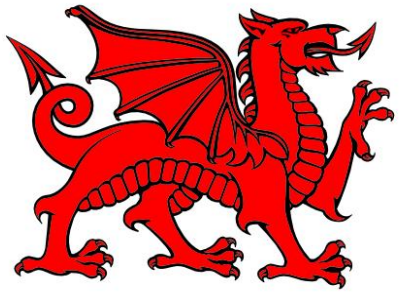
LowCVP Low Carbon Vehicle Partnership

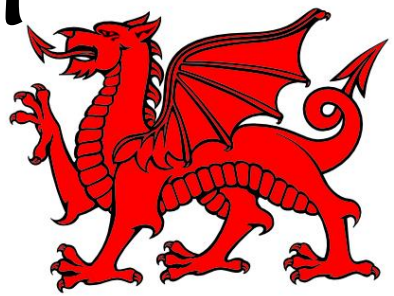
Low Emission Bus workshops 2018

CARDIFF | CAERDYDD

Welcome to the Principality Stadium



Thursday 19th July



Lower Carbon and Cleaner Air: Opportunities for Buses

Low Emission Bus Workshop Cardiff

Principality Stadium, 19th July

LowCVP
Low Carbon Vehicle Partnership
Connect | Collaborate | Influence

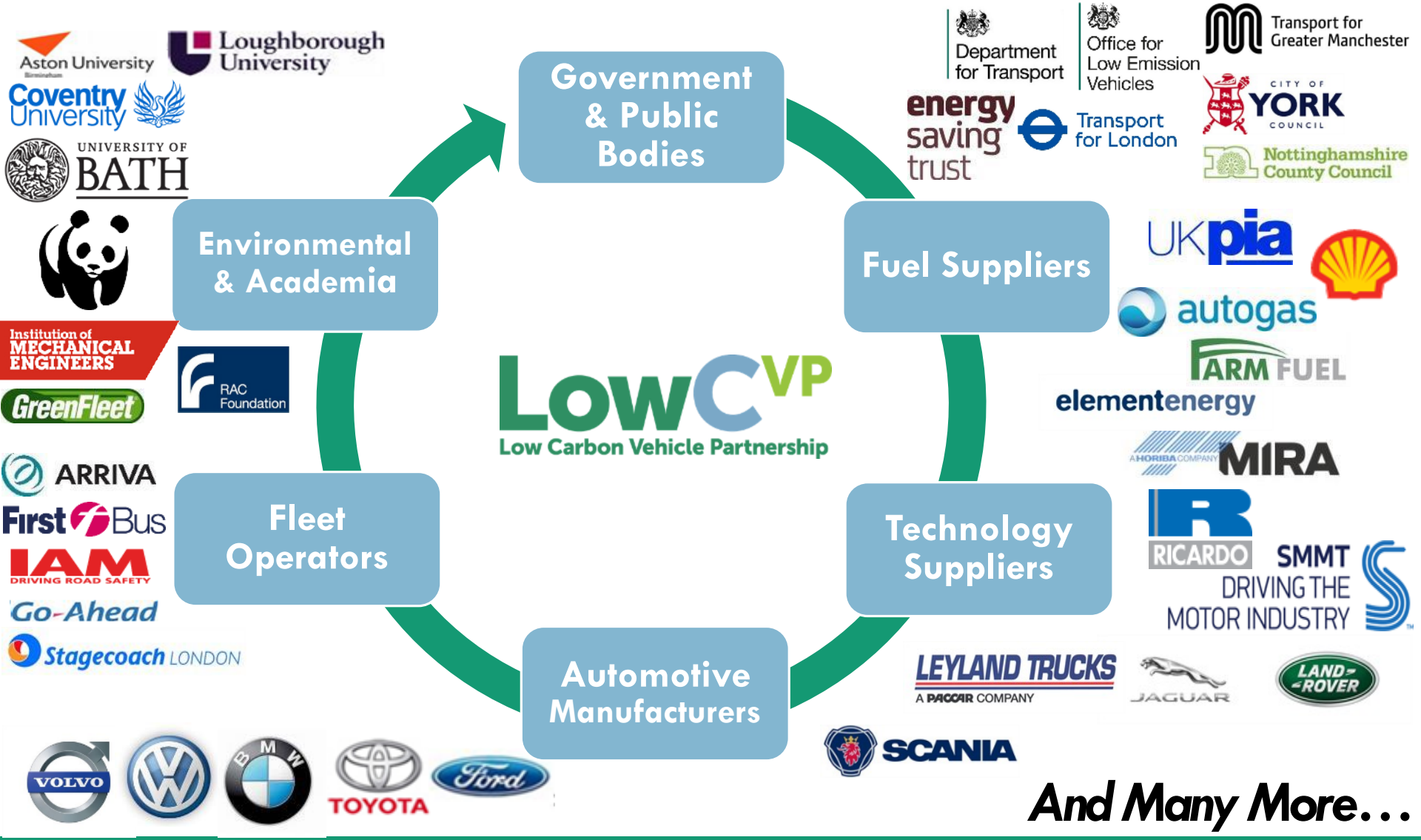
Daniel Hayes

Project Manager

Low Carbon Vehicle Partnership

LowCVP: A unique public-private membership organisation, building evidence and creating robust policies and innovation in the UK

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence



Aston University · Loughborough University · Coventry University · University of Bath · Department for Transport · Office for Low Emission Vehicles · Transport for Greater Manchester · energy saving trust · Transport for London · City of York Council · Nottinghamshire County Council · UKpia · Shell · autogas · Farm Fuel · elementenergy · MIRA · Ricardo · SMMT Driving the Motor Industry · Leyland Trucks · Jaguar · Land Rover · Scania · Volvo · Volkswagen · BMW · Toyota · Ford · WWF · Institution of Mechanical Engineers · RAC Foundation · GreenFleet · Arriva · First Bus · IAM Driving Road Safety · Go-Ahead · Stagecoach London

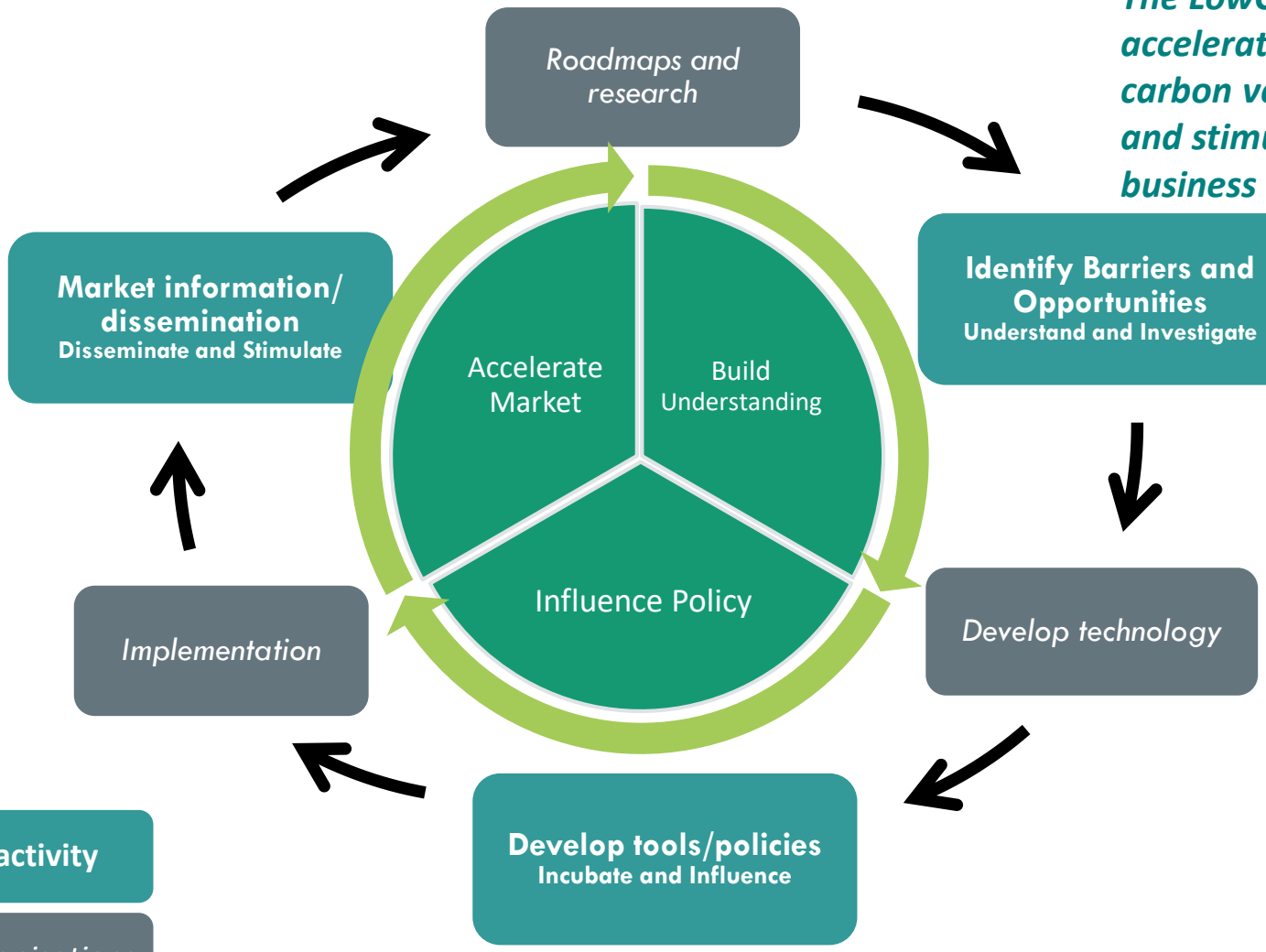
And Many More…

LowCVP Activity & Policy Cycle

- Robust Research, Policy and Information

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

The LowCVP exists to accelerate shift to low carbon vehicles and fuels and stimulate UK business opportunities



Key:

- **LowCVP activity**
- *Member organisations*

Current State of Play in Wales

Low Carbon Vehicle Partnership
Connect Collaborate Influence

In 2016/17…

- 1,500 registered PSV buses in Wales (-25% from 2006/7)
- 2,100 citizens/bus, *GB average is 1,600 citizens/bus*
- 100 million passenger journeys (-16% from 2006/7)
- 32 journeys per head, *GB average is 77 journeys per head*
- *45% of all bus journeys are concessionary fares (34% GB average)*
- *1 car for every two people in Wales … only NI has more cars/head*

Plenty of Opportunities for Growth of Bus Market in Wales!

Long term transport strategy must include modal shift

Bus strategy must include reduction of emissions (CO2, NOx)…

National UK Bus Policy Evolution

Low Carbon Vehicle Partnership
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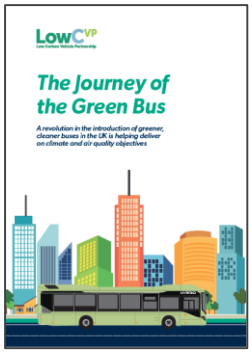
Development of evidence based bus policy over the last decade to reduce emissions…

2007-08	2009-15	2015-16	2016-2018
Definition of a Low Carbon Emission Bus (LCEB)	Creation of a LCEB Accreditation Scheme	Green Bus Fund BSOG LCEB incentive Scottish Green Bus Fund 1-5	£30m OLEV Low Emission Bus Grant Scheme Scottish GBF 6	£3m SGBF 7 B.E.A.R. Retrofit £40m CBTF	Defining an Ultra Low Emission Bus £48m

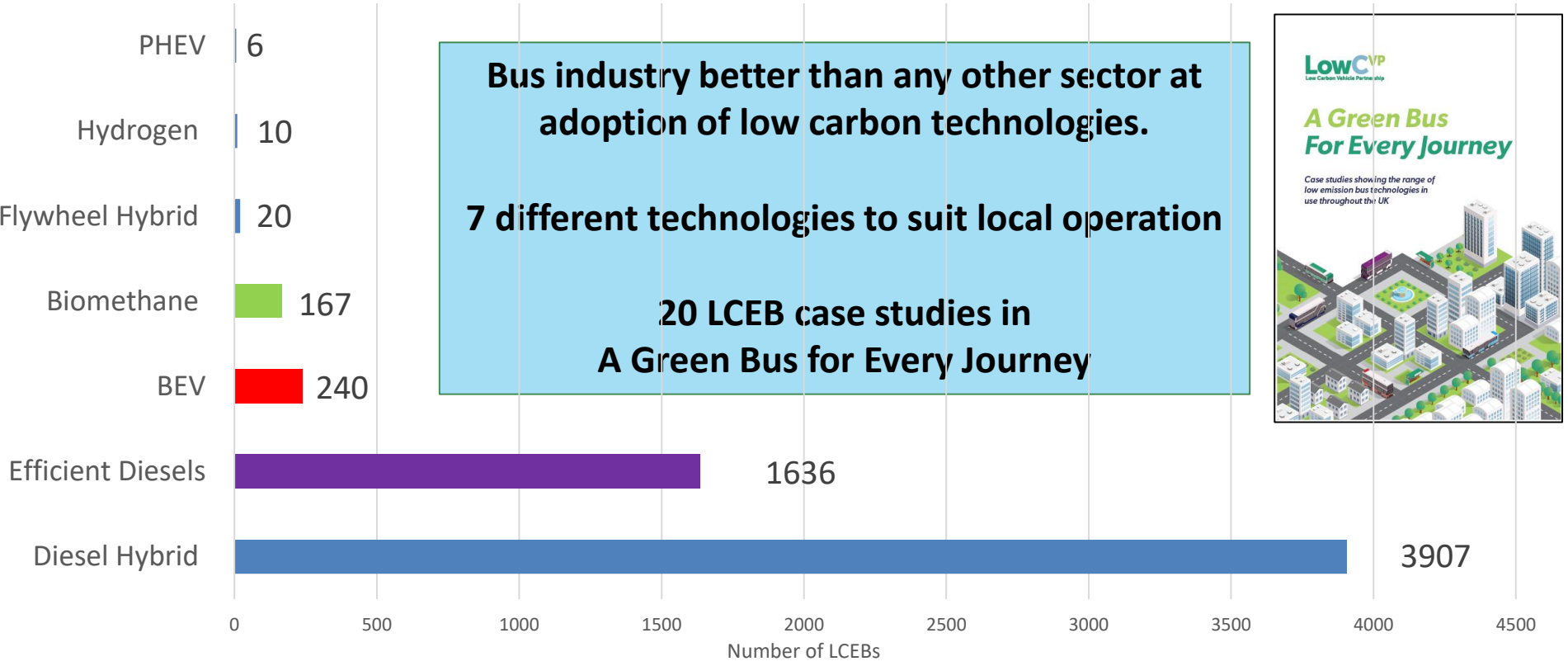
… detailed in The Journey of the Green Bus



Low Carbon Emission Buses

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

- 30% well-to-wheel greenhouse gas saving vs Euro III diesel
- £90m for 1240 LCEBs in England, £14m for 275 LCEBs in Scotland
- July 2018: **5,904** LCEBs in service in UK, No LCEB BSOG incentive in Wales



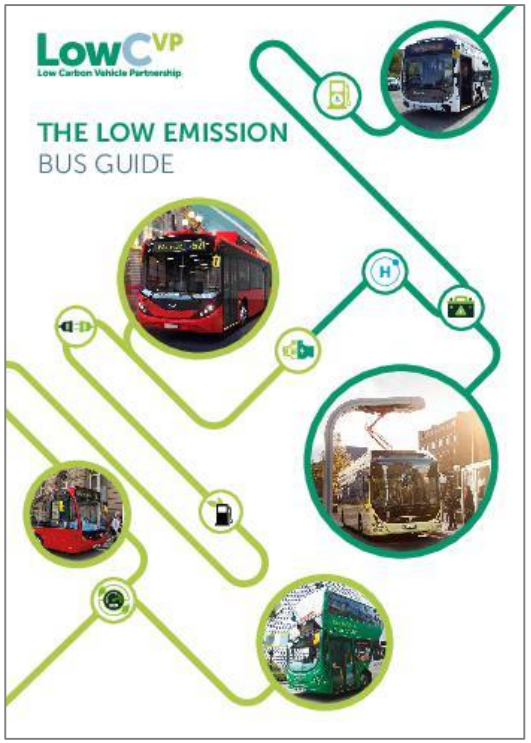
Bus industry better than any other sector at adoption of low carbon technologies.

7 different technologies to suit local operation

20 LCEB case studies in A Green Bus for Every Journey

Low Emission Buses – includes AQ

- 15 % well-to-wheel greenhouse gas saving vs Euro V diesel buses **& buses must be Euro VI.**
- £41m funding 476 buses in England, 93 LEBs funded by SGBF 6 & 7
- Test certificates published on LowCVP website
- TRL monitoring programme of LEBS in England
- Estimated 2,570 Low Emission Buses in service
- See Low Emission Bus Hub for more info



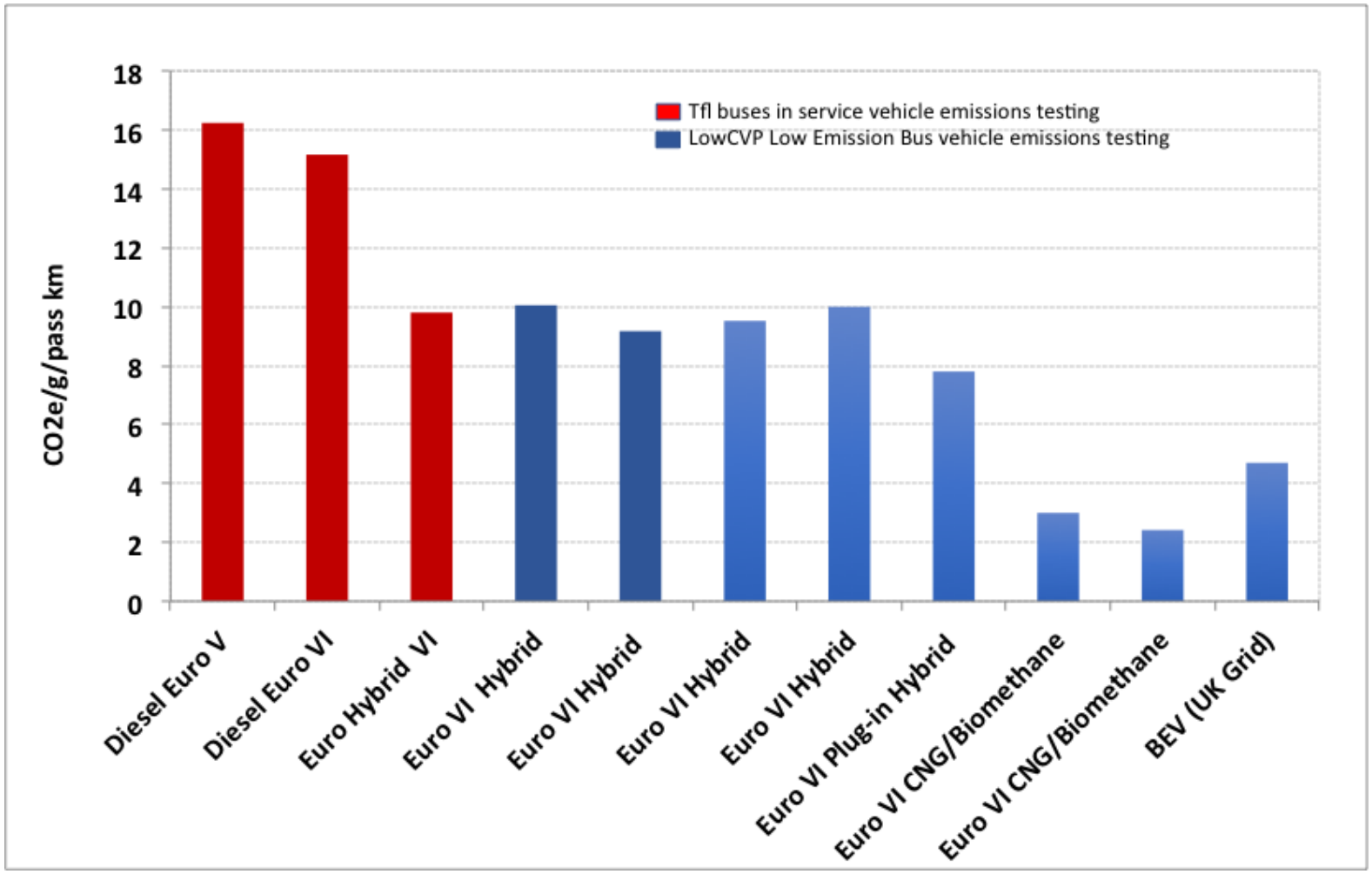
The Low Emission Bus Guide:

- Accredited Models
- Infrastructure options
- UK and EU Case studies

Well-to Wheel Greenhouse Gas performance

Low Carbon Vehicle Partnership
Connect Collaborate Influence

Range of technologies , fuels and infrastructure solutions available – no one solution for all operations!



Euro VI is clean for all technologies

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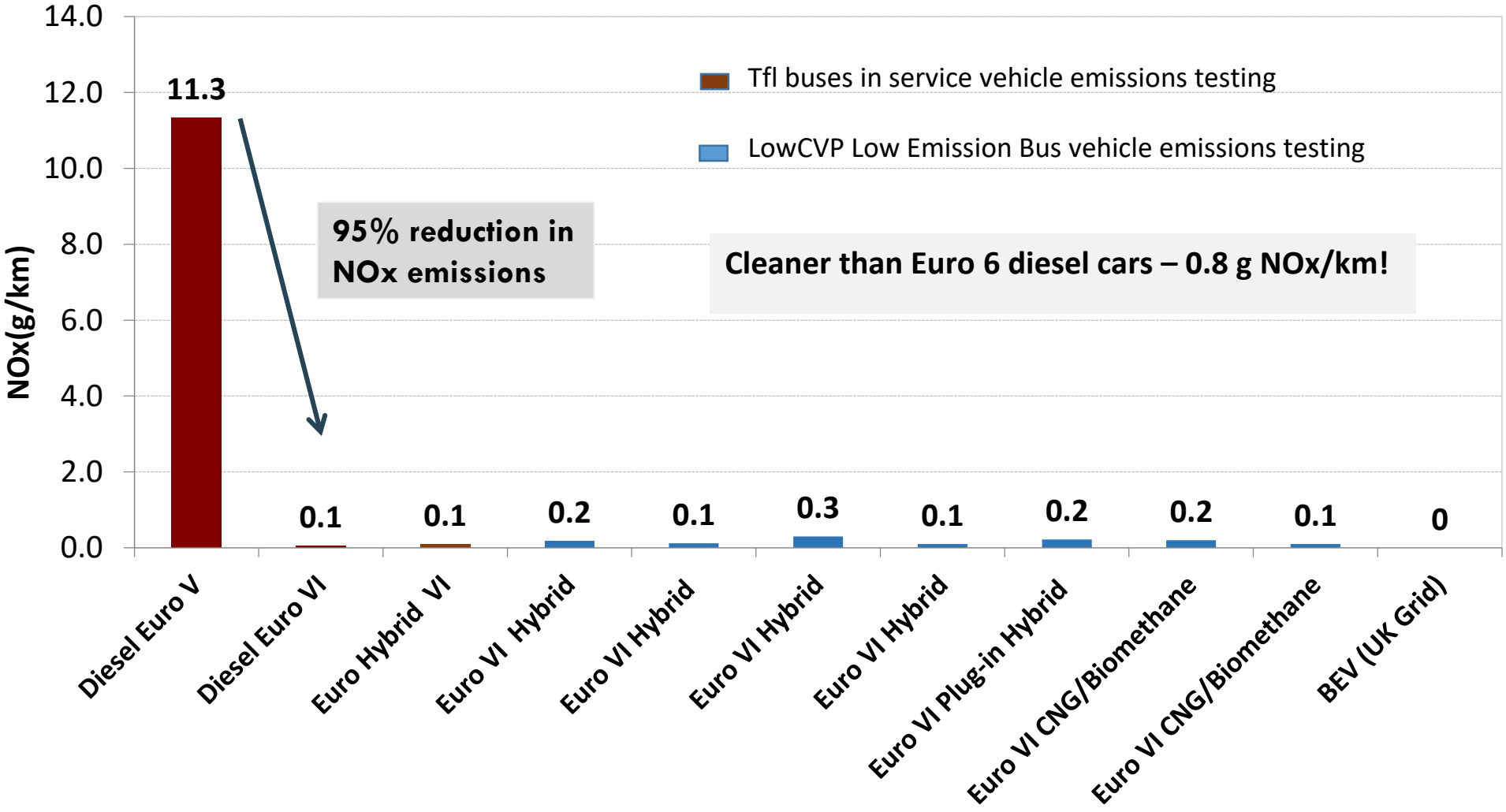


Retrofit Solutions

LowCVP Low Carbon Vehicle Partnership | Connect Collaborate Influence

How to support bus industry to meet Euro VI CAZ criteria?

- Need consistency in standards : Euro VI diesel UK wide

Clean Air Zones = Low Emission Zone = ULEZ

- LowCVP evaluation of retrofit programmes 2013-15
- UK accreditation scheme for retrofit technologies

Clean Vehicle Retrofit Accreditation Scheme (CVRAS)

- £40m in England & Wales, £1.6m B.E.A.R. 1 in Scotland
- At least 1,000 buses for potential upgrade in Wales.
- LowCVP working with industry to encourage solutions for coaches and trucks
- LowCVP looking to develop Low Carbon Coach scheme


LowCVP Low Carbon Vehicle Partnership | Connect Collaborate Influence

Clean Vehicle Technology Fund and Clean Bus Technology Fund Programmes

Evaluation Report

Prepared for the DEFRA/DfT Joint Air Quality Unit

Report
August 2017

Next Gen: Ultra Low Emission Bus

LowCVP Low Carbon Vehicle Partnership | Connect Collaborate Influence

- LowCVP conducted test programme of 8 Euro VI diesels
- Test Cycle Development - even more representative test

e.g. temperature of test cell to 10^{o}C / cabin heating turned on

Ultra Low Emission Bus Definition – foster ambition

- 30% well-to-wheel GHG savings vs **Euro VI** baseline
- Funding encourage zero emissions mileage (Road to Zero)
- Continue to encourage vehicle efficiency improvements.
- Align terminology with other vehicle sectors – future use in CAZ?

Welsh Policy Update

- Buses are part of the solution to tackle congestion, air quality, climate change and improved health and well-being.
- Ken Skates has hosted two Wales Bus Summits to explain his vision and to encourage more partnership working.
- Consultation on Clean Air Zone Framework for Wales closes 19 June – responses being assessed.
- Welsh Government coordinated support for ULEB applications – 3 bids in from Wales.
- WG initiated with Volvo Bus - and Cardiff Bus and Council - a trial of an all-electric bus between Cathays Park and Cardiff Bay.

Review of BSSG operational support mechanism

- Working with LowCVP, local authorities and CPT to ensure best future design of BSSG.
- Plan to adjust BSSG to encourage cleaner and greener buses in Wales as part of a wider strategy.
- BSSG could become a Better Bus Fund, with wider scope, potentially including bus priority and retrofitting of green technology.
- BSSG also adjusted to improve service reliability and availability of data to consumers, plus A/V.

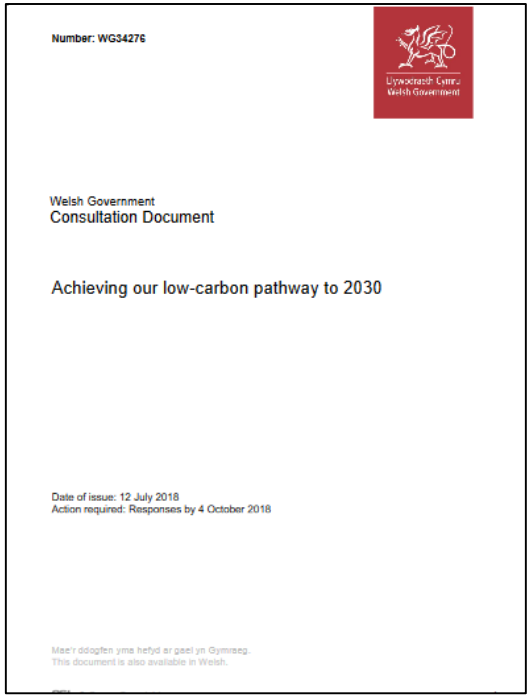
Consultation on Low Carbon Pathway

Low Carbon Vehicle Partnership
Connect Collaborate Influence

- Welsh Gov't consulting on how to achieve 80% greenhouse gas reduction by 2050.
- This consultation presents initial thoughts on how we might reduce greenhouse gas emissions by **45% between now and 2030.**

Proposals include:

- accelerating sustainable energy production and foster local ownership
- improving opportunities for active travel and develop a comprehensive charging network for electric vehicles
- setting higher energy efficiency standards for new building projects.



Number: WG34276

Welsh Government
Consultation Document

Achieving our low-carbon pathway to 2030

Date of issue: 12 July 2018
Action required: Responses by 4 October 2018

Mae'r ddogfen yma hefyd ar gael yn Gymraeg.
This document is also available in Welsh.

https://beta.gov.wales/low-carbon-pathway-wales

Facing challenges together

LowCVP Low Carbon Vehicle Partnership
Connect Collaborate Influence

- Improving Air Quality will benefit all (business & public)
- Need pragmatic approach given timescales and target all vehicles.

Forming partnerships will benefit all:

- Bus need to seize opportunity = Urban Mobility Solutions
  - Range of options for different operations
  - Clean & Low Carbon – catalyst for other vehicle types
  - Focus on emissions/ passenger km
- Local authorities should support bus priority measures. Operators will invest if supported.

Long term: Zero Emission Zones

Industry and Gov't need to work together to tackle challenges

Thanks for listening.

Connect
Collaborate
Influence

Daniel Hayes

Project Manager

Daniel.Hayes@lowcvp.org.uk / 0207 973 1244

Interested in joining the Partnership?

Szilvia Libor

Membership Coordinator

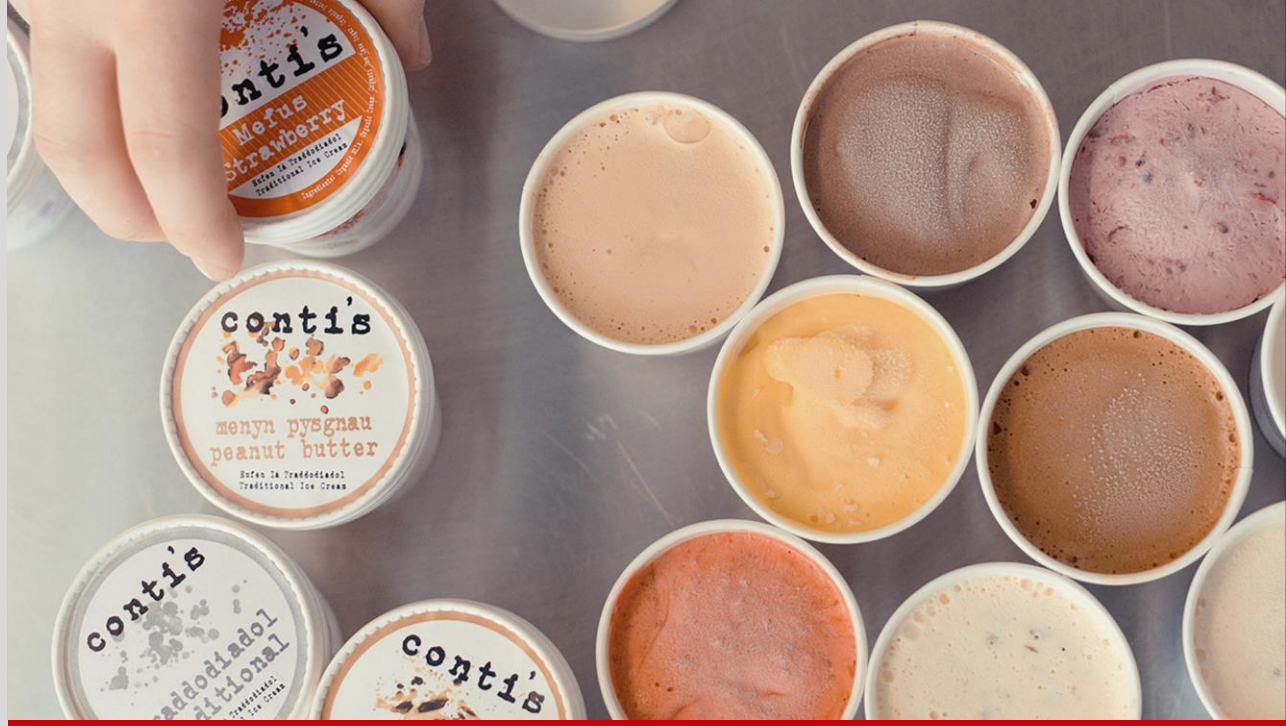
Szilvia.Libor@LowCVP.org.uk / 020 7304 6880

Busnes Cymru | Business Wales

THIS IS BUSINESS

What is Business Wales/ who is it for?

Business Wales is the Welsh Government's bilingual business support service, launched in January 2013 and refreshed in January 2016, to make it easier for Welsh businesses and aspiring entrepreneurs to access the information, advice and support they require to start and grow their businesses.



Busnes | Business
Cymru | Wales

The BW service supports entrepreneurs and SMEs of all levels of growth aspirations in Wales. This ranges from promoting and encouraging entrepreneurship in schools and FE/HE institutions through to supporting business start-ups and existing SMEs to grow and prosper.

Team of experienced entrepreneurs providing advice on topics including:

- Business Planning
- Marketing
- Access to Finance
- Business growth
- Innovation

B U S I N E S S A I M S

Busnes Cymru | Business Wales

- general business advice
- tendering advice
- equality and HR advice
- environmental management and waste advice
- international trade support
- business mentoring
- workshops on a wide range of subjects including accessing business finance, international trade and recruiting staff
- advisers at our network of business support centres have knowledge and understanding of the local support that is available to businesses. BW can offer face-to-face business advice either at your premises or at one of our local centres.

B U S I N E S S A I M S

Busnes | Business
Cymru | Wales

B U S I N E S S A I M S

2018 Seminar/Workshops for PSV Operators

- Recruitment
- HR Compliance
- Succession
- Access to IT training
- Meet the Buyer / Supplier Briefings
- Live tender support workshops
- Safeguarding

Busnes | Business
Cymru | Wales

ACCESS POINTS

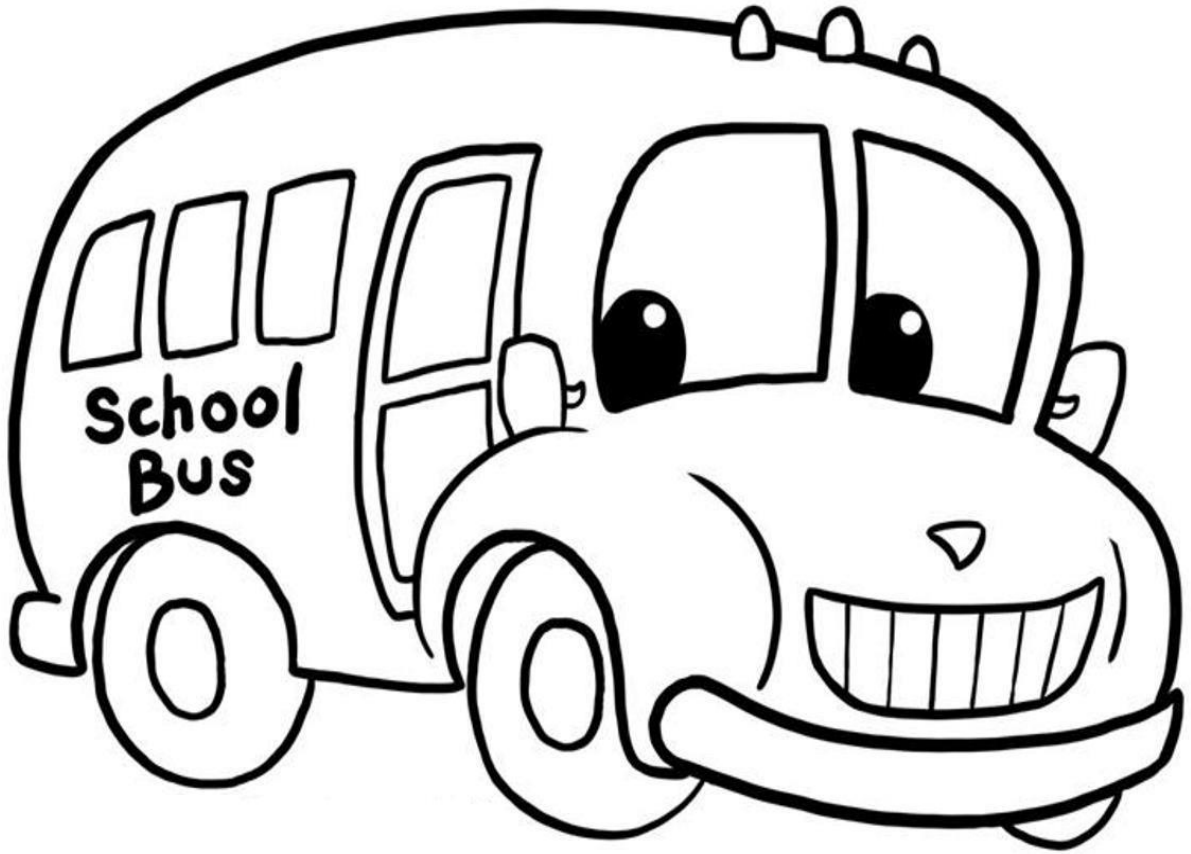
Business Wales offers a single point of contact for businesses and entrepreneurs to advice and support from public, private and voluntary sectors, and can be accessed
online via http://businesswales.gov.wales
and associated social media channels;
the 03000 6 03000 helpline; and a network
of offices located across Wales.

St Asaph Office

01745 585025

Clive. Barnard@businesswales.org.uk

northwales@businesswales.org.uk



A C C E S S P O I N T S

Busnes | Business
Cymru | Wales

19TH JULY 2018

Bus Fleet - Emission Reductions

Lisa Dipnarine
Commercial Development Manager, Bus Operations

The scale of our operation

- **6.5 million passenger trips every weekday**

- **Around 700 routes**
  - All wheelchair accessible
  - Over 100 operate 24/7

- **19,000 bus stops**
  - 95% fully accessible

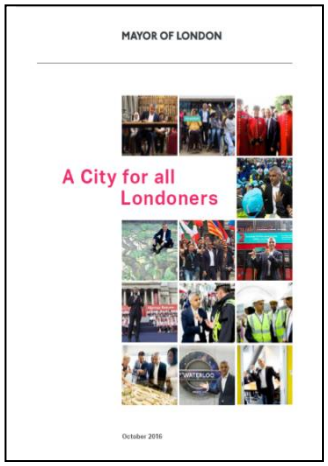
- **9,500 buses**
  - 3,000 Hybrids
  - 4,100 Euro VI
  - 96 Pure Electric, 10 fuel cell

- **24,000 bus drivers**

- **79 bus garages**

- **10 bus operators**

A new Mayor, a new agenda



"A City for all Londoners" sets out the Mayor's vision for London:

- **Environment, Transport and Public Space**
- Accommodating growth
- Housing
- Economy
- A City for all Londoners

Underpinning all of his priorities is a high quality public transport system.

Healthy Streets for London to create a healthy city:

- **Clean air**
- People choose to walk, cycle and use public transport
- Pedestrians from all walks of life
- Easy to cross
- Places to stop and rest
- Shade and shelter
- People feel relaxed
- Things to see and do
- Not too noisy
- People feel safe

Mayor Transport Strategy is to create a better place for all of those people to live in:

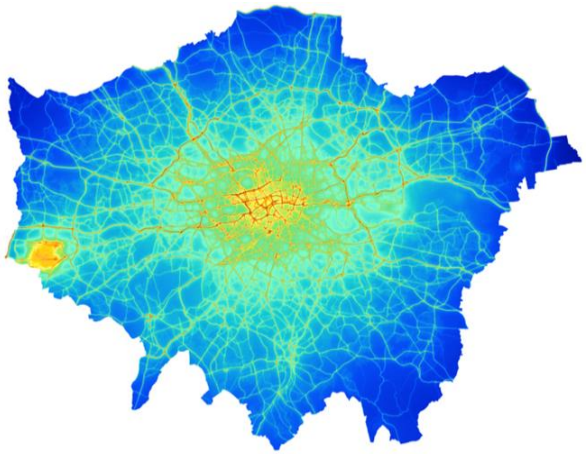
- **Improve air quality and the environment**
- Take action to reduce emissions
- **Introduce the Ultra Low Emission Zone in 2019**
- **Ensure all TfL buses meet the Euro VI standards by 2020**
- Tackle pollution in local air quality hotspots and at sensitive locations (incl Mayor's Air Quality Fund)

Clean Air Challenge

The Mayor stated that our “most pressing environmental challenge is cleaning up London’s air”

The challenges are:

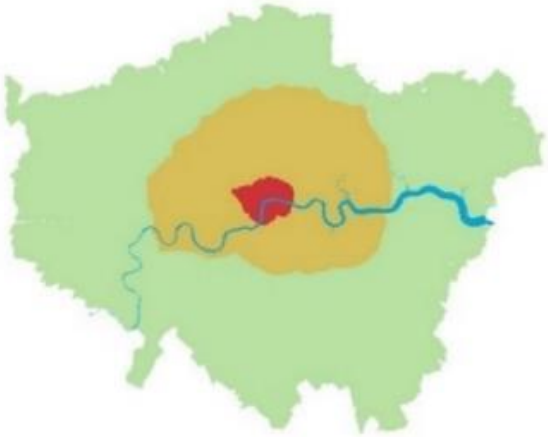
- Achieving compliance with NO_2 legal limits as soon as possible
- Further driving down Particulate Matter
- Becoming a zero-carbon city by 2050



NO_2 concentrations London, 2020 without ULEZ

To achieve this, there is an imperative to reduce emissions from vehicles in London:

- Encouraging more walking, cycling and use of public transport
- Reducing air pollutant and CO_2 emissions from transport
- Reducing motorised vehicles



Buses contribute to 27% of NO_2 in Inner London

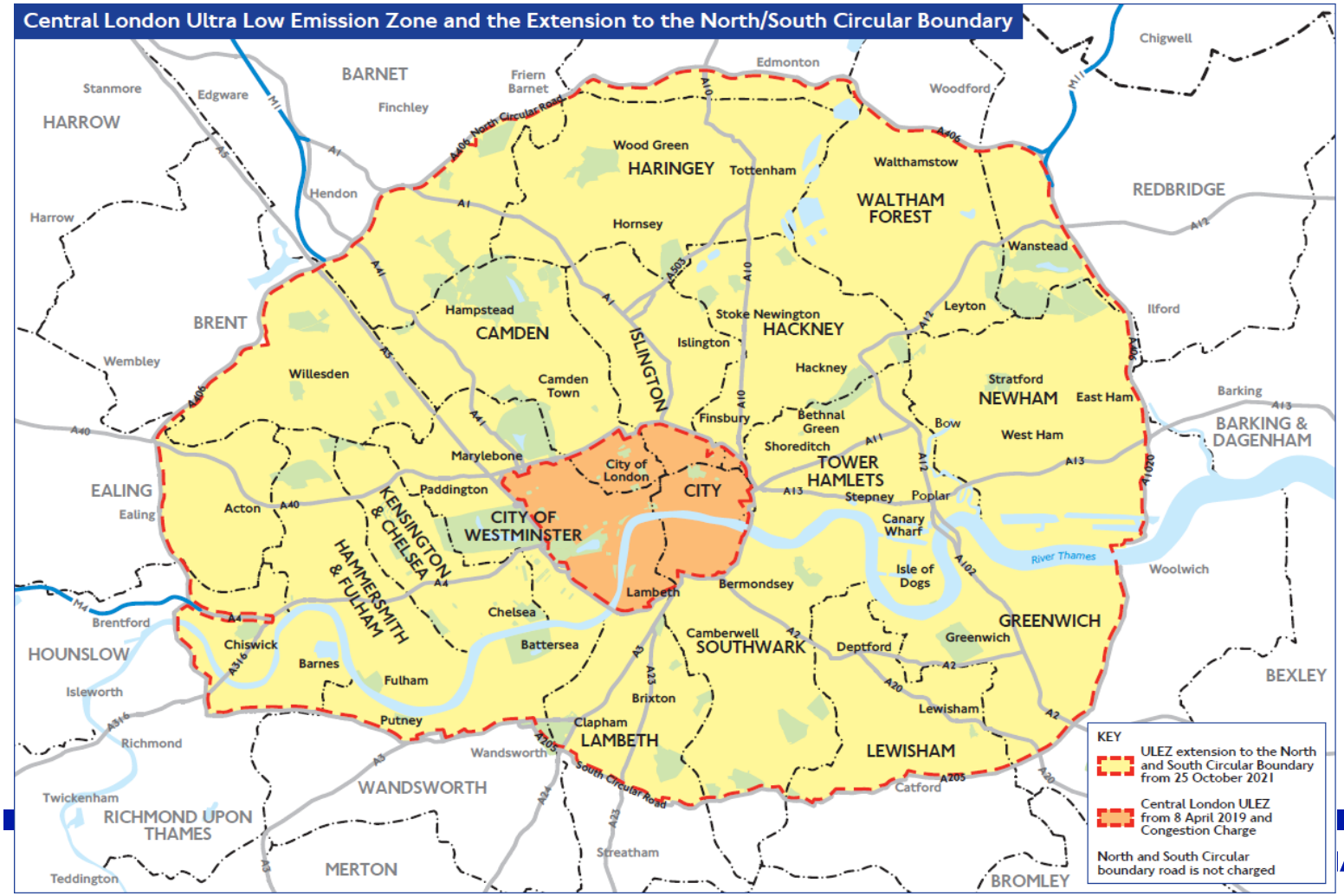
Air Quality Bus Commitments

- Delivering TfL's central London Ultra-Low Emission Zone requirements
- Delivering 12 Low Emission Bus Zones by 2020
- London-wide retrofit programme by 2020
- Hybrid buses and Zero Emission buses

Central London ULEZ and Extension

TfL Bus fleet requirements

- Up to 3,000 double deck hybrid buses – Euro VI emissions by April 2019
- Up to 300 single deck zero emission buses – by 2020



Low Emission Bus Zone (LEBZ)

Tackling the worst pollution hotspots by concentrating cleaner buses on the dirtiest routes.

Key criteria:

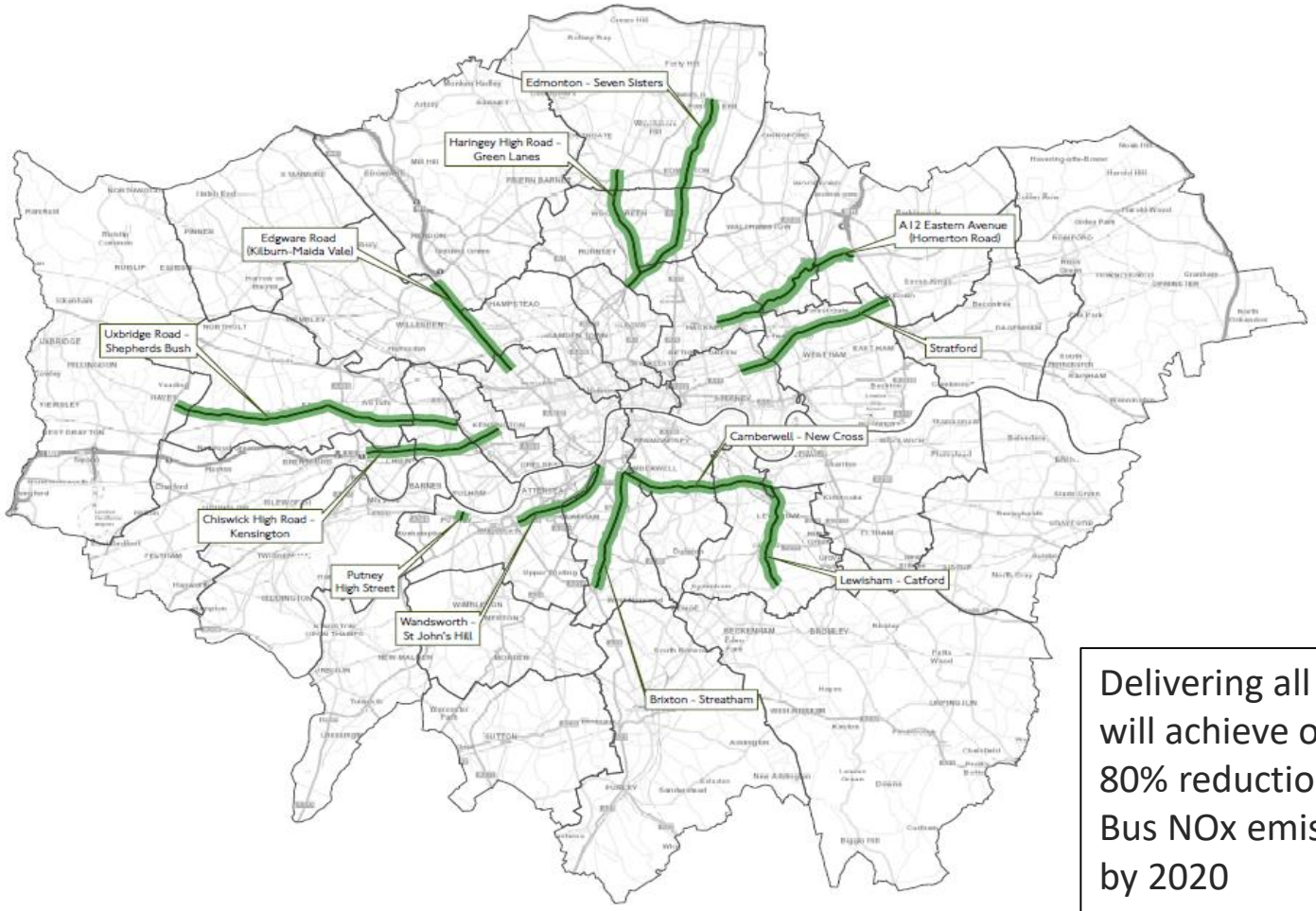
- Where buses are forecast to still be contributing 40% or more of road transport NOx in 2020;
- Where pollutant concentrations are currently above EU limit values for NO_2 and are forecast to still be exceeded in 2020; and
- Outside of the central Ultra-Low Emission Zone.

Defined by:

- All scheduled TfL bus routes along the corridor meeting a minimum standard of Euro VI (or better)
- The corridor has effective bus priority to ensure that buses keep moving, minimising unnecessary pollution from sitting in traffic.

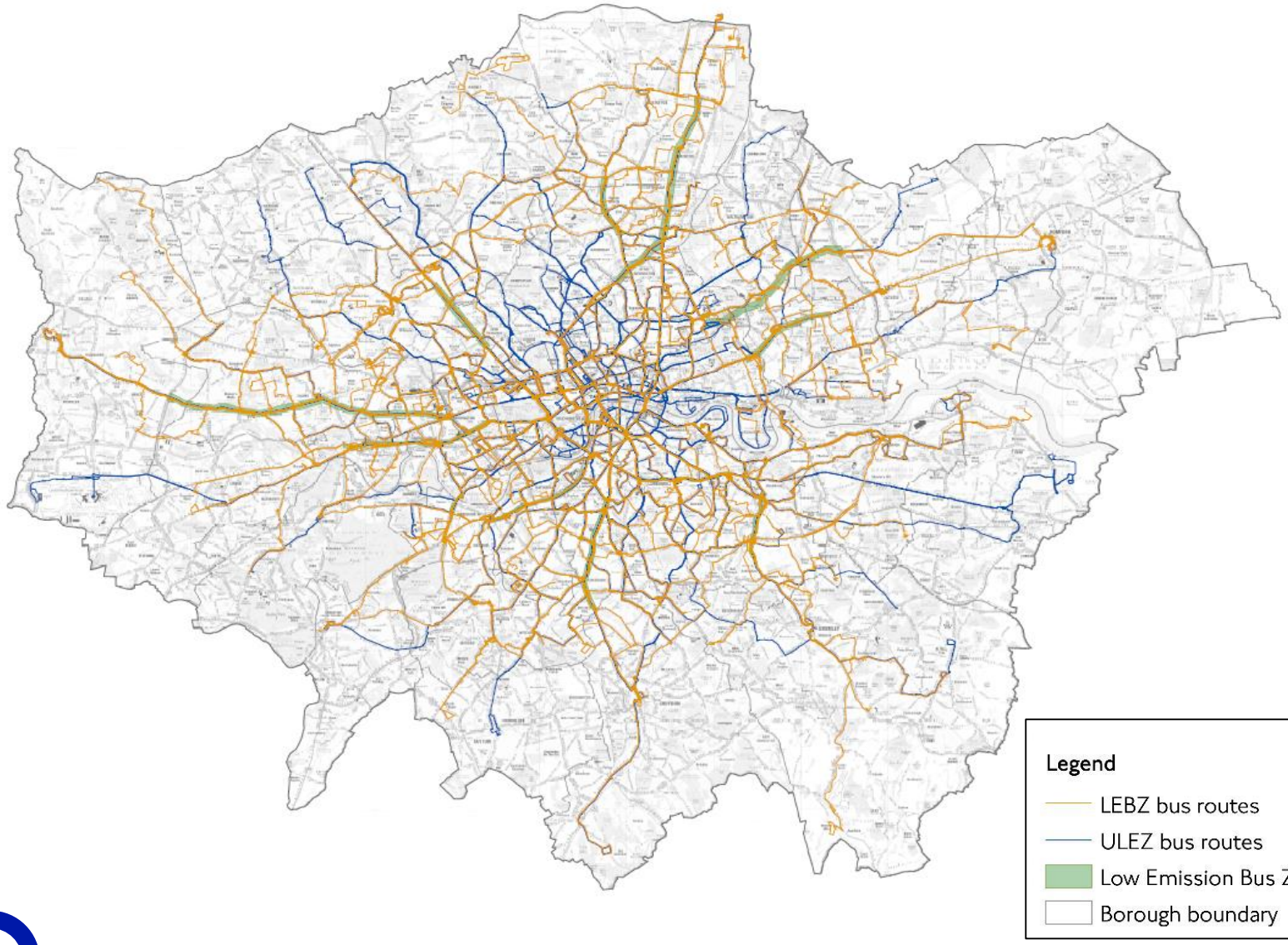
Low Emission Bus Zone (LEBZ)

Low Emissions Bus Zones



Delivering all LEBZs will achieve over 80% reduction in Bus NOx emissions by 2020

LEBZ and central London ULEZ routes



London wide Retrofit Programme

Reducing emissions from existing diesel and hybrid fleet to Euro VI standards by 2020.

Scope of work

- Up to 4,200 buses

Euro V – VI: Up to 3,200 vehicles in fleet

Euro IV – VI: Up to 1,000 vehicles in fleet

Up to 15 bus models (each might require different retrofit kit) – not just plug and play

Euro III + SCR: 1,000 vehicles in fleet

No solution, however, we expect all of the Euro III + SCR buses to leave the fleet naturally between now and 2020.

London wide Retrofit Programme

What we have achieved

- Procurement (mid 2016) - Open competition via OJEU process
- Five suppliers on Framework (May 2017) – some systems signed off, trials and development of others continue
- Installation and approval for funding in TfL's Business Plan (Summer 2017)
- Developed a Technical Specification – Retrofit suppliers must meet emissions criteria at Millbrook and 6 months on road testing
- Regular meetings with suppliers and bus operators to agree detailed schedule for retrofits

- Over 1,430 buses retrofitted
- 4 companies fitting almost 40 buses a week
- On target to complete programme by 2020

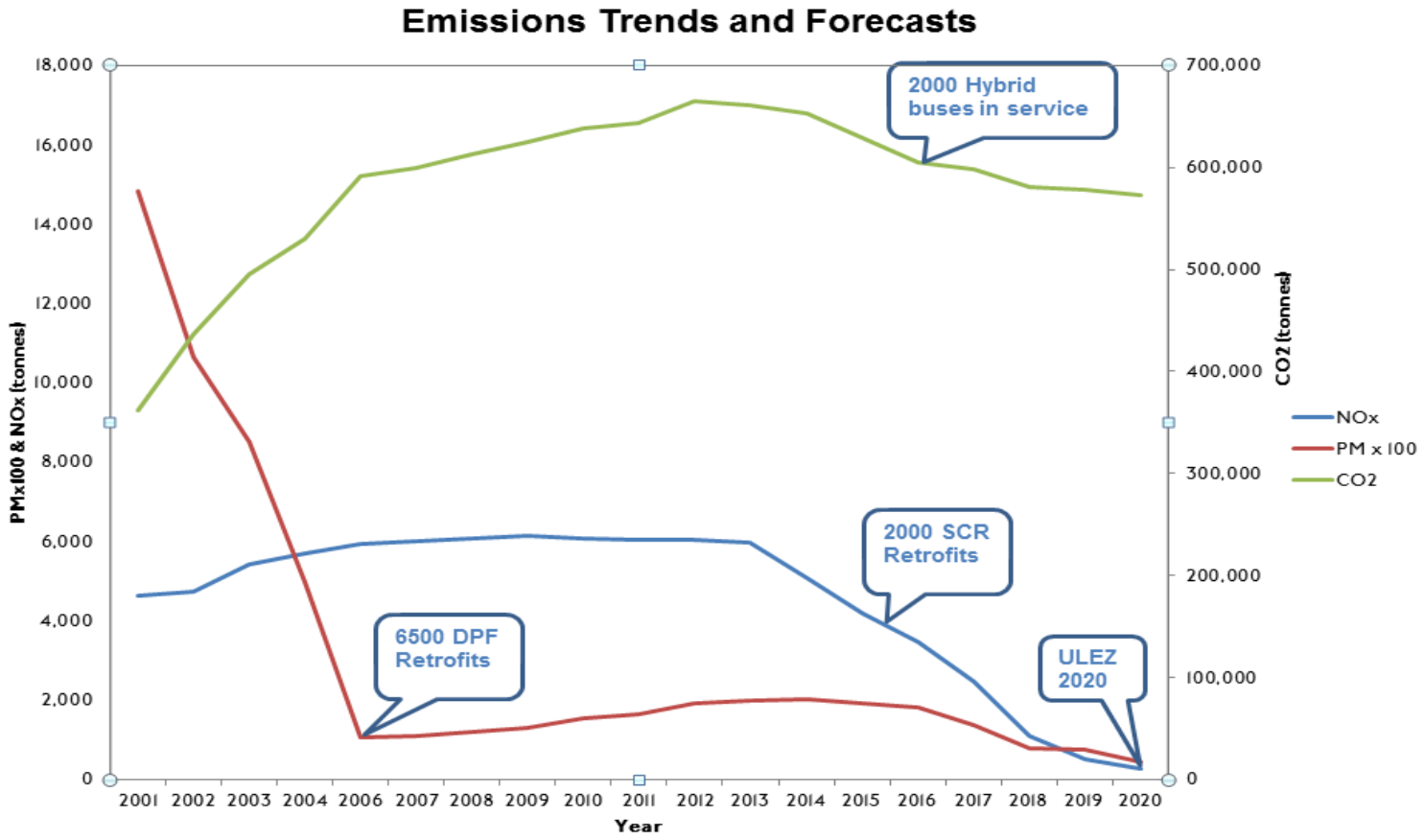
London wide Retrofit Programme

The Challenges

- Limits of the technology
- Greater pressure to deliver
- Tougher financial environment
- Variety of vehicle types in scope

Fleet emission trends – Diesel buses

- The DPFs have shown a 90% reduction over TfL's real world test cycle.
- CO2 and NOx increased due to fleet enlargement, current retrofit programme significantly reducing Nox.



Hybrid buses

- Offer the most cost effective means of CO_2 reduction (30%)
- 2006 to 2010 – Trials with 56 buses across 8 operators
- Double decks most effective
- 2012 – 300 vehicles in fleet, followed by a series of milestones
- 2012 – New Routemasters introduced (1,000 now in service)
- **2018 – Over 3,000 in service, and TfL procuring only hybrids (and/or zero emission) double deck buses**
- Technology evolves, to reduce costs for the same outcomes - supercapacitors or lower voltage systems are being introduced.

Hydrogen fuel cell buses

- Trial buses - 10 single deck fuel cell buses in service
- 2 new Van-Hool buses recently joined the fleet
- Most of the current contracts run out in 2020
- Tendering for 20 more single or double decks and new hydrogen fuelling station using European project grant funding (JIVE)
- Outcome expected later this year
- Vehicle cost is still a challenge.

Electric Buses – Single Deck

- Currently 91 single deck

Vehicle Type	Operator	Route	Charging Strategy
Irizar i2e 2 Buses	Go-Ahead	108	Overnight
BYD K8SR 5 Buses	Metroline	98	Overnight
9 Buses	Arriva	312	Overnight & Fast charge mid duty at depot
Optare Metrocity 4 Buses	London United	H98	
ADL/BYD E200 51 Buses 13 12	Go-Ahead	521/507 360 153	Overnight

Electric Buses – Double Deck

- 5 buses have been on trial since 2016
- Awarded contracts for two trunk double deck routes to operate with electric double decks
  - *Route 43 – 37 BYD / ADL buses*
  - *Route 134 – 31 Optare buses*
- The largest fleet of double deck zero emission buses in Europe
- Stimulate market, encourage development of zero emission double deck buses
- Currently, limited models in market, but the tendering process has accelerated development.

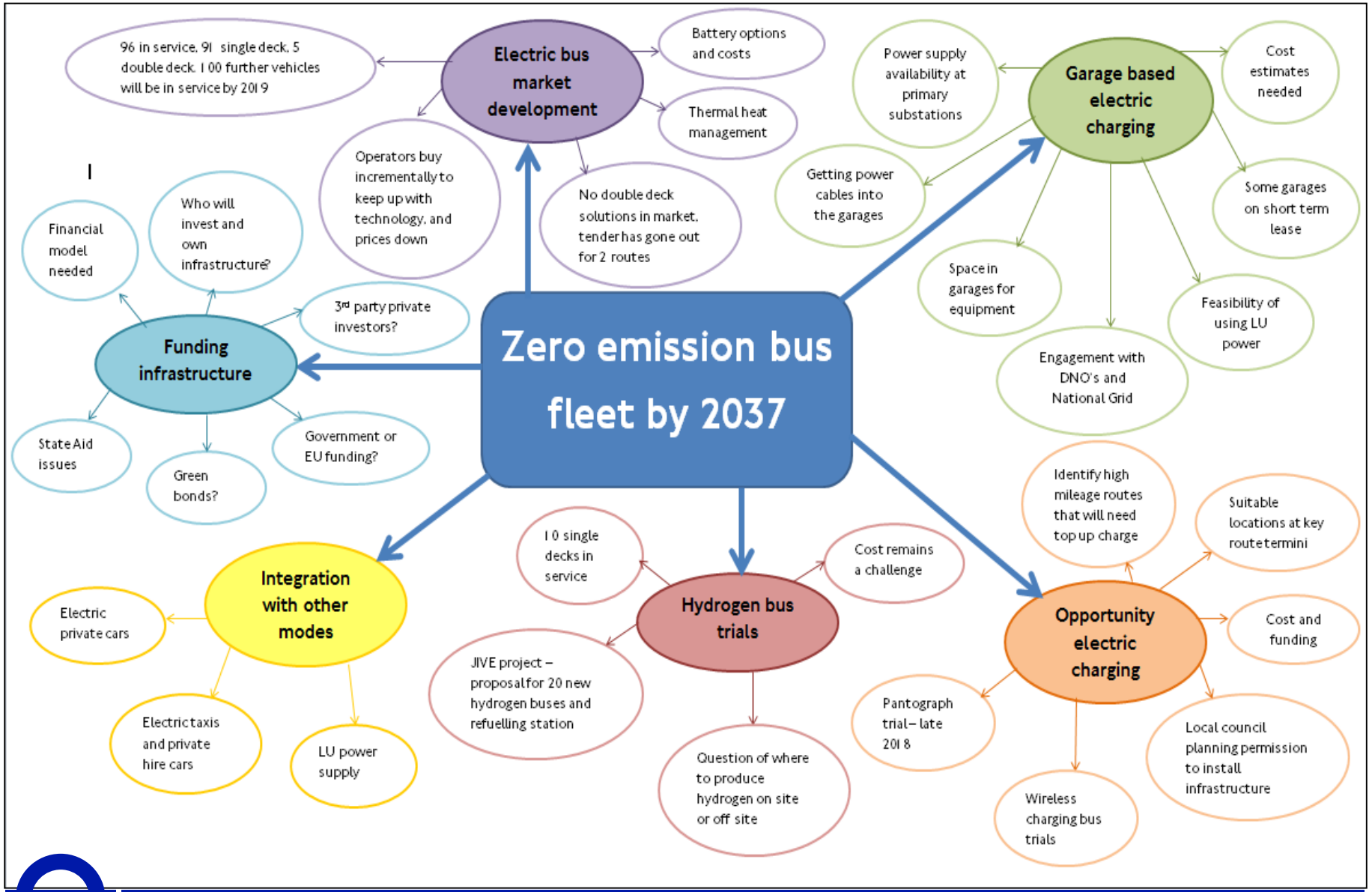
Electric Buses - Charging Infrastructure

- Operators bid for entire cost of running a route – includes vehicles and charging infrastructure
- Current focus on garage based charging – 79 garages across London – every site different
- Opportunity on route charging will also be required on longer routes
- Power supply upgrades required at some locations i.e. new sub-stations
- Waterloo bus garage – first electric bus garage in London
- TfL is looking at how to supply electricity to all 79 bus garages and associated costs
- Electrification of garages comes with challenges.

Electric Buses - Challenges

- Overall costs remain higher than diesel
- Suitable vehicle weight / range/ capacity for London environment
- Battery Life – we do not know yet the life of a battery
- Heating – impact on the battery range?
- Ability of Distribution Network Operator(s) to support rollout – mainly garage based charging supplemented by opportunity charging
- Energy storage – need to better understand alterative solutions
- Space limitations in some garages
- Limited funding available.

Roadmap to Zero Emission - 2037



Summary...

- Clear agenda for air quality from now until 2020
- Developing a roadmap to achieve 2037 target
- Technology is constantly developing
- We are all learning – wrong decisions could be expensive.

Action on Air Quality

&

Leadership by Example

Patrick Warner

Business Development Manager

Brighton&Hove

METROBUS

Success

- More than doubling of passenger numbers in past 20 years in Brighton & Hove and Crawley/Gatwick
- Brighton has highest bus use per head in UK outside London – 158 per head, three times national average
- Award winning
  - Top City Operator last 2 years
  - Top National Depot at Crawley for 3 years
- Profitable – strong investment

We're part of The Go-Ahead Group

Brighton&Hove

METROBUS

BRIGHTON & HOVE: THE CLEAN AIR CITY

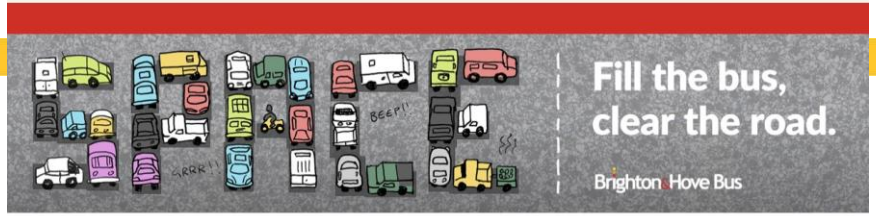
A BLUEPRINT FOR THE ROLE OF SUSTAINABLE PUBLIC TRANSPORT

2018

Brighton&Hove

Brighton&Hove menu

METROBUS



Freeing up valuable road space for everyone

Brighton & Hove Buses has launched an advertising campaign around the city drawing residents' attention to the growing problem of congestion on our roads.

The adverts show spaces filled by cars that spell out the words Full, Jam and Space. The strapline is Fill the bus, clear the road.

A full double decker bus can take 75 cars off the road - that's enough to free up the length of three football pitches.

It is the volume of traffic that creates congestion on our roads and slows down all vehicles making journey times much longer for everyone. And it's getting worse.

It's also congestion that leads to high emissions that leads to toxic air, illness and death.

It's time to tackle congestion. It's time to clear the roads.

Look out for an animated version of the advert on the Bright Light Screen on North Road, and on billboards and bus stop panels across the city as well as the back of some buses.

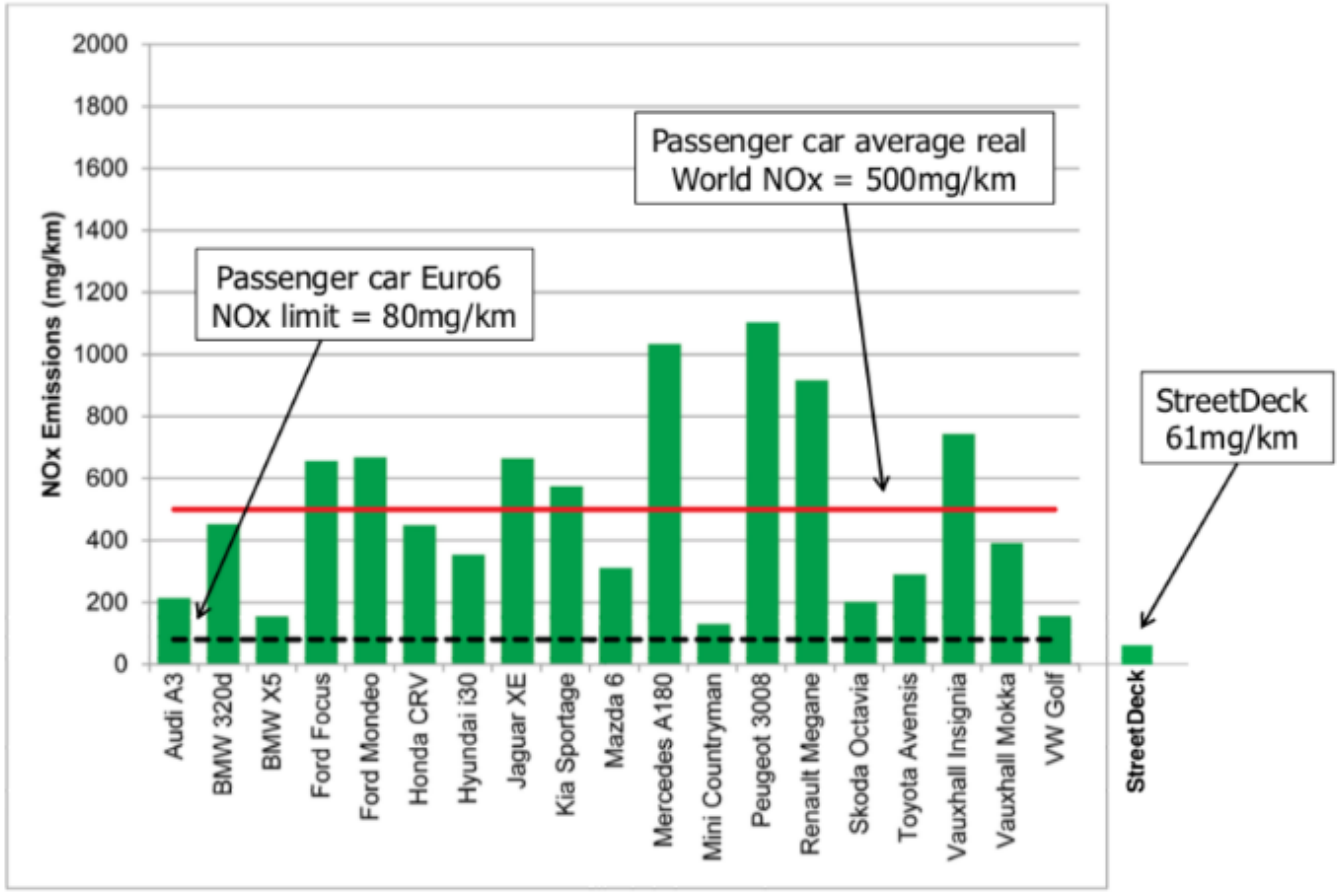
Heavy investment in Euro 6 low emission diesel since 2015

Innovative Microhybrid Wrightbus Streetdeck and Streetlite buses

Brighton&Hove

METROBUS

StreetDeck NOx compared to Euro6 Passenger Cars



StreetDeck NOx from MLTB test April 2016 / Passenger car NOx from DfT emission testing April 2016

Visionary progress towards zero emission in London

- Go Ahead London's Waterloo Garage is the first all electric fleet in Europe at launch
- 50 Alexander Dennis/BYD E200 single deckers operating former Red Arrow commuter routes 507 & 521
- Visionary thinking and learning by our colleagues which has shown what can be achieved and got a lot of other towns, cities and operators thinking about how they can go zero emission

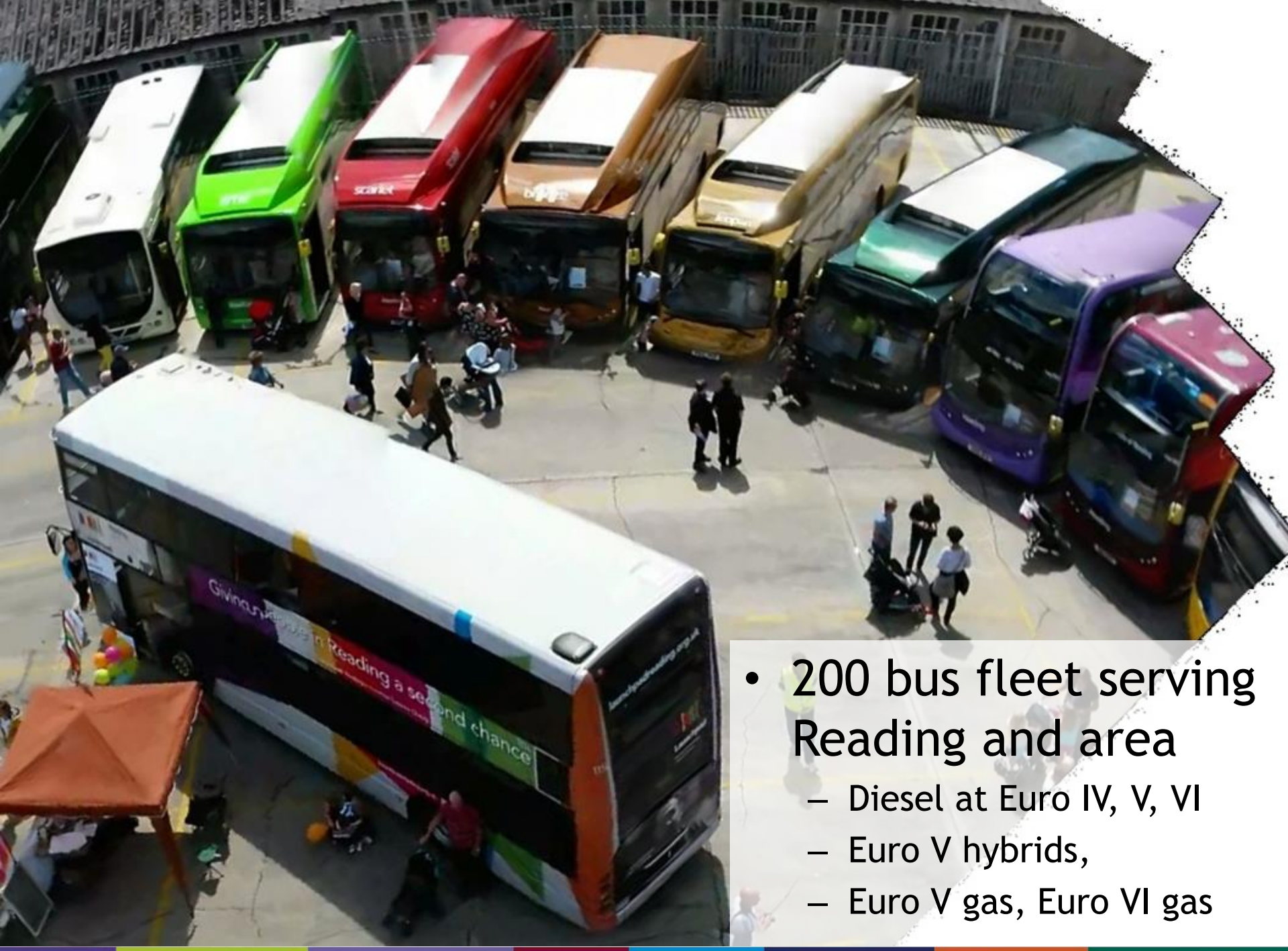
So where next in our quest to go zero emission?

- 20 Hydrogen Fuel Cell Electric buses for our premium Fastway BRT service in Crawley, Gatwick and Horley
- Jive 2 Project – helping get Fuel Cell Electric buses into production and on a pathway to reduced prices of both the buses and the fuel
- OLEV Ultra Low Emission Bus fund helping to bridge the gap in current business case (if successful with our bid

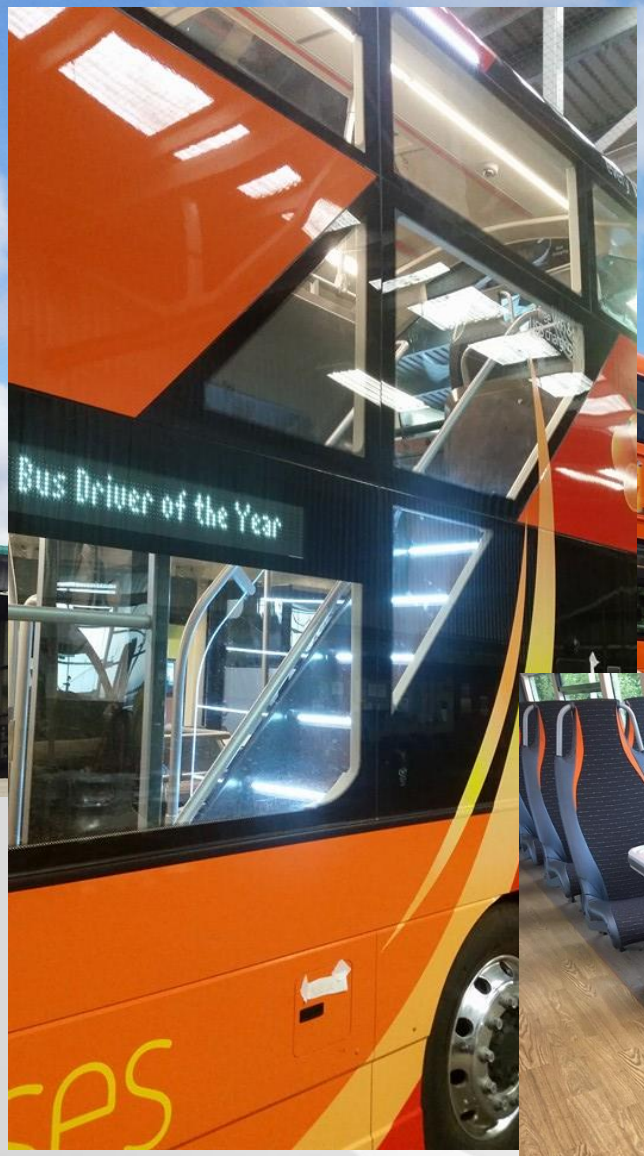
Why Hydrogen Fuel Cell Electric?

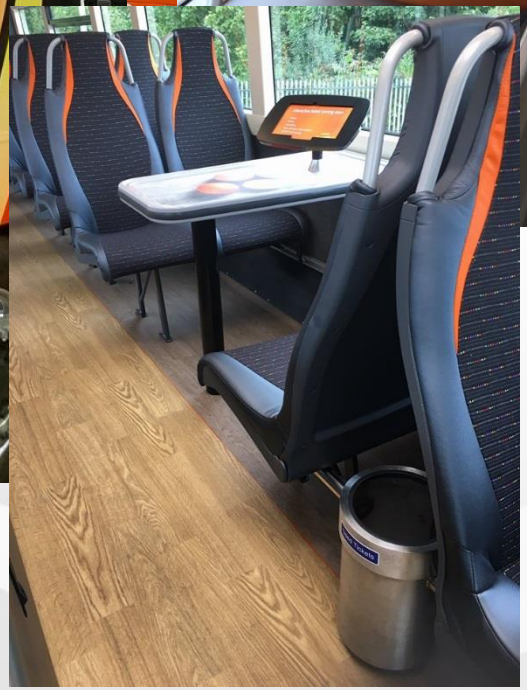
- The only current means of electric bus that is capable of matching the operational flexibility of conventional diesel powered buses
- On the road for up to 400 miles and 24 hours
- Refuelled in just a couple of minutes longer than it takes to fill a tank with diesel
- Less intensive use of a far smaller number of batteries because the fuel cell keeps them fully charged with no destructive drain/recharge
- Green hydrogen means no costly major substation upgrades, no unsightly top up charge roadside infrastructure, easy refueling process alongside diesel in bus depots and a genuinely zero emission bus no just at the tailpipe but in the power generation too
- Fast moving pricing progress now with multiple fuel suppliers offering parity with diesel and whilst there is still a gulf in vehicle pricing, projects like Jive are aimed to raising profile of hydrogen and bringing costs down

Questions



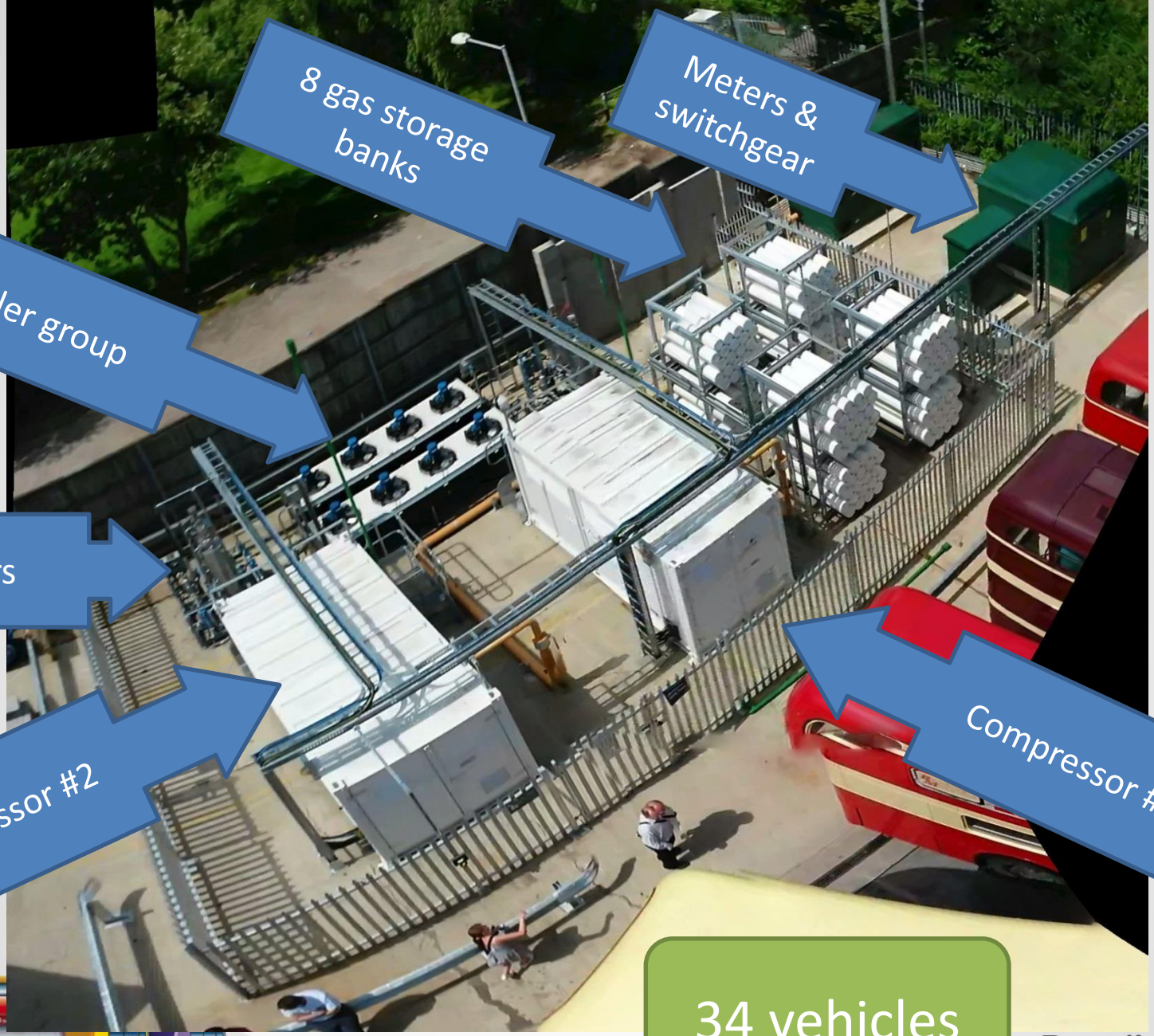
- 200 bus fleet serving Reading and area
  - Diesel at Euro IV, V, VI
  - Euro V hybrids,
  - Euro V gas, Euro VI gas





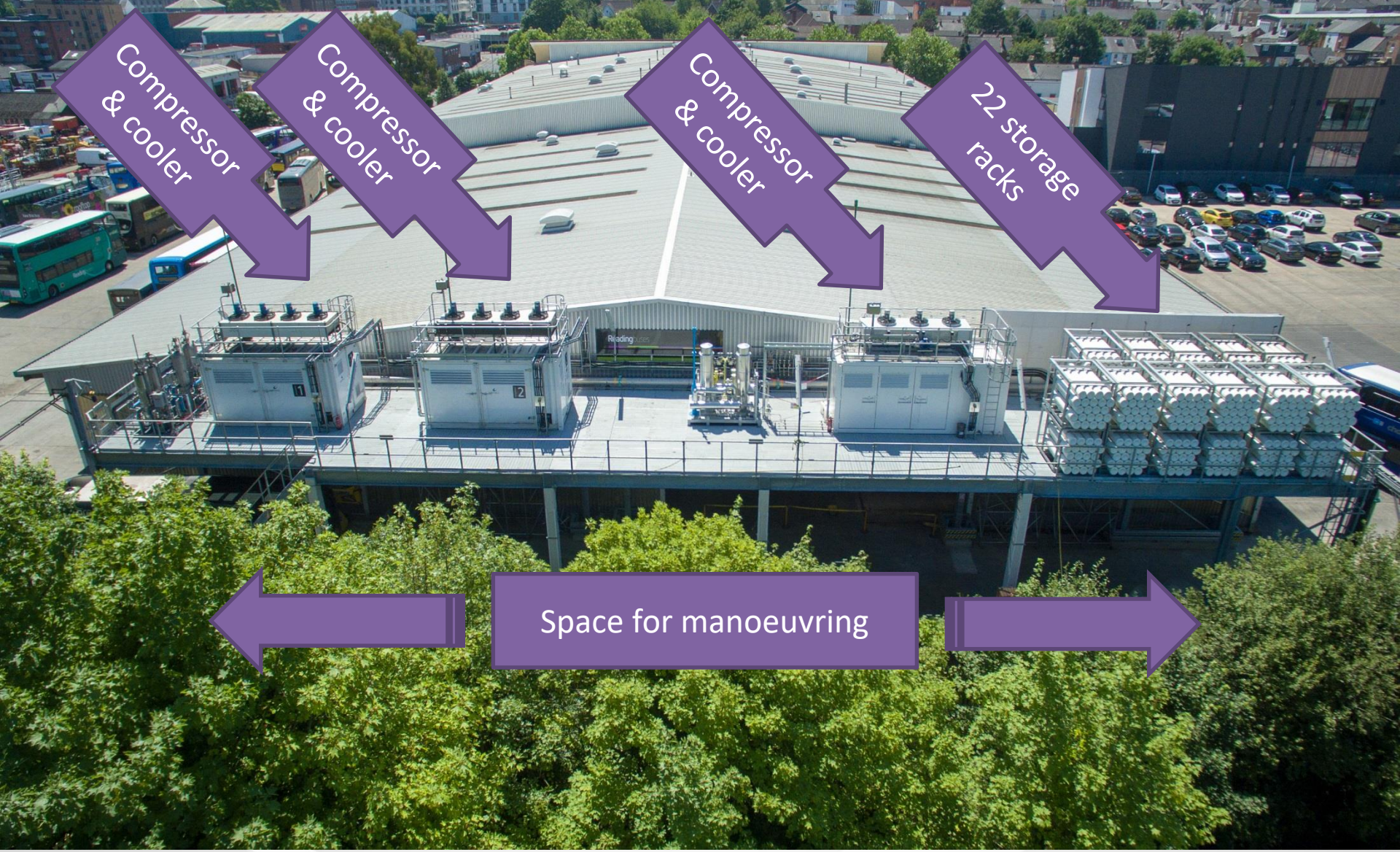
Readingbuses

Readingbuses



34 vehicles

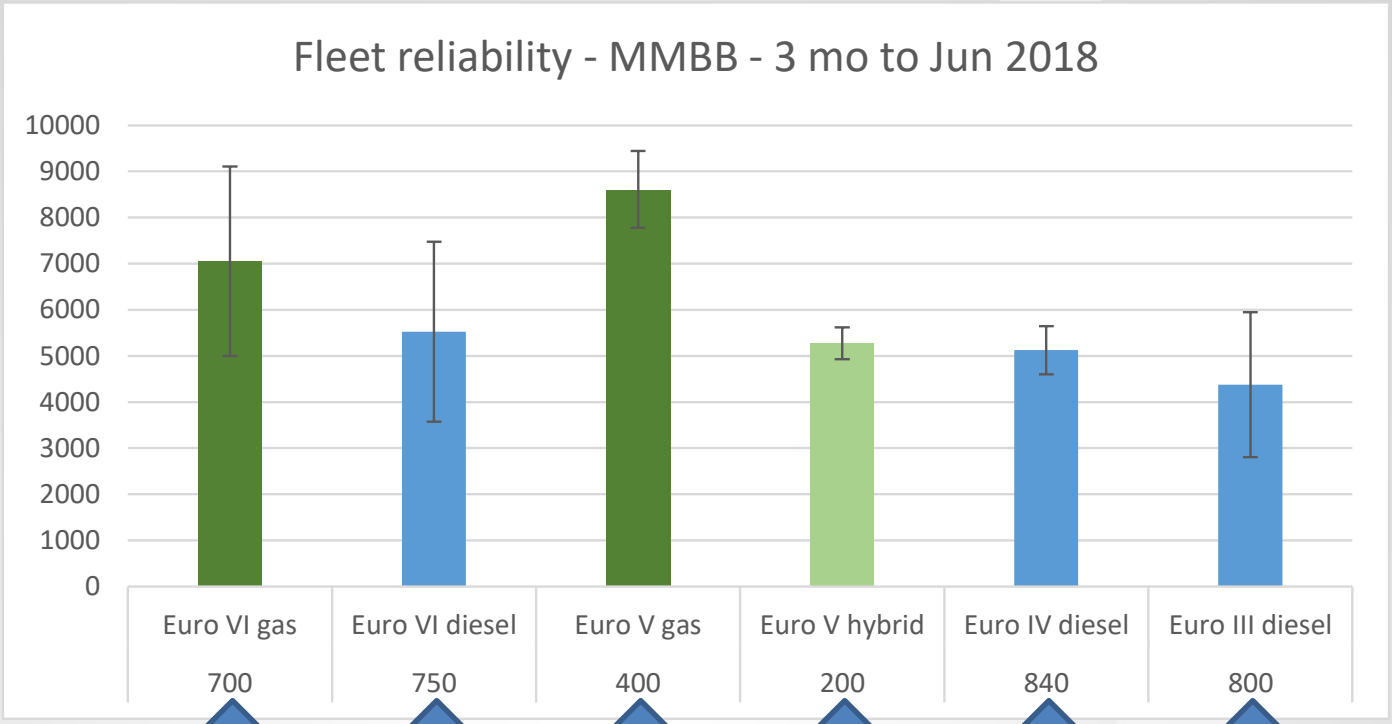
Readingbuses



72+ vehicles

Readingbuses

Readingbuses



Budget materials

Warranty

Labour, facilities, training, contracts

£1200*

£3600

£4600

£6000

+£10k

£4900

£4300

Readingbuses

- Gas is clean, reliable, cheap(er)
- Electric is the future, technology developing, battery risk must be managed and costed
- Vehicle, and the service provided, comes first.

Reading buses

How quickly will EVs penetrate the UK bus parc?

Low Emission Bus Workshop Cardiff, 19th July

Principality Stadium

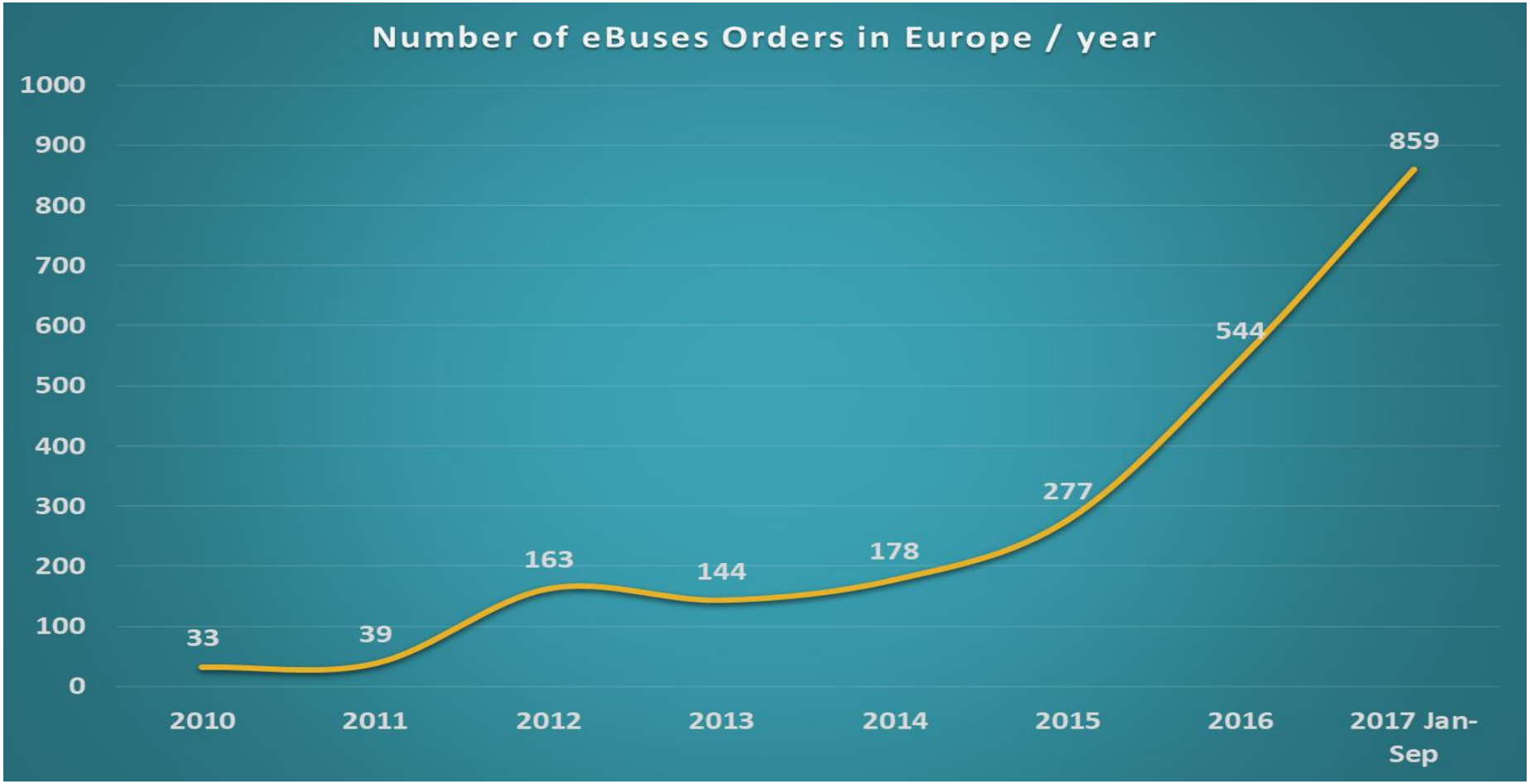
LowCVP
Low Carbon Vehicle Partnership
Connect | Collaborate | Influence

Discussion Panel

European EV uptake

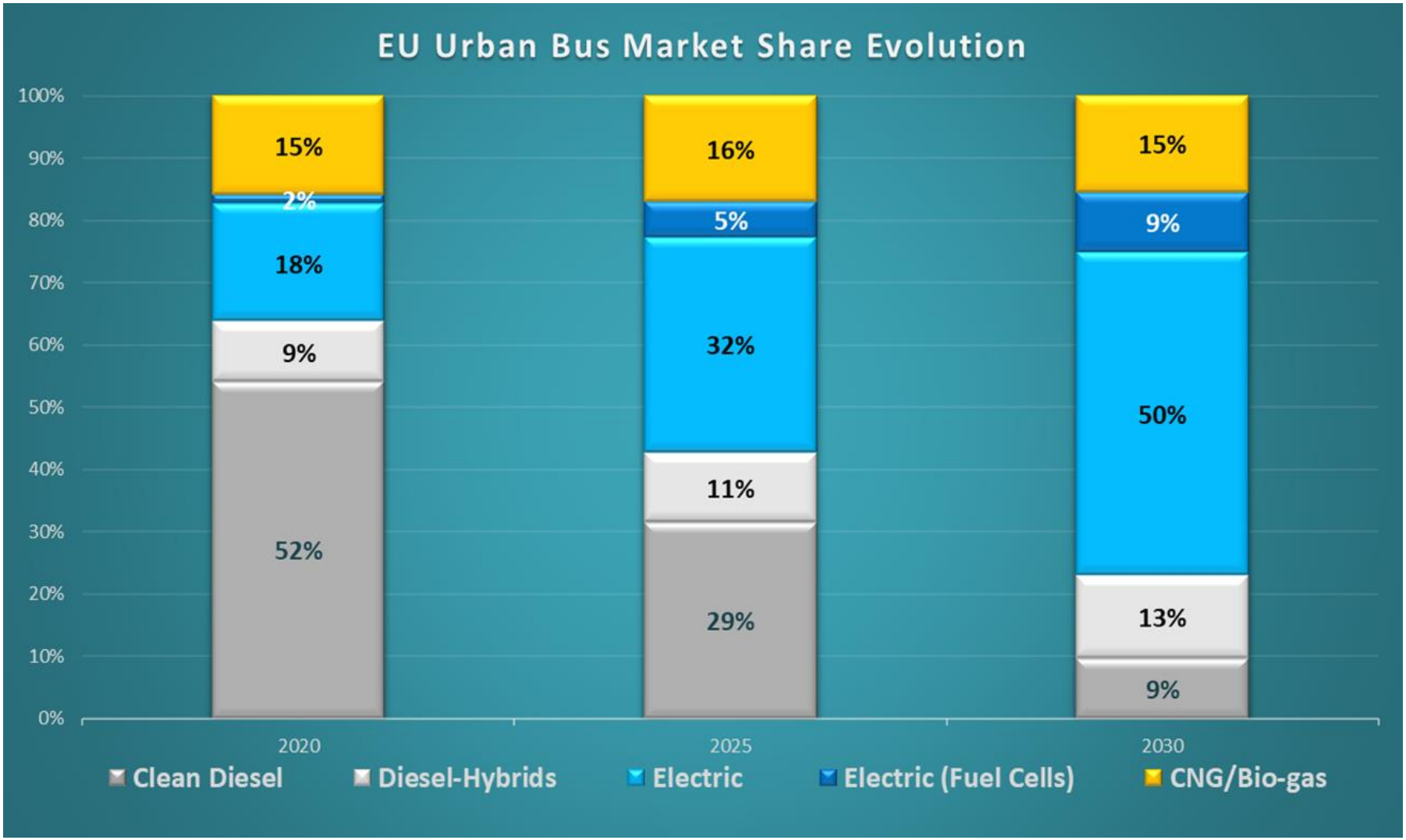
Connect Collaborate Influence

Significant increase in EV registrations across EU over last few years



Source: UITP 2017

EU Markey share predictions (UITP)



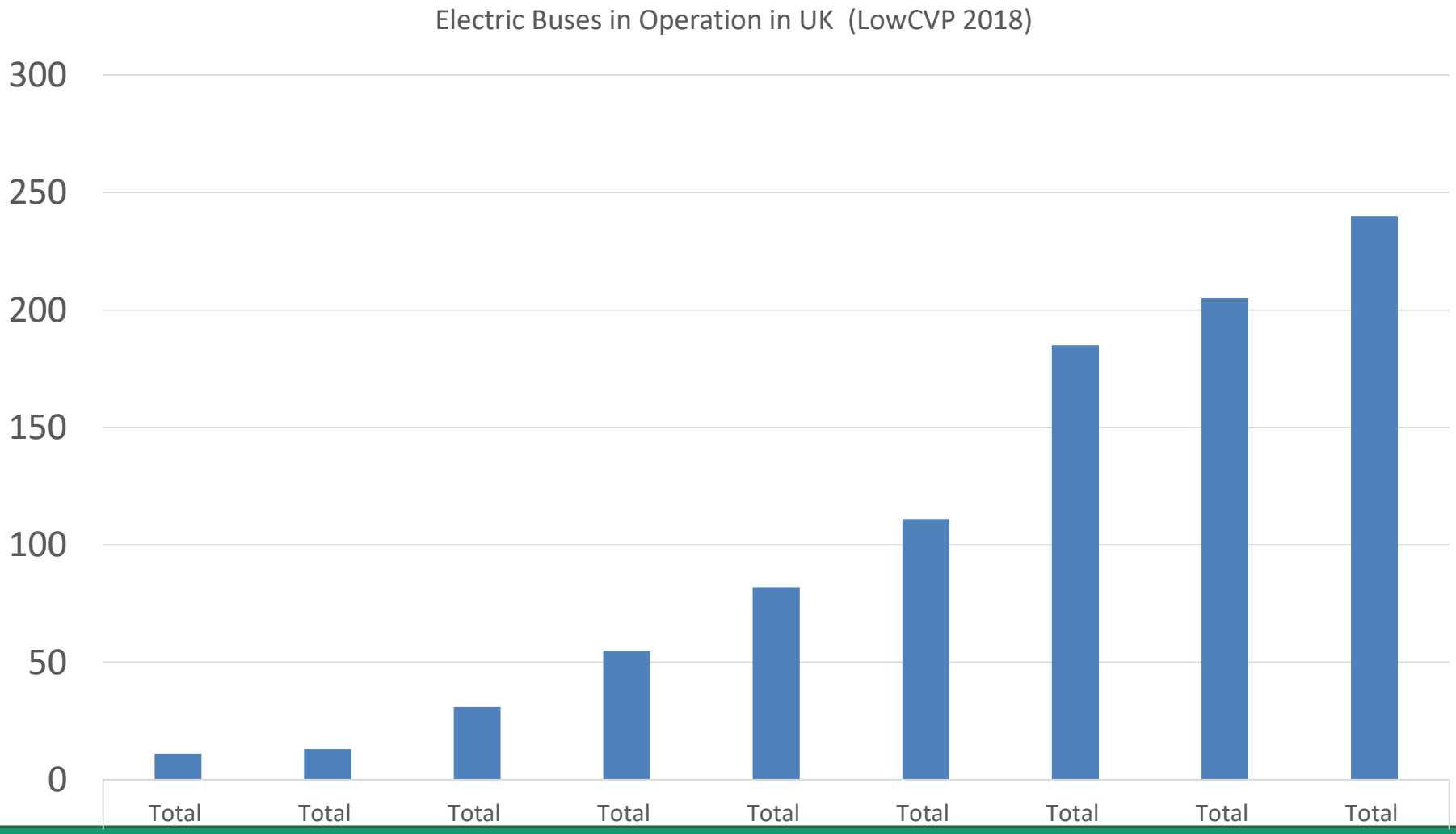
Source: UITP 2017

UK EV uptake

Low Carbon Vehicle Partnership

Connect
Collaborate
Influence

Steady EV deployment – still <1% total UK bus parc



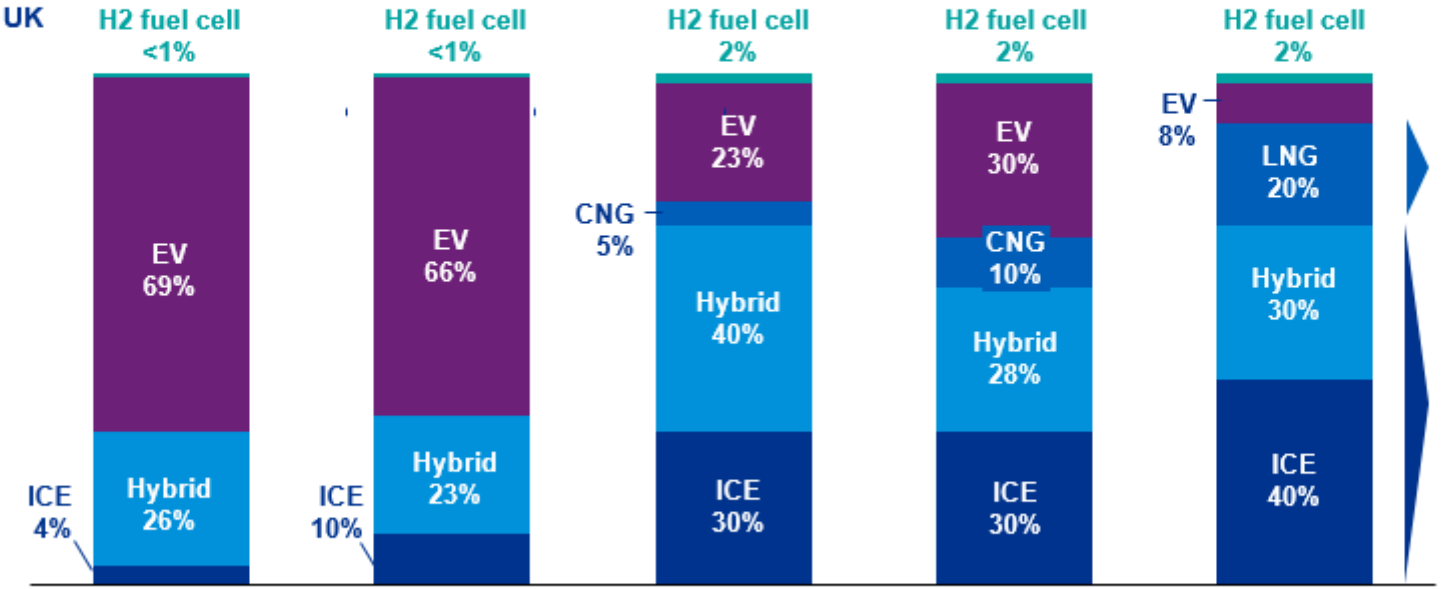
UK Parc by 2030 – KPMG Analysis

Low Carbon Vehicle Partnership — Connect Collaborate Influence

2030	Passenger Cars	LCV	Bus & Coach	MCVs	HGVs
Total parc	32m	4m	75k	180k	375k
ULEV or low carbon % of parc	20%	25%	10%	14%	6%

KPMG

Market share - UK sales % by drivetrain type



'Sustainable' CNG/LNG would use bio-gas

Biofuels currently constitute 4.75% of the fuel mix. By 2032, this will be mandated to be 12.4% by volume

Notes: (1) Commercial vehicle classes defined by weight as: 3.5t (LCV); 3.5t-16t (Bus); 3.5t-16t (MCV); >16t (HGV); >40t (Gigaliner)

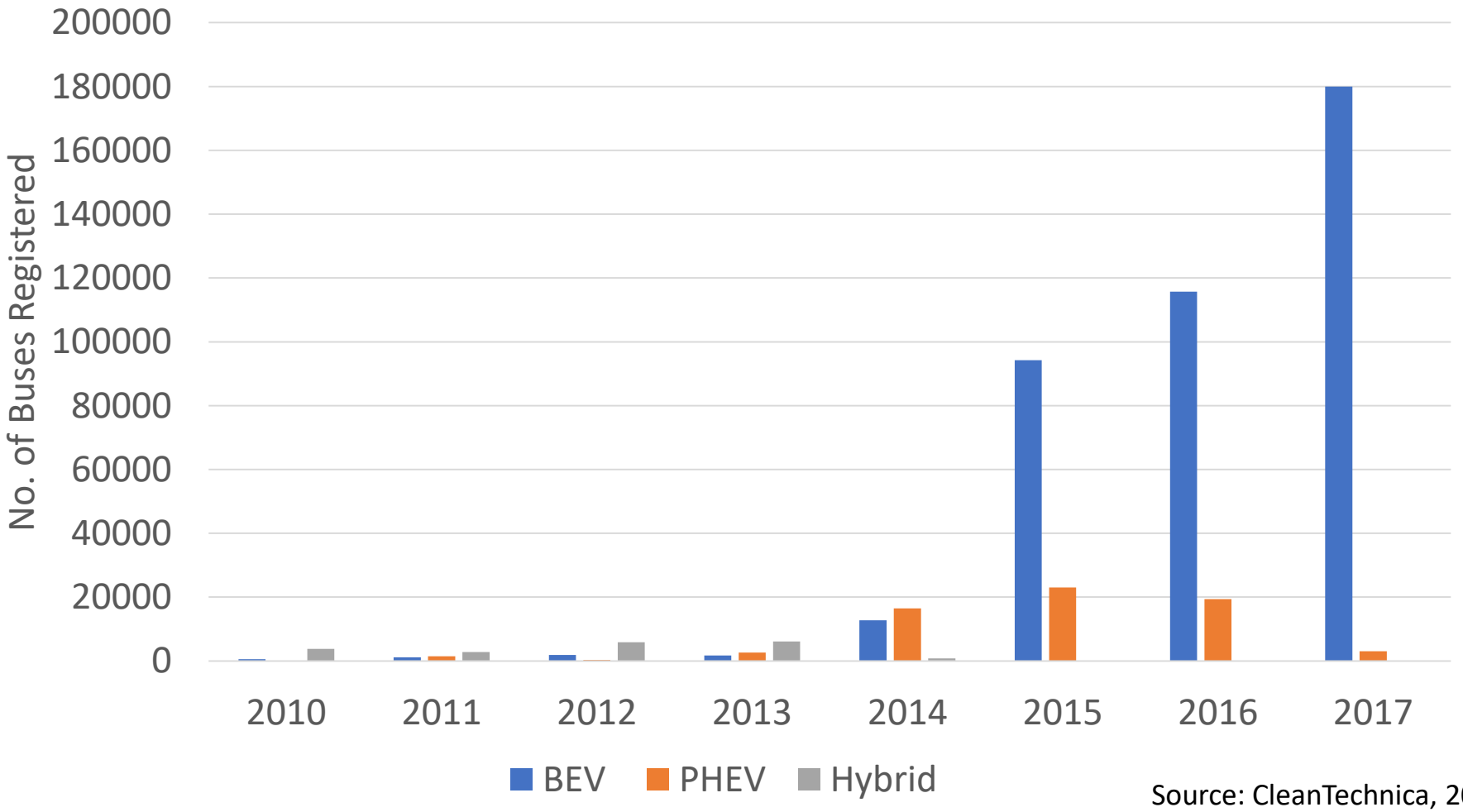
(2) Hybrid is non plug-in electric hybrid. (2) H2 Fuel Cells convert H2 to electricity in the vehicle. (3) EVs include BEVs and PHEVs only. (4) ICE include all vehicles using either petrofuels or biofuels.

Source(s): (1) National Statistics: UK Department for BEIS (2) KPMG Mobility 2030 analysis (3) International Council on Clean Transport (4) SMMT (5) ACEA (6) TfL

Source: KMPG, Mobility 2030, 2018

Chinese market way out in front

Huge production volumes in China, one city has over 16,000 EV buses



Source: CleanTechnica, 2018

UK Battery Electric Suppliers

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

Optare

WRIGHTBUS

Irizar e-mobility

VOLVO

ALEXANDER DENNIS

BYD Build Your Dreams

YUTONG

Small bus

mellor

Expected in future

SCANIA

Supporting infrastructure

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

Overnight charging in depot

Slow/Fast: *4-8 hours*, low power: *3-80kW*

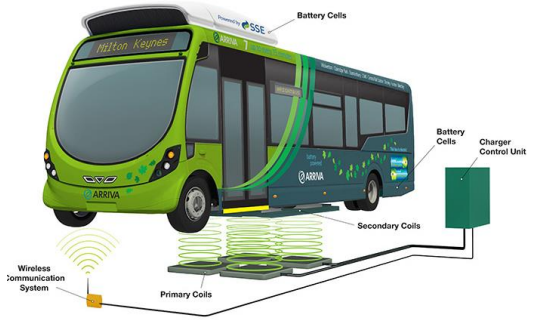
Stabilise cells in battery to ensure long-life

On–Route "Opportunity" Charging : Charge at start/middle/end of route at bus stop or during driver break.

Short charge time: *2mins – 1 hr* at high power: *40kW-650kW*.

Conductive – Pantograph/Plug-in connection

Inductive – power transfer between grid connected coils and bus



Battery Electric Buses

LowCVP Low Carbon Vehicle Partnership — Connect Collaborate Influence

OEMs: Optare, Wrightbus, ADL/BYD, Yutong, Irizar Magtec (reftofit)

UK Fleet: 230 in service across UK

Key Fleets:

London: 53x ADL/BYD E200EVs (plug-in charge)

York – 6 x Magtec retrofit double deck sightseeing buses (overnight + plug-in on route)

Nottingham – 45 Optare Solo/Versa + 13 BYD k9 (plug-in)

Milton Keynes: 10 x Wrightbus (overnight + inductive)

Harrogate: 8 x Volvo 7900 E (OppCharge on-route)

Lothian : 6 x Wrightbus StreetAir (plug-in – no gov't funding!)