRID

Diesel hybrids were first adopted by bus operators in the UK in 2009. Today they are the most abundant low emission buses in operation with 2,307 currently being deployed. TfL pioneered the introduction of hybrid buses, primarily motivated by the aim of improving air quality in London. TfL and Transport for Greater Manchester operate the largest hybrid bus fleets in the UK. There are three major hybrid bus manufacturers based in the UK. Alexander Dennis has the lion's share of the hybrid market, followed by Wrightbus and Optare.

MICRO HYBRID

Wrightbus and ADL launched their first micro hybrid buses in 2013 and 2015. While not a 'propulsion hybrid' in the usual sense of providing alternative drive energy, this vehicle recovers energy lost from braking to power the vehicle's electric and compressed air systems. There are 782 micro hybrids in operation, with the largest number running in Glasgow.

FLYWHEEL HYBRID

Electrical flywheel hybrids are one of the recently adopted hybrid technologies, entering the low emission bus market in 2014. First exploited by Williams in Formula One motor racing, the technology was transferred to buses by GKN in partnership with Alexander Dennis. Wrightbus and Torotrak are planning the introduction of a new type of mechanical flywheel hybrid bus. There are currently 19 flywheel hybrids in deployment, with the largest fleet operating in Oxford.

DID YOU KNOW...

There are now (Jan 2016) approaching 3,500 low carbon emission buses operating across the UK covering a variety of technologies and fuels.

2007
First ethanol powered bus in UK

2009
Greener Journeys, campaign to promote modal switch to buses founded

UK policy initiatives

Over the last decade, UK government policy has focused on accelerating the introduction of clean, low carbon buses. The bus sector has been a key area of attention because of the contribution buses have made to air pollution in the most congested urban areas.

One of the key challenges faced by bus operators is the high capital cost of cleaner buses. In order to overcome this barrier, the LowCVP helped to devise two incentive mechanisms in 2009 to help kick-start the low carbon bus market – the Bus Service Operators Grant (BSOG) Low Carbon Emission Bus Incentive and the Green Bus Fund. These were adopted by the Department for Transport and embedded into national transport policy.

Following the DfT's approach, Transport Scotland introduced their own Green Bus Fund and BSOG LCEB incentive to galvanise the low carbon bus market in Scotland.

The LowCVP has also focused on identifying the low carbon technologies and fuels most suitable for buses, seeking to understand the barriers to growing the market, and devising appropriate incentive mechanisms.

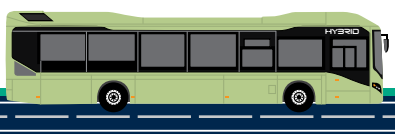
Through research in 2014 the LowCVP showed that ongoing fiscal incentives were required to encourage further uptake of low carbon buses. Support was needed for the purchase of new kinds of bus technologies and accompanying recharging/refuelling infrastructure.

BACKGROUND

London leads

London has a well-developed strategy for improving air quality by 2025, including the implementation of an ultra-low emission zone (ULEZ) by 2020, retrofitting of buses and licensing new taxis to be zero emission capable from 2018. Transport for London (TfL) has led the way in trialling and adopting low carbon and low emission bus technologies.

The Government ran four rounds of the Green Bus Fund between 2009 and 2014, allocating a total of £88.9m to support take up of low carbon buses.



2009
LCEB accreditation scheme developed by the LowCVP

2009
DfT Green Bus Fund Round 1

The Green Bus Fund provided funding to bus operators and local authorities to cover the additional capital cost of adopting low carbon buses.

BACKGROUND

The Bus Service Operator's Grant

The Bus Service Operators Grant (BSOG) is a subsidy paid to bus operators in England to support bus services, keeping fares affordable and enabling operators to run services that might not otherwise be profitable.

The amount is based on operators' annual fuel consumption achieved by the entire fleet of public service vehicles. The rates vary for different kinds of road fuels. The BSOG was reformed in 2009 to provide a level playing field for low emission buses.

The LowCVP was involved in the creation of the BSOG LCEB incentive. The incentive enables bus operators to receive an additional payment of six pence for each kilometre they operate with a Low Carbon Emission Bus.

Studies show LCEBs also cut air pollution

In 2013 the LowCVP commissioned the consultancy Ricardo to review the air quality impacts resulting from the rapid growth in uptake of Low Carbon Emission Buses (LCEBs) in the UK, a result of subsidies provided through the Government's Green Bus Funds. The report recommended that legislation needed to consider hybrid technology impacts in the test processes to maximise the benefits in terms of local emissions.*

*In a separate study**, the most robust data available (supplied by Transport for London's bus fleet) showed that carbon emissions, fuel consumption and local air quality emissions were reduced for the low carbon vehicles compared with conventional buses. However, the researchers found further scope to optimise emissions control and after-treatment systems around the operating cycle.*

* *Air Quality Emissions Impacts of Low CO_2 Technology for Buses, Ricardo, Oct 2013.*

** *In-service emissions performance of Euro 6/VI vehicles. TfL 2015.*

BATTERY ELECTRIC

Battery electric buses use an electric motor powered by a (typically) lithium ion battery for propulsion rather than an internal combustion engine.

Electric buses are zero emission at the point of use and therefore offer great benefits, particularly in terms of local air pollution. Using renewable electricity for recharging means electric buses also achieve high well-to-wheel greenhouse gas emission savings.

Electric buses started operating the UK in 2010 and there are now (Jan 2016) 111 deployed in the UK with Nottingham City Council running the largest fleet.

Innovative methods of recharging electric buses are being explored with Milton Keynes (see illustration below) and London trialling wireless (inductive) charging infrastructure to increase the range and operational capability of electric buses.

Optare is currently the largest supplier of electric buses. Alexander Dennis and Wrightbus also supply vehicles using this technology.


Illustration © Mitsui-Arup

IN FACTS

First Bus is the largest operator of LCEBs in the UK; it has over 700 in operation.

2010
Inaugural LowCVP award for buses given to TfL

2010
LowCVP bus technology roadmap published

2011
DfT Green Bus Fund 2

Recent policy developments

The Government department responsible for air quality (Defra) published an air quality plan in December 2015. It outlines national and local measures to increase the adoption of cleaner vehicles in towns and cities and achieve the air quality standards for nitrogen dioxide (NO_2) as well as ensuring targets for particulate matter (PM) are met.

One of the main reasons that UK cities have continued to face air quality problems has been the failure of (particularly smaller) diesel vehicles to deliver expected emissions reductions in real world driving conditions. The EU is set to introduce more stringent emissions testing designed to ensure that vehicles live up to their low emission credentials.

Photos: © Courtesy Norman Adams – Aberdeen City Council

DID YOU KNOW...

Government plans to introduce Clean Air Zones in the areas of worst air quality. Low emission buses are a key part of the prescription.

Under Defra's plan, targeted Clean Air Zones in five regions across England will be introduced by 2020, together with the Ultra Low Emission Zone (ULEZ) previously announced for London. The plan devolves responsibility for implementing and enforcing Clean Air Zones to local authorities.

By 2020 the most polluting diesel vehicles – old polluting buses, coaches, taxis and lorries – will be discouraged from entering the centres of Birmingham, Leeds, Southampton, Nottingham and Derby; areas of the worst air quality.

The Government has made £30m funding available between April 2016 and March 2019 for the purchase of Low Emission Buses (LEBs) and the infrastructure to support them.

The scheme builds on the success of the Green Bus Fund, but it will work in a different way. It puts a premium on supporting the uptake of the most innovative, lowest emission vehicles.

The Low Emission Bus (LEB) test has been redefined to better reflect the UK bus operating cycle. Under the new tests, an LEB will have to produce at least 15% less greenhouse gas emissions than the average conventional Euro V equivalent diesel bus and meet, or exceed, Euro VI emissions regulations.

HYDROGEN

Hydrogen fuel cell buses are powered by fuel cells which convert the chemical energy of hydrogen and deliver electrical energy into the powertrain. Hydrogen is, typically, stored compressed in tanks on the roof of the bus with hydrogen refuelling facilities normally located at the bus depot. These buses produce no greenhouse gases or air pollution in use; water vapour is the only tailpipe emission.

Hydrogen can be produced from a variety of sources including fossil fuel-based industrial processes and the electrolysis of water using renewable electricity. The largest hydrogen bus fleet is currently run by Stagecoach in Aberdeen. The buses are powered by renewable hydrogen. London has been operating eight hydrogen fuel cell buses over a number of years and plans to buy more.

IN FACTS

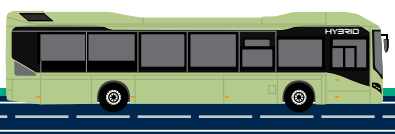
Buses essential to the economy

The UK's 88,683 buses and coaches deliver 5.2 billion passenger journeys amounting to 18.1 billion miles each year.

The automotive industry is a vital part of the UK economy accounting for more than £95 billion turnover and £15.5 billion value added. (Source: SMMT, 2016)

DID YOU KNOW...

In 2015, Low Carbon Emission Buses saved nearly 70,000 tonnes of CO_2 compared with their standard diesel equivalents.



2011
The Local Transport Authority Toolkit for Low Carbon Buses (TTR report for LowCVP)

2012
DfT Green Bus Fund 3

Almost 2.5 million people in the UK travel to work by bus, and a further one million use the bus as a vital back up.

Institute for Transport Studies, University of Leeds, 'Buses and Economic Growth', 2012.

BIOMETHANE

Gas buses are equipped with a spark ignition engine and store compressed gas in tanks on the roof of the vehicle. Most gas buses around the world are powered by natural gas. In the UK, however, gas buses must run on renewable gas to lower well-to-wheel emissions and achieve Low Emission Bus status.

Biomethane is a renewable form of natural gas derived from the decomposition of organic waste material in an anaerobic digestion plant such as farm slurry and municipal waste. In the UK there are over 120 anaerobic digestion plants producing biomethane. The fuel is compressed and injected into the national gas grid. The Renewable Energy Association (REA) has created a Green Gas Certification System which allows companies to certify the volume of gas they have extracted from the grid, enabling its use as a vehicle fuel.

Biomethane buses first arrived on the UK bus market in 2012. There are currently 112 in operation with Reading Buses running one of the largest fleets. Scania and ADL are jointly manufacturing compressed gas buses in the UK and the first double-decker version is expected to be in operation in 2016.

IN FACTS

Greener Bus Fuels

It's not just the buses that are greener. Low carbon fuels to power bus fleets come from a very wide range of places; some may be closer than you really want to consider!

Biodiesel from waste cooking oil and biogas from farm slurry have powered buses in service. In Bath and Bristol the number 2 route was serviced by a methane gas bus with the biofuel recovered from the Wessex Water Sewage plant. Affectionately named the 'Poo Bus' this must be one of the first examples of a truly 'circular economy' working in transport.

Dec 2012
750 LCEBs in operation

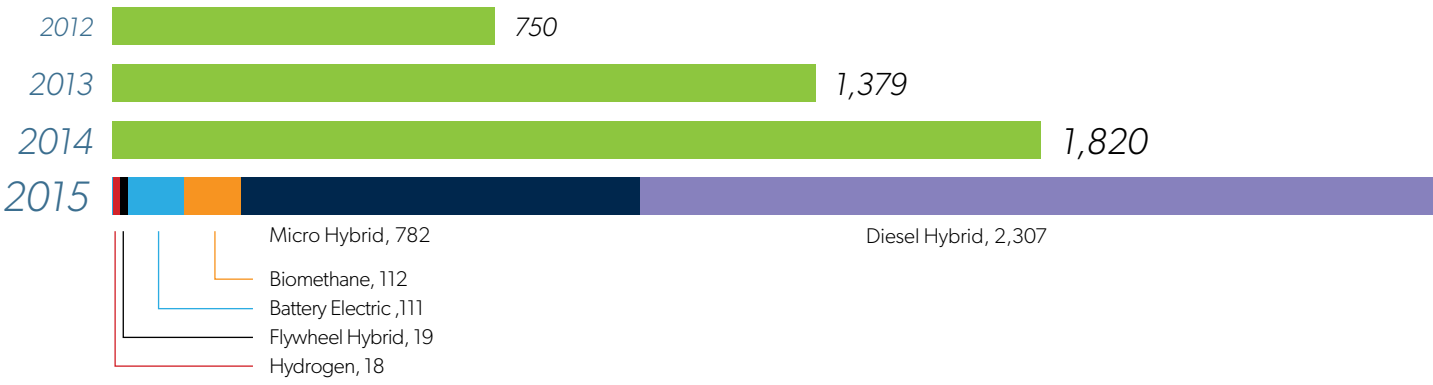
2013
Green Bus Fund 4

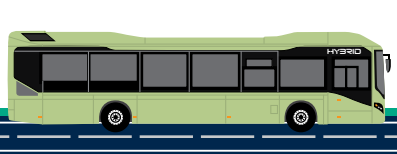
2014
Barriers and Opportunities to Expand the Local Carbon Bus Market *(TTR/TRL report for LowCVP)*

The Green Bus has arrived…

Low carbon and low emission buses are here today in large numbers and are already making a vital contribution to improving air quality and cutting greenhouse gas emissions. The journey of the green bus, though, continues as work goes on to further reduce emissions, commercialise new technologies and increase their uptake throughout the country. Today's low emission buses will meet the requirements of the recently announced Clean Air Zones. They're also delivering carbon and fuel savings which benefit the climate and cut operators' costs. The UK bus industry continues to innovate, drawing on a diverse range of technology and resources from Formula One to farm manure! The UK continues to lead the world in comprehensive assessment of the real impact and undoubted benefits of greener buses. The green bus has arrived but its journey goes on… .

Low Carbon Emission Buses on the Road (2012–15) and by Technology (2015)





2014
Introduction of Euro VI buses

2015
6th round of Scottish Green Bus Fund announced

The bus sector's achievement in terms of the rate of innovation of low emission technology has been unmatched by any other vehicle sector in recent years.

BACKGROUND

What is a Low Emission Bus?

In 2015, on behalf of OLEV and the DfT, the LowCVP revised the definition of a Low Emission Bus (LEB) to take into account the dual goals of cutting greenhouse gas emissions and improving local air quality.

A Low Emission Bus is defined as a bus which can achieve a reduction of more than 15% well-to-wheel greenhouse gas emissions compared with a Euro V diesel bus, and achieve the Euro VI engine standard in terms of other emissions.

The LEB accreditation scheme entails a new bus test cycle; the LowCVP UK Bus Test Cycle, measuring both greenhouse gas and air pollution emissions.

Another difference from the earlier (2009) Low Carbon Emission Bus scheme, is that technologies that can demonstrate zero emission capability – i.e. travel at least 2.5 km of a route without emitting any emissions – can benefit from top-up funding.

BACKGROUND

The 'Factor 100' concept

Recent research in Europe has calculated that one electric bus can remove from a city the same tailpipe emissions as 100 electric cars, to say nothing of the reduced congestion and the parking/charging space needs of those 100 cars.

The largest city buses can carry up to 100 passengers and run over 18hrs per day, compared to a typical car driver just commuting an hour per day and parking for 8hrs.

1 BUS, 18 HRS DAILY USE
100 PEOPLE EVERY HOUR

100 E-CARS, 1HR DAILY USE

X 100

DID YOU KNOW...

Air pollution in the UK results in almost £1bn in terms of lost economic productivity.

(Ref: European Environmental Bureau, 2010)

IN FACTS

The Low Emission Bus Grant

In 2015 the Office of Low Emission Vehicles (OLEV) introduced a new bus incentive scheme called the Low Emission Bus Grant which superseded the Green Bus Fund.

The Low Emission Bus Grant is a £30million fund to be run over three years (2016–2019) which aims to stimulate the purchase of Low Emission Buses – not to be confused with the earlier LCEB definition – by local authorities and bus operators.

It forms part of a larger £500m financial package made available by OLEV to increase the take of ultra-low emission vehicles. The grant supports the extra capital cost of low emission buses and refuelling, or recharging, infrastructure. The LowCVP has helped OLEV and the DfT to design the scheme.

The grant is innovative in that it funds Low Emission Buses in accordance with their well-to-wheel greenhouse gas emission savings, offering additional support for technologies that are 'zero emission capable' such as battery electric buses.

More than half (53.5%) of all new buses and coaches registered in 2015 met the latest Euro VI emissions standard.

(Source: SMMT)

3,349

2015
New Low Emission Bus (LEB) and accreditation scheme introduced

2015
Defra air quality action plan announced

Commissioned by Greener Journeys

Greener Journeys is a campaign dedicated to encouraging people to make more sustainable travel choices. It aims to reduce CO_2 emissions from transport by encouraging people to switch some of their car journeys to bus or coach instead. It is a coalition of Britain's leading bus companies and other supporters including Transport for London, Transport Focus, Transport for the North, the RAC Foundation, Confederation for Passenger Transport and the Campaign for Better Transport.

www.greenerjourneys.com

greener journeys

Report produced by the Low Carbon Vehicle Partnership

The LowCVP was established in 2003 as a public–private partnership working to accelerate a sustainable shift to lower carbon vehicles and fuels and create opportunities for UK business. Around 200 organisations are engaged from diverse backgrounds including automotive and fuel supply chains, vehicle users, academics, environment groups and others.

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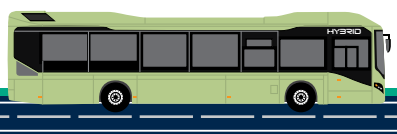

Jan 2016
Approaching 3,500 LCEBs in the UK

Feb 2016
The Journey of the Green Bus Published