Cleaning London's Fleets – TfL's Approach to Cleaner Vehicles

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Clean Fleets Workshop
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MAYOR OF LONDON

Transport for London

An Integrated Transport System

TfL manages the Tube, DLR, London Overground, Emirates Air Line, Tramlink, Barclays Cycle Hire, Taxis, River Services and all London's buses

Every weekday in Greater London, around 28 million transport trips are taken:

- 11 million car / motorcycle trips
- 6.5 million journeys are made on London's buses
- 6 million on foot
- 3.1 million on the Underground
- 0.5 million by bicycle
- 0.2 million by taxi

Are EVs right for London?

Electric Vehicles...

- Emit 40% less CO_2 using today's UK grid mix – potentially very low / zero carbon in the future
- Have no tailpipe emissions

➔ Mayor's Electric Vehicle Delivery Plan launched in Seoul, May 2009

London's Taxis and Private Hire Vehicles

- Around 22,000 licensed taxis and 50,000 private hire vehicles (minicabs)
- Contribute around 20% of harmful emissions from ground transport in Central London
- 15 year age limit for taxis and 10 year age limit for private hire vehicles introduced
- TfL and Mayor working with taxi and vehicle manufacturers to develop a low emission (zero emissions capable) taxi by 2018

TfL Plug-In Support Fleet

- 14 pure electric & Plug-In Hybrid (PHEV) cars & vans trialled since 2010
- Pool cars & dedicated fleet vehicles

TfL Plug-In Fleets: End-User Feedback

Q1: Is the EV as easy to use as a conventional vehicle?

YES	NO	Key Issues
64%	36%	• No air con during Summer • Range reduced by heating/fan

Q5: Are you able to be as flexible when using an EV as when using a conventional vehicle?

YES	NO	Key Issues
21%	79%	• Insufficient range on single charge • More workload planning required due to battery life

Q7: Have weather or other conditions impacted on usage?

YES	NO	Key Issues
50%	50%	• Heating in Winter/air con in Summer greatly reduce battery range

Q8:Are there sufficient suitable charge points?

YES	NO	Key Issues
36%	64%	• In addition to lack of charge points, slow charge rates hinder usability

Are there other faults can you think of with this particular EV?

YES	NO	Key Issues
57%	43%	• Poor range • Poor ergonomics/design • Lack of engine noise perceived as a hazard • Battery depletes when not in use

TfL Plug-In Fleets: Overcoming Barriers

Technical Issues

- Real world performance (primarily pure EVs):
  - operational issues (range, plugging in, recharge times)
  - specifications (effectiveness of ancillaries & impact on range)

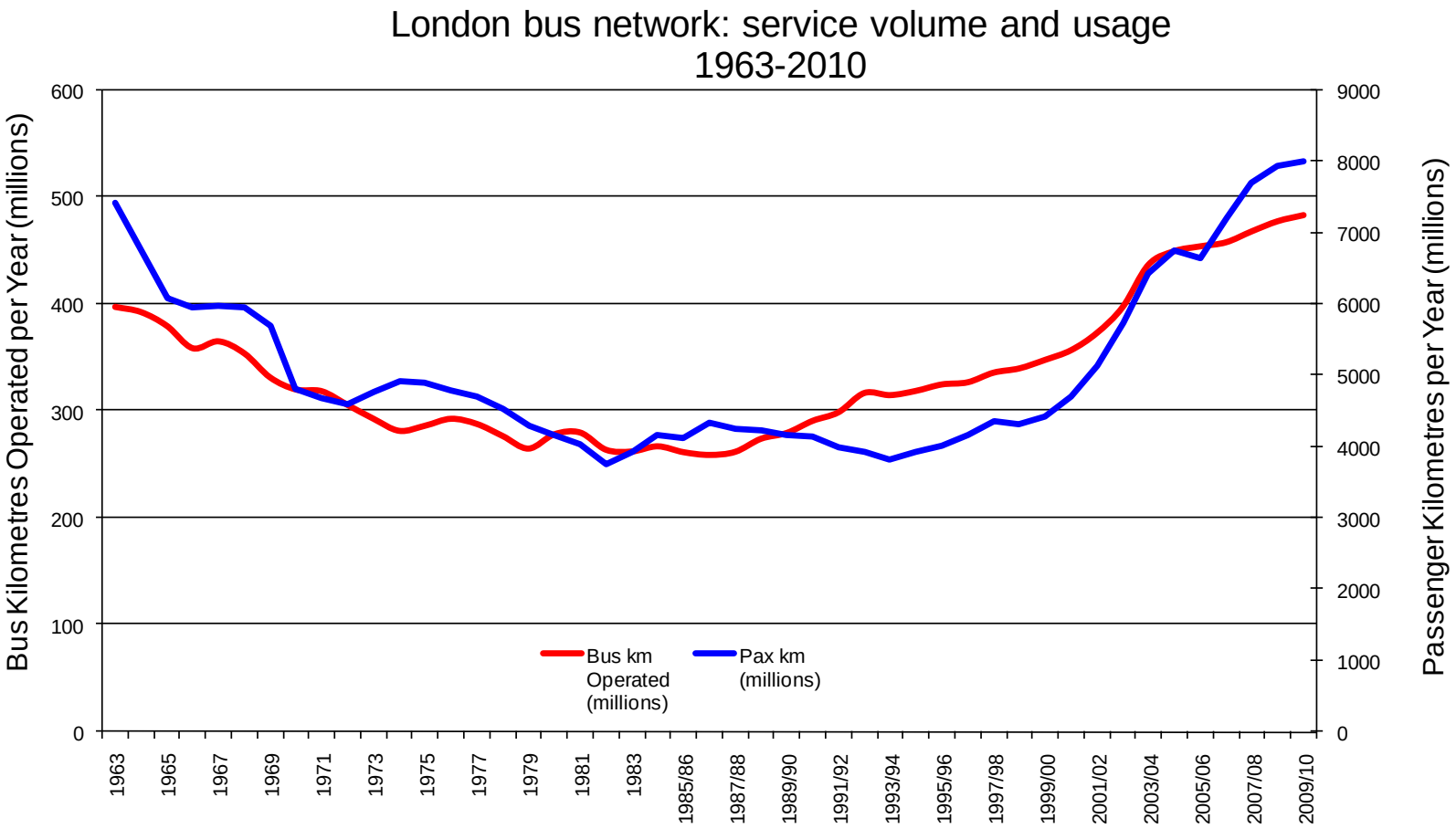
Solutions

- Technology:
  - Hydrogen fuel cells
  - PHEV vans
- More EV charge points – workplaces
- Service providers / contractual obligations (defined duty cycles)
- But – type approval cycle suitability for plug-in hybrid vehicle CO_2 certification & customer / user expectations

London's Bus Network

- One of the largest and most comprehensive urban bus systems in the world
- Over 50% of all public transport journeys in the Capital are bus journeys
- 30% morning peak rail journeys in London either start on a bus or are followed by a bus trip
- Weekly bus journeys made in London equate to around half the number of all bus journeys in England
- 8,700 buses carry over 6.5 million passengers every weekday; 2.3 billion passengers a year
- London's buses serve 700 routes with ~20,000 bus stops

Bus Usage in London: 1963 - 2010



Environmental Challenges from London's Buses

- Size of London's bus fleet and km have grown rapidly since 2000 and absolute emissions have subsequently increased
- Euro standards have not delivered expected improvements under congested urban operating conditions
- Consequently, air quality limit values for nitrogen dioxide (NO_2) and PM_{10} have not / are not being met

➔ Mayor has set a challenging target of reducing London's CO_2 emissions by 60% by 2025 from 1990 levels, along with a 40% reduction in PM_{10} and 50% in NOx emissions from road transport by 2017/18

Reducing the Environmental Impact of Buses

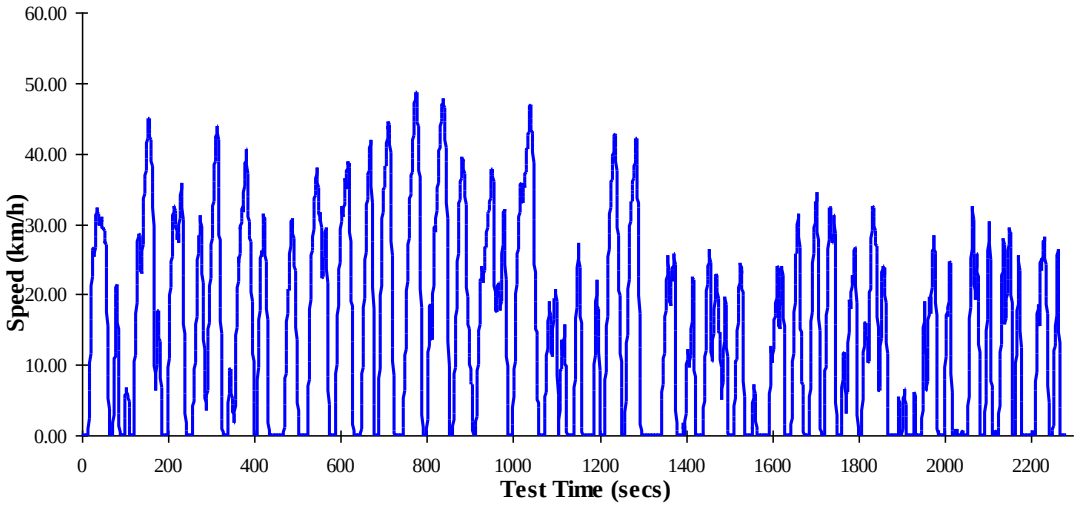
- Eco-driving, telematics & automatic engine shut down
- Biofuels
- Diesel-electric Hybrids
- New Bus for London
- Battery Electric & Induction Charging Trials
- Hydrogen Fuel Cell technology

TfL developed with Millbrook a 'real world' drive cycle based on Route 159 (Brixton to Oxford Street).

Every new type of bus is tested to measure CO_2, PM and NOx emissions.

Enables TfL to model the impact of the buses on London's emissions inventory & predict the impact of interventions.

This cycle has representative exhaust temperature – essential for development of after-treatment, such as SCR



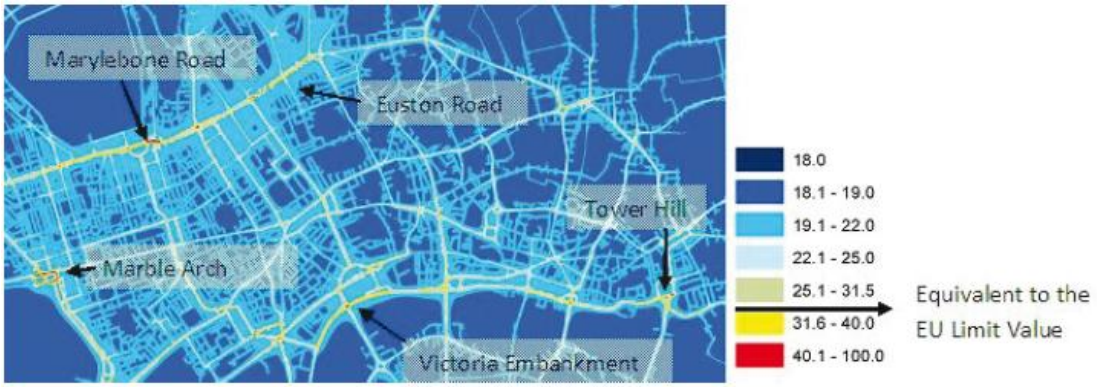
Hybrid Buses and the Environment

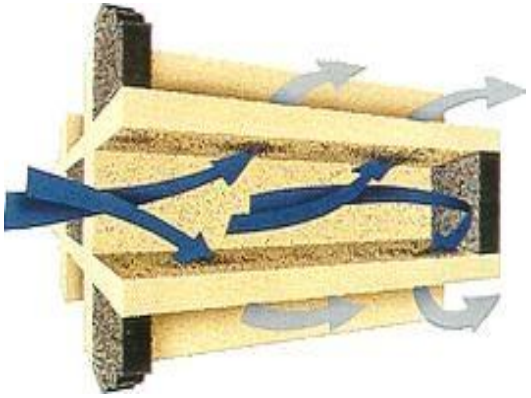
London Buses operates Europe's largest fleet of green buses, and they're getting greener

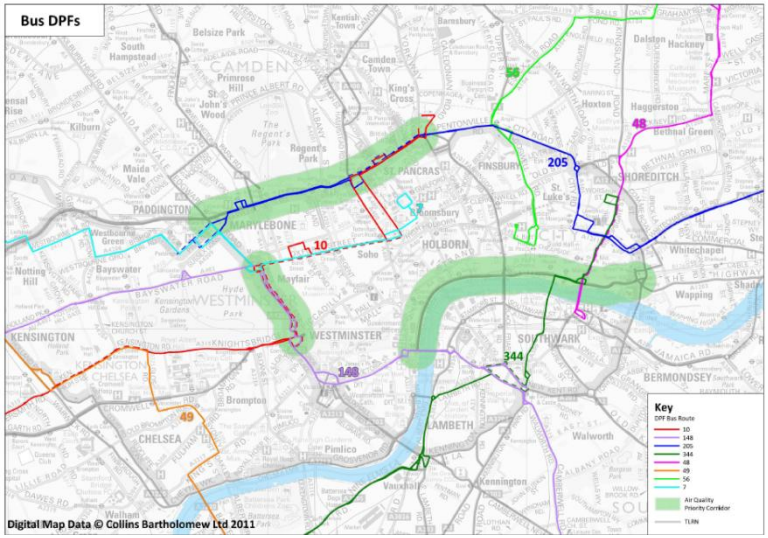
- 600 New Bus for London ('New Routemaster') vehicles will be in service by 2016. The NRm is the greenest diesel-electric hybrid bus in the world
  - When all the NRm's are in service, CO_2 emissions in the capital will be reduced by around 20,600 tonnes a year

- By 2016, 20 per cent of London's bus fleet will be hybrids - over 1,700 buses
  - Hybrid buses are much cleaner, quieter and more efficient than their conventional diesel-powered counterparts
  - Hybrid buses deliver a minimum 30 per cent reduction in CO_2 emissions and 30 per cent better fuel economy when compared to conventional diesel buses

Clean Air Fund DPF Retrofit to Euro IV & V Buses





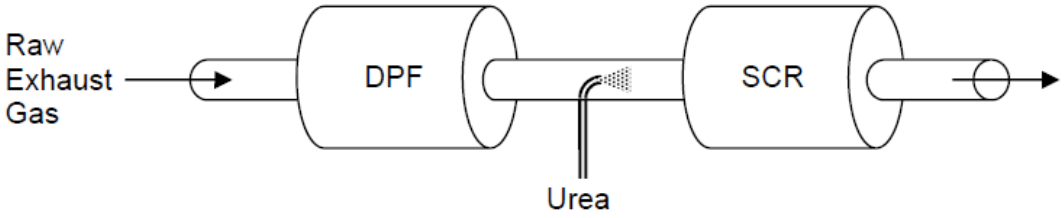


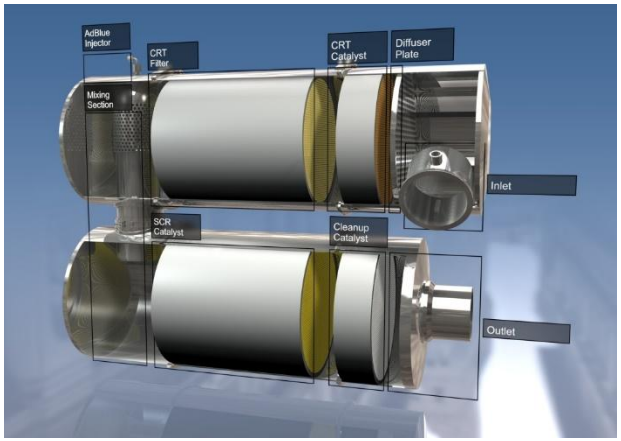
NOx Abatement Retrofit Programme

- £10 million funding (DfT/TfL) to retrofit 900 Euro III buses with SCR
- TfL developed a bespoke NOx retrofit standard
- 900 buses will be retro-fitted by March 2014
- NOx reacts with ammonia over the catalyst and reduces it to nitrogen and water:

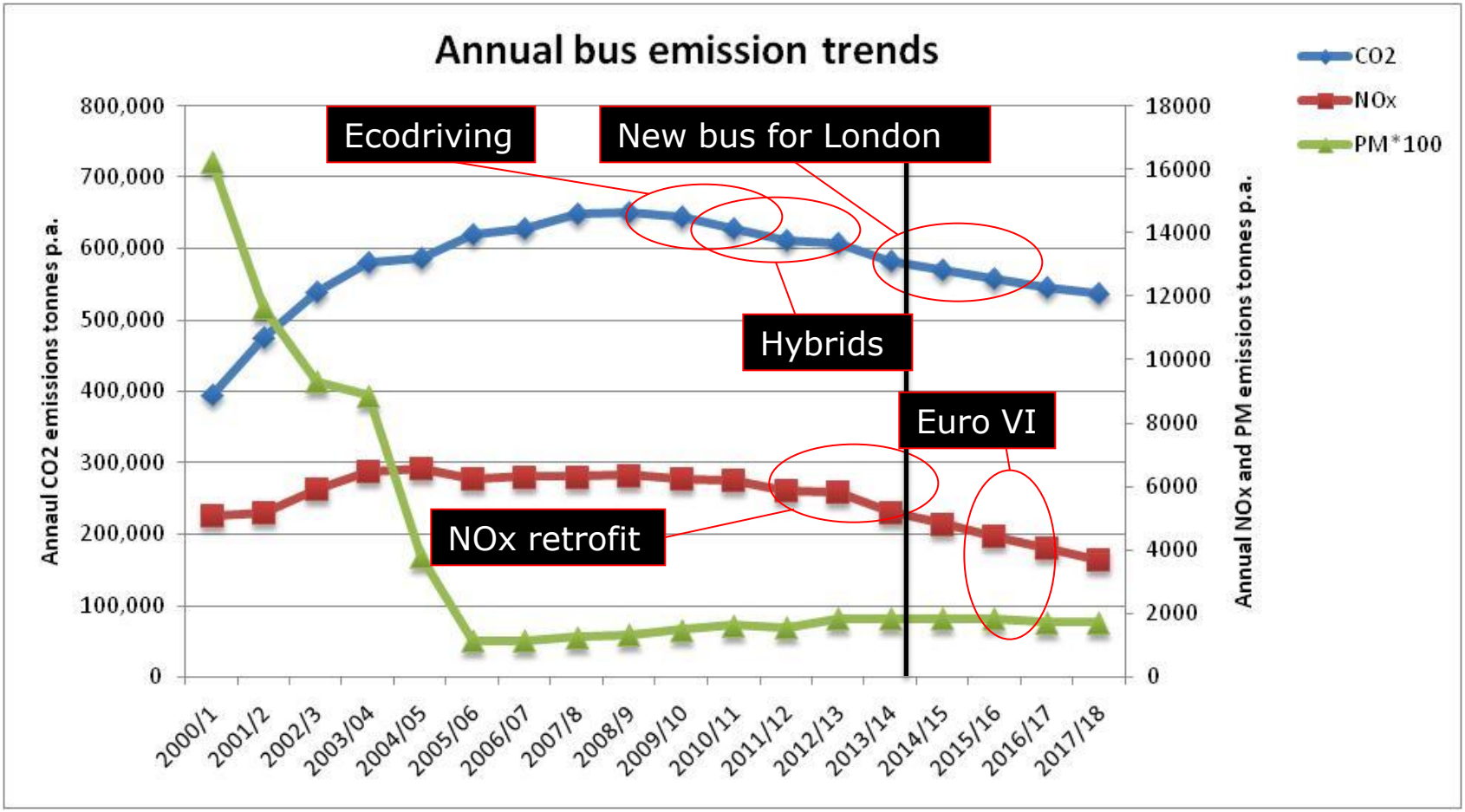
$$(NO \text{ and } NO_2) + NH_3 \rightarrow N_2 + H_2O$$

$$N_2O + NH_3 \text{ (Secondary Emissions)}$$





Impact of Bus Emissions Reduction Strategy



Hydrogen Buses

CUTE Programme (2004 – 2007)

- 3 buses in operation in Central London
- Demonstrated fuel cells could be used to reliably power buses in operation
- Limited range, 8 hrs of operation/day

CHIC Programme (2010 – 2016)

- 8 buses in service
- Introduction of hybrid technology alongside the fuel cell
- Increased range and fuel efficiency
- Operating equivalent service to diesel (up to 20 hrs/day)

Hydrogen Refuelling Stations in London

- A new refuelling facility was constructed at Lea Interchange bus garage
- Static gaseous hydrogen storage (500kg), replenished by a dual-phase tanker (3.5t – liquid H_2)

- Additional high-pressure (700 bar) HRS built at Heathrow
- Serves 5 FCEV taxis and Hyundai ix35 fuel cell cars

Research Priorities for e-Buses

- Pure electric buses: the need to address operational viability & durability of battery technology (realistic vehicle range, recharging time, battery degradation)
- Plug-in hybrid or range-extended diesel-electric hybrid buses: to address practicality & operational demands, and to quantify potential fuel / carbon savings over existing hybrid bus technology
- Opportunity charging: investigate the potential of static (e.g. bus stations), en-route (e.g. bus stops) and dynamic (e.g. bus lanes) wireless charging systems and fast / rapid charging for extending range and maximising asset availability

Electric Bus Trials in London

- TfL, via bus operators, are undertaking a number of electric bus trials in 2014
- These will involve 8 single deck pure EV buses in both central London and outer suburbs / boroughs

- Size of batteries in this application is important: to provide a range of 250 km (~150 miles) implies a battery mass of well over 2 tonnes – equivalent to the weight of some 30 passengers

Challenges for Electric Buses

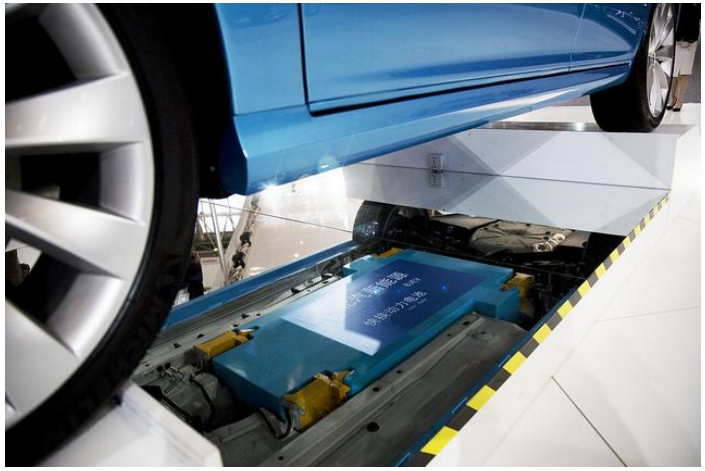
- Impact of ancillary loads (lights, HEVAC, air compressor, power steering, battery cooling) reduces available range. During extreme weather these can be as much as the energy for moving the vehicle
- Key to successful operation of electric buses is maximising asset utilisation. This can be achieved by:

  ➔ recharging during the inter-peak period(s), but this can impact on TVR / PVR ratio, or

  ➔ rapid charging, either through DC chargers (plug-in charge points or overhead/underground conductors, such as at bus stops) or by wireless charging (via inductive power transfer) embedded in the roadway

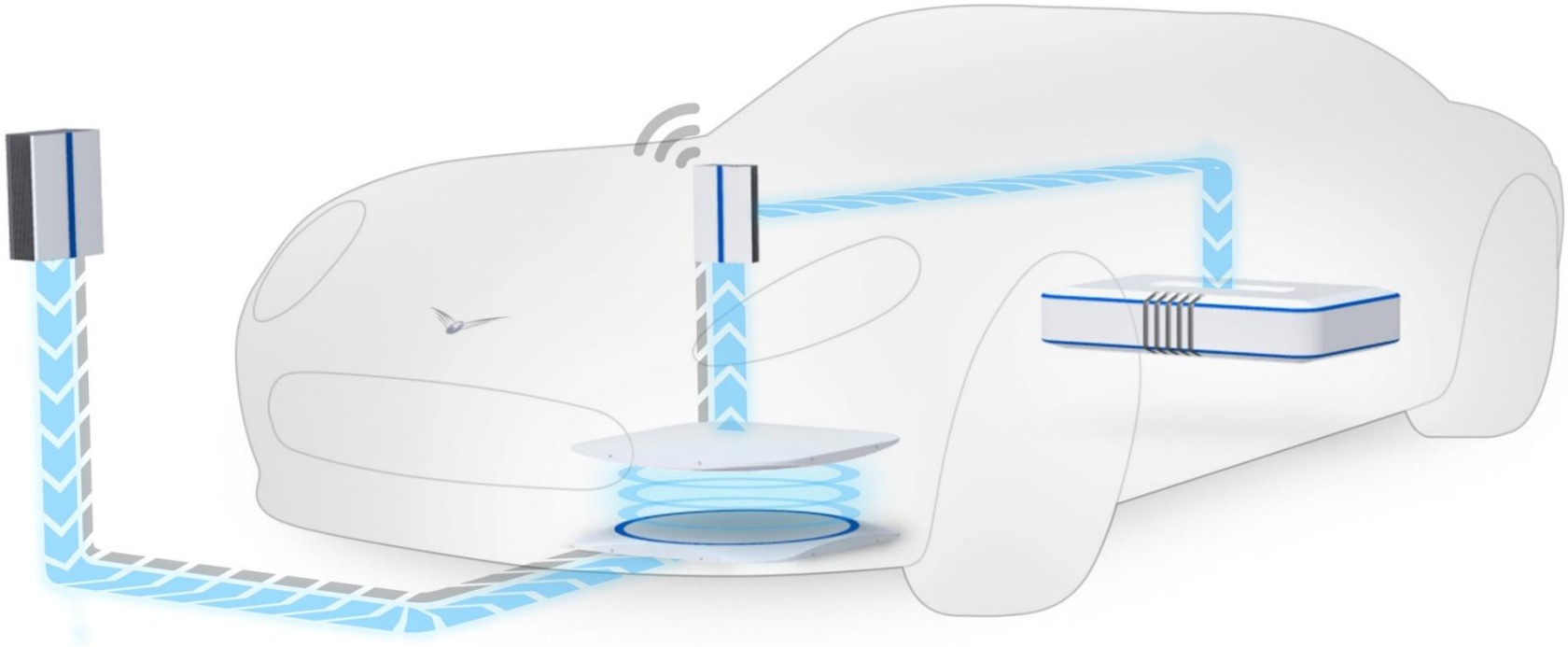
Solutions?

Improvements?



Wireless Energy Transfer (Induction Charging)

- Wireless charging / high power energy transfer at strategic transport interchanges could be a key enabling technology for bus electrification and other (fleet) applications, such as taxis
- This technology is not yet fully commercialised and will be trialled by TfL as part of an 8-city EU FP7 demonstration project



TfL's Wireless Charging Bus Trials ('ZeEUS' project)

- TfL is planning a demonstration of "plug-in" hybrid (or range-extended electric) buses
- Recharging will be by induction (wireless) charging, or 'Inductive Power Transfer'
- Primary IPT infrastructure to be installed in TfL bus stations at either end of demonstration route(s)
- Aim is to operate the vehicle on grid electricity as much as possible; battery system to provide a significant amount of the energy needed to run each leg of the route

Conclusions

- Mayor's climate change targets and exceedence of air quality limit values are driving environmental improvements in vehicle fleets
- Emissions reduction strategies have three strands – operational improvments (including behaviour change), retrofitting and new technology & alternative fuels / energy paths
- Hybrid buses are the biggest contributor to TfL's own fleet emissions reduction to date
- Electric and hydrogen fuel cell vehicles offer the potential to meet any future zero emissions policies
- Infrastructure requirements (& investment) key to many solutions – electric vehicles, hydrogen fuel cells, some biofuels ...
- Acknowledgement that future clean fleets could be more fragmented than today's choices; more niche applications & tailored solutions are likely