TRANSPORT FOR THE South East

TRANSPORT EAST

ENGLAND'S ECONOMIC HEARTLAND

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Bus Back Better Support Programme

Support Package 11 – Alternative and Low Emission Fuels

Webinar

31 March 2023

Q & A

Please submit your questions throughout the webinar

We will also be producing a FAQ document

Contents

Support Package 11 Overview

Alternative and Low Emission Fuels

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Support Package Objectives

This support package aims to provide you with an increased understanding of:

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1 **The range of alternative fuels available and how applicable they are for your specific region/network**

2 **Appropriate funding and procurement mechanisms**

3 **The steps required to transition your bus network to alternative and low emission vehicles**

1: Stagecoach (2022) *Cambridge's First Electric Buses*. Available from: https://www.stagecoachbus.com/promos-and-offers/east/cambridges-first-electric-buses

Today’s Presenters

Dominic Taylor
Subject Matter Expert

Michael Payne
Subject Matter Expert

Anshel Cohen
Subject Matter Expert

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Context

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Context

Overview

Meeting climate mitigation goals would require transformative changes in the transport sector.[2]

By law the UK's emissions must be net zero by 2050.[3]

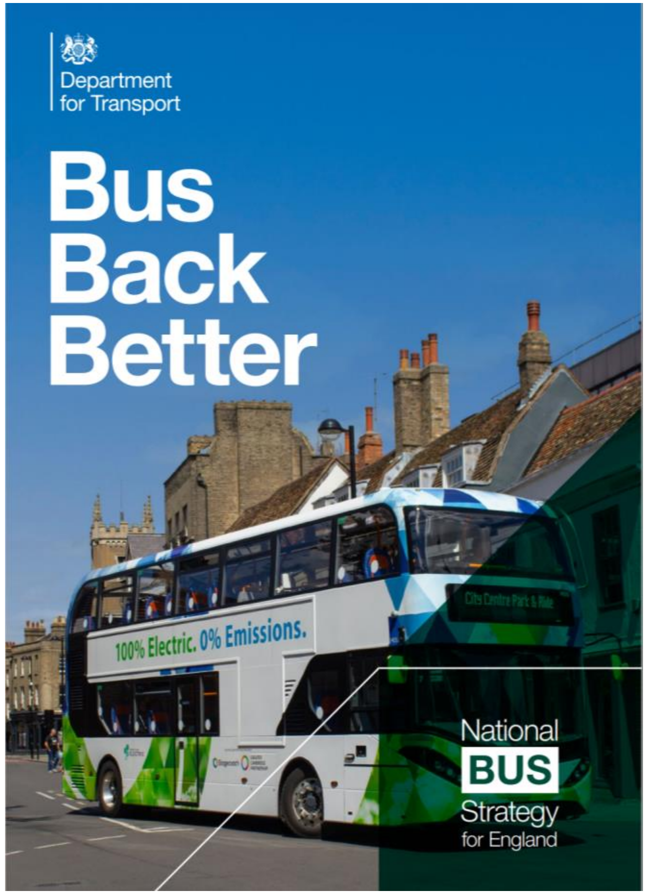
- Transport is the largest contributor to UK domestic greenhouse gas (GHG) emissions, responsible for 27% in 2019.[4]
- Decarbonisation is driving the transport industry's biggest change in half a century. The scale of the challenge is vast, but so are the potential benefits.
- Buses are vital to ensuring the economy meets net zero carbon emissions and driving the green transformation.

5: UK Government (2021) *Chancellor: UK will be the world's first net zero financial centre*. Available at: https://www.gov.uk/government/news/chancellor-uk-will-be-the-worlds-first-net-zero-financial-centre

2: IPCC (2022) *Climate Change 2022: Mitigation of Climate Change – Chapter 10 Transport*. Available at: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter10.pdf
3: UK Government (2019) *Climate Change Act 2008 (2050 Target Amendment) Order 2019*. Available at: https://www.legislation.gov.uk/ukdsi/2019/9780111187654
4: BEIS (2021) *2019 UK Greenhouse Gas Emissions*. Available at: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics1990-to-201

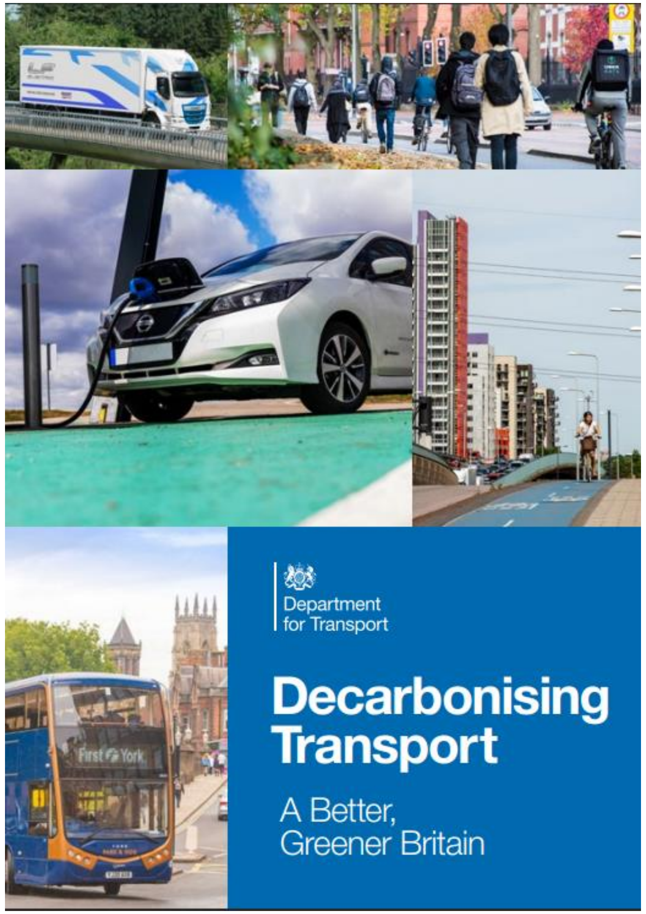
Context

Government policy and strategy



Roadmap to net zero bus services[6]:

1. We will consider all **technologies** fairly, assessing their cost, contribution to decarbonisation and utility.
2. We will provide the **financial support** and **incentives** needed for the market to scale up quickly.
3. We will take a **place-based approach** to investment wherever appropriate.
4. Both **operators and LTAs** must play their part.
5. We will ensure our plans for buses lead to **overall carbon reductions**.



Government commitments for decarbonising buses[7]:

1. Deliver the National Bus Strategy's **vision**.
2. Consult on modernising the **Bus Service Operators' Grant** in 2021.
3. Support delivery of **4,000 new zero emission buses** and the infrastructure needed to support them.
2. Deliver the first **All Electric Bus Town or City**.
3. Consult on a **phase out** date for the sale of new **non-zero emission buses and coaches**. The government anticipates that this date would be **between 2025 and 2032.**

6: Department for Transport (2021) *Bus back better – National Bus Strategy for England.* Available at: Bus Back Better (publishing.service.gov.uk)
7: Department for Transport (2021) *Decarbonising Transport A Better, Greener Britain.* Available at: Decarbonising Transport – A Better, Greener Britain (publishing.service.gov.uk)

Context

Why we need to be proactive[8]

If shaped proactively,
widespread adoption of alternative and low emission fuels could:

- Reduce carbon emissions and improve air quality (ensuring compliance with Clean Air Zones)
- Reduce bus operating costs
- Encourage sharing of charging/refuelling infrastructure
- Integrate infrastructure into the urban realm, seamlessly and efficiently
- Improve perceptions of bus
- Encourage more users

If left unchecked,
a poorly planned adoption of alternative and low emission fuels could:

- Lead to redundant infrastructure if opportunity charging is deployed in the wrong place
- Increase electricity grid costs and local grid supply issues
- Potentially leave important routes to be transitioned late
- Ignore region-wide efficiencies and opportunities for funding
- Fail to encourage more bus usage

10: Brighton and Hove (2019) *30 new buses for Brighton & Hove in UK zero-emissions first*. Available from: https://www.buses.co.uk/30-new-buses-brighton-hove-uk-zero-emissions-first

> **"The prize for greening our transport network: more than a million new bus passengers."**
>
> **– Stagecoach, March 2022[9]**

8: Arup (n.d.) *10 Thoughts for the Future of Low-Emission Mobility*. Available at: 10 thoughts on low emission mobility – Arup
9: Stagecoach (2022) Road map to zero. Available at: zeb-report.pdf (stagecoachgroup.com)

Context

Operator commitments

Stagecoach commitments:

Carbon neutral by 2050[11]

Go-Ahead commitments:

Net zero business by 2045

ZEB fleet by 2035[12]

First Bus commitments:

ZEB fleet by 2035

Purchase of no new diesel buses after December 2022[13]

National Express commitments:

ZEB UK fleet by 2030[14]

Arriva commitments:

Carbon neutral by 2025[15]

11: Stagecoach (2022) *Road map to zero.* Available at: zeb-report.pdf (stagecoachgroup.com)
12: Go-Ahead (2021) *Climate change strategy*. Available at: GOG_Climate_change_strategy_interactive
13: First Bus (2021) *First Bus Environmental Policy*. Available at: First%20Bus%20Environmental%20Policy_2021.06.pdf
14: National Express (2022) *The future of sustainable mobility.* Available at: national-express-sustainability-report-2022
15: Arriva (2022) *Zero Emission Institute.* Available at: https://news.arriva.co.uk/news/arriva-group-announces-its-new-zero-emission-institute

Context

Local context

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Zero emission bus regional areas (ZEBRA) scheme

Successful LTAs within the EEH/TE/TfSE regions[16]

Fast track

- Cambridgeshire and Peterborough Combined Authority
- Milton Keynes Borough Council
- Kent County Council

Standard track

- Portsmouth City Council & Hampshire County Council
- Oxfordshire County Council
- Hertfordshire County Council
- Norfolk County Council

Note: Arriva withdrawal from ZEBRA projects in Milton Keynes and Hertfordshire

100% Electric. 0% Emission.
Cambridge Citi 6
A proud partnership between Stagecoach | Greater Cambridge Partnership

Kent begins construction of first zero-emission bus route
17 FEBRUARY 2022 #BUS AND COACH

Electric buses are coming to Portsmouth
26 March 2022

Hertfordshire unveils first electric bus route
1 year ago Wed 19th Jan 2022

Electric buses driving into Norwich after £3.2million funding is secured
28 March 2022

Milton Keynes electric bus

Oxford electric bus

16: UK Government (2021) *Zero Emission Bus Regional Areas (ZEBRA) scheme.* Available at: https://www.gov.uk/government/publications/apply-for-zero-emission-bus-funding

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Overview

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Low and zero emission fuels

Comparison of types in use in the UK

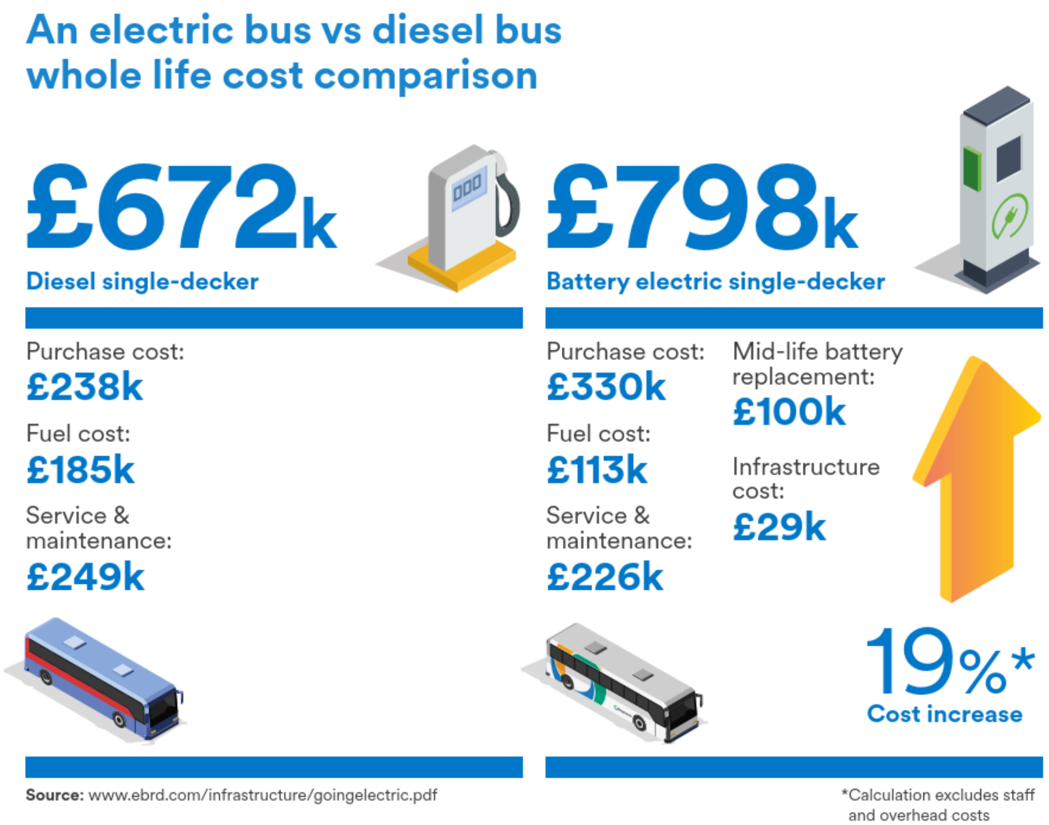
Fuel Type	Zero-emission at tailpipe?	Maturity	Scalability	Capex	Fuel costs	Maintenance costs (relative to Diesel)	Supply chain availability	Retrofit possible?
Hydrogen	Yes	Some use	Low	High	High	High	Limited competition	Yes (not widely applied)
Battery Electric	Yes	Wide use	High	High	Low	High	Extensive competition	Yes (not widely applied)
Biogas/ CNG	No	Some use	Locally Dependent	High	Low	High	Limited competition	Yes (not widely applied)
HVO Diesel	No	Very limited use	Low	Low	High	Equal	Limited supply exists	Retrofit not needed

- Biogas/CNG and Hydrotreated Vegetable Oil Diesel are not considered further as they are not zero-emission at tailpipe.
- Alternative technologies, namely plug-in hydrogen and supercapacitor electric buses, are also excluded from this presentation due to their relatively immature stage of development and lack of UK presence.

Zero-emission costs compared to diesel

Battery electric example

- Estimates of the whole-life cost comparison between zero-emission and diesel emissions vary, with some bus operators assuming a higher whole-life costs for Zero-Emission Buses (see example on right).[17]
- However, other studies suggest that the whole-life costs of electric buses will be less than that for diesel buses.[17]
- The relative prices of diesel and electricity/hydrogen, and changes to the costs of new batteries and fuel cells will be key future factors in this cost comparison.



18: EBRD (2020) *Costs and Benefits of Electrifying and Automating Bus Transit Fleets*. Available at: https://www.mdpi.com/2071-1050/12/10/3977

17: Stagecoach (2022) *Road map to zero*. Available at: zeb-report.pdf (stagecoachgroup.com)

Battery electric and hydrogen comparison

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Battery electric and hydrogen

Comparison[19]

Comparison factor	BEV	Hydrogen
Range	c.200-250 km	c.300-400 km
Time to full charge	3-6 hours (overnight)	<10 minutes
Approx. fuel cost*	£0.23/km	£0.60/km
Estimated maintenance cost	£0.27/km *(Key component: Battery Replacement)*	£0.27/km *(Key component: Fuel Cell Replacement/ Refurbishment)*
Typical Capital Cost	£380,000- £450,000	£430,000- £505,000

*Average of single/double decker, based on historic BSOG structure (future changes expected to reduce ZEB fuel costs for operators)

Battery electric and hydrogen

Hydrogen production methods

- There are several different production methods for Hydrogen, with significant differences in terms of the amount of CO_2 produced. These are typically referred to using colours. Four key types are shown below.
- It is essential that Hydrogen buses are powered using Hydrogen produced by a method that does not release CO_2 (i.e. Green or Blue Hydrogen) to achieve the Government's net zero ambitions.

Colour	Production Method	CO_2 emissions	Usage
Green	Electrolysation of water using renewable electricity	None	In limited use
Blue	Steam reforming using natural gas and heated water	Yes, CCS used	In very limited use (UK examples in planning)
Grey	Steam-methane reforming using natural gas	Yes	Most common current production method
Black/ Brown	Gasification from fossil fuel e.g. coal	Yes	In limited use (not used in the UK)

Battery electric and hydrogen

Advantages and disadvantages

Reasons for choosing BEVs

- Current costs per vehicle are lower
- Lower fuel costs
- More developed market with greater range of manufacturers and infrastructure suppliers

Reasons for choosing Hydrogen

- Greater range and faster refuelling than electric buses
- Ability to link with local economic policies to support hydrogen clusters and hydrogen-based growth, where locally relevant

- **BEV likely to be favourable on routes with shorter operating mileages, with hydrogen more competitive on longer-range routes.**
- There may be local strategic reasons for choosing Hydrogen in some areas - for example, where a hydrogen cluster is being developed.
- Most areas will have some routes that favour electric operation, with Hydrogen optimised for others of greater length and/or with steeper gradients. Rural areas are likely to require more Hydrogen buses with BEVs dominating in urban areas.
- There is potential to overcome the range limitations of BEVs through a concept of operations involving opportunity charging.
- The optimisation of fuel type for each route would need to be balanced against the additional costs of installing both Hydrogen and BEV infrastructure at bus depots.

Existing BEV case study

Caledonia Depot, Glasgow

- **Phase 1 (2020)** - 11 charging units for 22 electric buses.[19]
- **Phase 2 (2021/22)** - 69 charging units for a further 126 electric buses.[19]
- Future plans for the 350-vehicle depot to become fully electric.[20]
- Third parties pay to charge other vehicle fleets during the day.[21]
- Funded with £35.6m by First Bus and £28.2m from Scottish Government's Scottish Ultra Low Bus Scheme (SULEB).

19: Intelligent Transport (2021) *First Bus to transform Caledonia depot into EV charging hub.* Available at: https://www.intelligenttransport.com/transport-news/125735/first-bus-caledonia-depot/
20: Glasgow Times (2022) *First Bus completes work on Caledonia depot in Glasgow's Southside*. Available at: https://www.glasgowtimes.co.uk/news/scottish-news/20164869.first-bus-completes-work-caledonia-depot-glasgows-southside/
21:Route One (2022) First Glasgow in deal for DPD to use Caledonia chargers. Available at: https://www.route-one.net/news/first-glasgow-in-deal-for-dpd-to-use-caledonia-chargers/

Existing hydrogen case study

Birmingham Hydrogen bus

- 20 Hydrogen buses.[22]
- Operated in Birmingham by National Express.[23]
- Purchased as part of the Council's Clean Air Hydrogen Bus Pilot.[22]
- Funded through OLEV (Office for Low Emission Vehicles), GBSLEP (Greater Birmingham & Solihull Local Enterprise Partnership), Birmingham City Council and JIVE project funding from the FCH JU (European Funding from the Fuel Cell Hydrogen Joint Undertaking).[22]
- The buses use green hydrogen, produced from water using electrolysis from renewables. This is supplied by the Motive Hydrogen Refuelling Station, part of the Tyseley Energy Park.[24]

22: Birmingham City Council (2021) *Birmingham gets first hydrogen bus.* Available at: https://www.birmingham.gov.uk/news/article/932/birmingham_gets_first_hydrogen_bus
23: National Express (2021) *National Express hydrogen buses out in service.* Available at: https://www.nationalexpressgroup.com/media/news-releases/2021/national-express-hydrogen-buses-out-in-service/
24: Tyseley Refuelling Hub (n.d.) *The UK's first multi-fuel, open access, low and zero carbon fuel refuelling station.* Available at: https://www.tyseleyenergy.co.uk/tyseley-refuelling-hub/

Region-wide case study

Liverpool City Region

- Analysis of scenarios for the uptake of zero-emission vehicles in the Liverpool City Region bus network, comparing the capex, opex and total costs of these.
- The scenarios included:
  - **All-hydrogen network**
  - **All-electric network**
  - **A hybrid solution**, with routes allocated electric or hydrogen buses based on operating characteristics such as route length.
- Electric buses are cheaper and more efficient, but this efficiency is offset by additional costs when opportunity charging or a larger fleet is required.

LCR All Scenarios Output: Total Cost (Capex / Opex)

Liverpool City Region Case Study [20]

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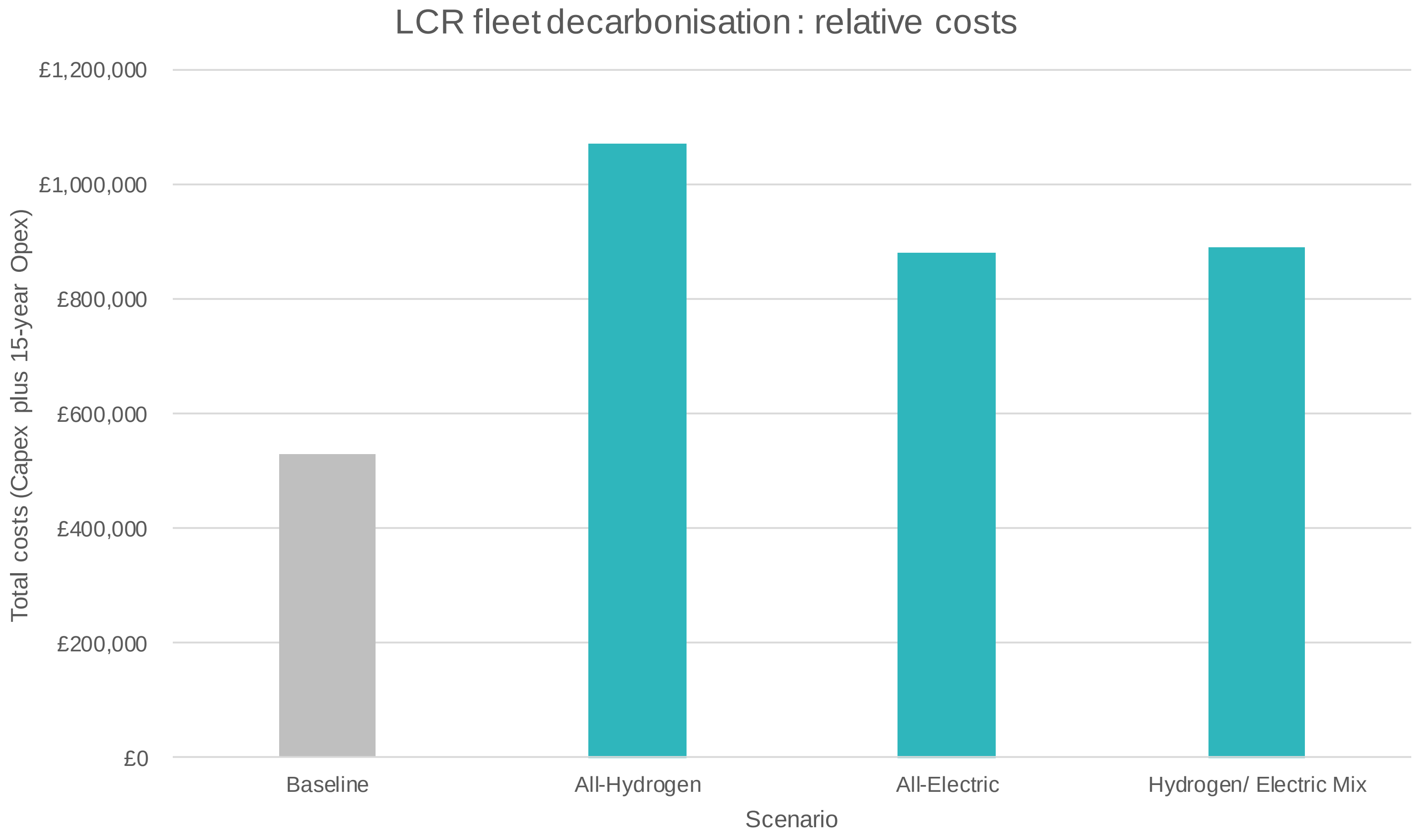

All Hydrogen costs £540m more than Baseline (+100%)

All Electric costs £350m more than Baseline (+67%)

All Hydrogen costs £190m more than **All-Electric** (22%).

The main cost difference between All Hydrogen and All Electric is the cost of energy. The assumptions used were:

- Hydrogen per km - £0.39/km
- Electric per km - £0.12/km

Alternative scenarios

- **Hydrogen/ Electric Mix** costs only £10m (1%) more than **All Electric** and so a small relative decrease in Hydrogen costs would reverse this difference. Other areas with more long-distance routes than the LCR may also find that a hybrid solution is more cost-effective than all-electric.

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Infrastructure requirements

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Infrastructure requirements

Challenges

1.

Grid connections to depots
Regulatory, planning and consents challenges to timely delivery

2.

Grid capacity and resilience upgrades to enable operation of ZEBs at scale
Response time from regional Distribution Network Operators (DNOs) to requests for grid upgrades

3.

Space for installation of depot charging infrastructure
Potential requirements to expand existing depots (where possible) or develop new depots

4.

Development of local hydrogen supply chains and infrastructure
Creating conditions for hydrogen suppliers and operators of fuelling infrastructure to invest

Depot charging

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- Charging infrastructure typically quicker, cheaper and safer to install at depots than in public-realm locations.
- Space constraints and grid capacity at existing depots may limit scale of implementation.
- Ground level and overhead charging interface options.
- Overnight charging avoids electricity use during peak demand times and minimises impact on bus schedules.
- More flexibility in charging time management.
- Potential to incorporate solar generation and battery for energy storage.
- Fewer vehicle battery cycles per year – potentially beneficial to battery life.
- Overnight charging likely to become the dominant charging strategy for electric buses as further improvements in battery technology increase range.

25%

potential increase in depot space required for charging infrastructure

16MWh

of power needed to charge 60 buses per day

Depot charging

Case Study – Warrington all-electric bus depot

- Successful ZEBRA funding bid for replacement of Warrington's Own Buses' entire fleet of diesel buses with 120 new electric buses.
- Fleet size adjusted to 105 to match the post-Covid requirement for delivery in 2024.
- Independent project for construction of purpose-built new £10m depot at Dallam Lane with capability to support an all-electric fleet nearing completion.
- New 11kV connection to the site.
- Depot design includes solar canopies and panels.
- Sixty 120kW rapid DC dual outlet plug-in chargers proposed to serve the 120 vehicle fleet, capable of charging two buses at 60kW simultaneously or delivering full power to a single bus.
- Smart charging and peak load lopping to be employed.

Opportunity charging

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- Charging strategy based on installation of high power charging stations at route terminal locations.
- Concept of operations and scheduling enables buses to receive top-up charge during layover periods between timetabled journeys.
- Most common method is overhead charging via pantograph mounted on charging station (‘panto-down’).
- Alternative is vehicle-mounted pantograph (‘panto-up’).
- BEVs optimised for opportunity charging can be fitted with a smaller battery pack, contributing to weight savings and energy efficiency.
- Installation of charging stations in public-realm locations (bus stations, bus stands etc) may be challenging.

Opportunity charging

Case Study – Harrogate Electrics

- Three rapid charging stations and an electricity substation installed at Harrogate Bus Station.
- Fleet of 8 Volvo 7900 electric buses.
- Overhead charging - pantograph mounted on charging stations connects to charging rails on bus roof.
- Charging is fully automated and takes 3-6 minutes.
- Buses can be loaded while charging.
- ‘OppCharge’ common interface between charging station and vehicles employed - supports competition and interoperability.
- Communication between the bus and charging station via Wi-Fi.

25: Transdev (2021) *Harrogate Electrics*. Available at: https://www.transdevbus.co.uk/corporate/electric-buses-harrogate
26: OppCharge (n.d.) *Fast Charging of Electric Vehicles*. Available at: https://www.oppcharge.org/

Hydrogen refuelling

- Refuelling system typically comprises bulk storage tanks, a compressor, a dispenser and safety sensors/systems.
- Pressure of vehicle's on-board storage (typically 350 bar for bus) is normally higher than pressure in storage tanks.
- Two methods for forcing gas into the vehicle tank at the correct pressure:
  - **Cascade or overflow fill system** - a small quantity of stored gas kept at higher pressure and recharged by a compressor within the storage infrastructure
  - **Booster fill system** - a compressor between the storage tanks and the vehicle tank to ramp up the pressure during refuelling
- Hydrogen dispensed to vehicle through a flexible hose and nozzle connected to the vehicle tank, similar to refuelling with petrol or diesel.

Hydrogen refuelling

Case Study – H2 Aberdeen

- Aberdeen City Hydrogen Energy Storage (ACHES).
- Combined hydrogen production and refuelling facility.
- Hydrogen produced from water by electrolysis using renewable electricity.
- Publicly accessible location.
- Hydrogen dispensed to vehicles at 350 bar (buses and trucks) and 700 bar (cars and vans).
- Hydrogen cooled to -40º C to enable fast refuelling.
- Large vehicles refuelled within 10 minutes.
- Safety sensors to detect any gas leak.
- Automatic shutdown if a gas leak or fire detected.

27: Net Zero Aberdeen (n.d.) *H2 Aberdeen Hydrogen is Here.* Available at: https://www.aberdeencity.gov.uk/net-zero-aberdeen/h2-aberdeen-hydrogen-here

Guidance

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Going electric

A pathway to zero-emission buses (EBRD, June 2021)[28]

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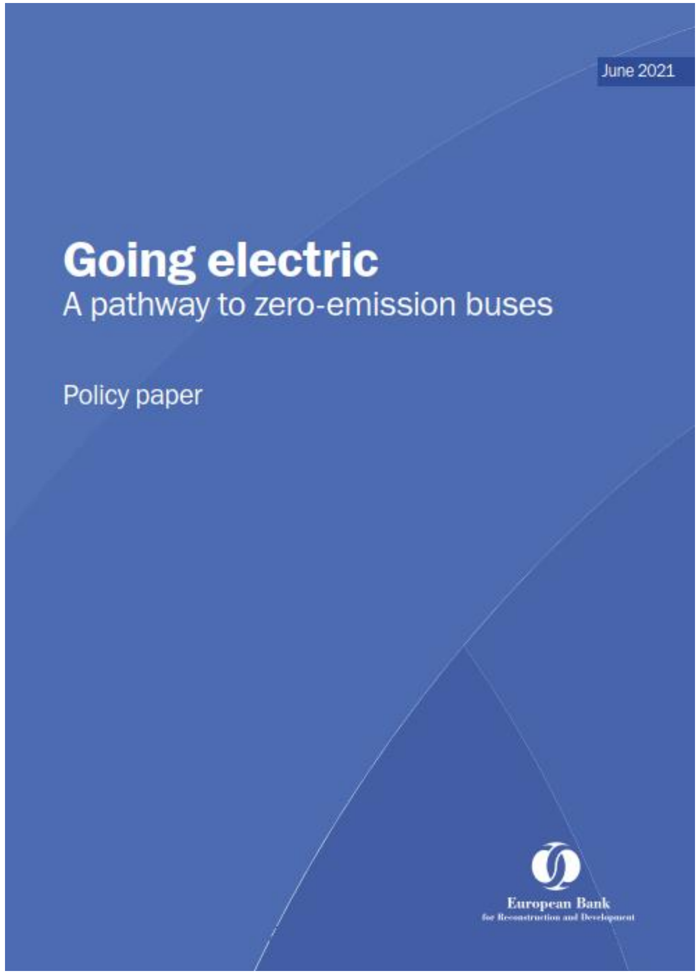
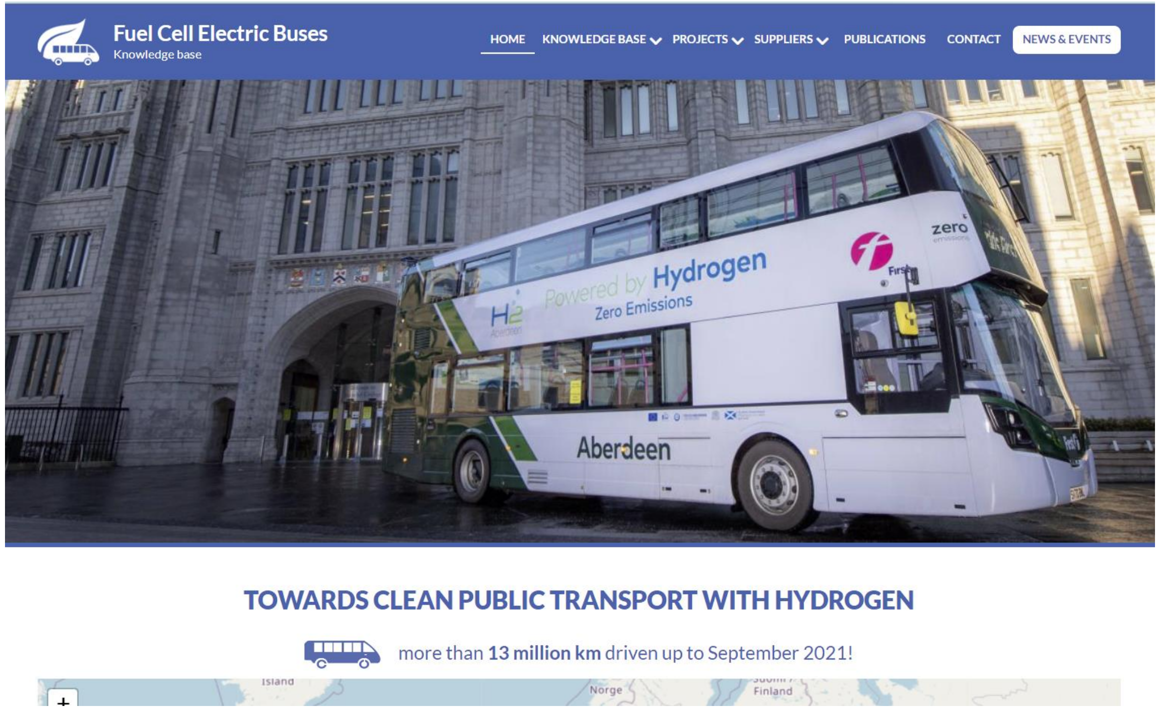
- Report intended to facilitate policymaking and the development of electric bus schemes, and to assist project finance.
- Summarises emerging good practice across a range of topics and geographies.
- Aimed primarily at scheme promoters and sponsors, including:
  - City region policymakers and politicians
  - Transport authority officials
  - Financing entities
  - Cities and/or transport operators seeking development loan financing

[Accessed via the UITP website]



Fuel cell electric bus knowledge base

- Provides an overview of data, knowledge and experiences about hydrogen fuel cell electric buses and hydrogen refuelling infrastructure in Europe.
- Includes content on:
  - Hydrogen buses
  - Hydrogen refuelling stations
  - Guidance on project development and implementation
  - Policy
  - Safety
  - Codes, standards and regulations



www.fuelcellbuses.eu

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Retrofitting versus new

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Retrofitting vs. new

Benefits

Retrofitting existing fleets

Value for money
- More cost effective than purchasing new vehicle

Short conversion time
- Equipmake - 5 each working week
- Kleanbus - 1 in less than 2 weeks

Finance and realisation
- Multiple ways of finance provided, where the vehicle and battery can be paid upfront or leased separately
- Depot upgrade can be arranged by supplier

Commercial viability
- Commercial options are available and have moved beyond the prototype stage to small scale production

Sustainability
- Extend the life and value of existing mid-life diesel buses instead of moving polluting vehicles for other uses
- Avoid carbon emissions of building new vehicles

Purchasing new fleets

Easy transitioning

There are many examples of low-emission vehicle procurement across the UK, particularly in metropolitan areas

A mature market

There are many suppliers in the market - for electric buses, most of them are also experienced suppliers of traditional diesel buses

Access to government funding

Purchasing new fleets allow LTAs access to government funding, e.g. Ultra-Low Emission Bus Scheme (2018-2021), Zero Emission Bus Regional Areas (ZEBRA) scheme

Retrofitting vs. new

Costs

Type	Retrofitting existing fleets	Purchasing new fleets
Electric	~£200,000	~£400,000
Hydrogen	~£250,000*	~£500,000
Biogas	NA	~£300,000

(Hydrogen) £250,000*: Rates proposed by Ricardo

Retrofitting

Examples for electric buses

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Equipmake (UK)

Zero Emission Drivertrain (ZED) product available for both new e-bus or retrofitting options

- Repowered 12 first-gen electric buses in York (First Bus) - **evidence of commercial-basis delivery within the UK**[28]
- Repowered a New Routemaster bus in London (Metroline, undergoing pre-service trials)

York electric bus, First Bus

Kleanbus (UK)

Target at retrofitting five-to-ten year old buses

- Completed first prototype vehicle with electric propulsion system installed in Jan 2023 (subject to a testing programme and aim to enter pilot with bus operators)[29]

Kleanbus prototype

Pepper (Germany)

Full type approved e-bus conversion solutions for a range of models, including Mercedes-Benz Citaro supplied to the UK market

- Formerly known as e-troFit
- Identify potential for 8000 buses to be converted to electric propulsion during period to 2030[30]

Mercedes-Benz Citaro bus in Oxford

28: Equipmake (2022), *First bus partners with Equipmake to upgrade York EV fleet*. Available at: https://equipmake.co.uk/first-bus-partners-with-equipmake-to-upgrade-york-ev-fleet/
29: Kleanbus (2023), *Bus & Coach Buyer: Kleanbus completes first re-power prototype.* Available at: https://kleanbus.com/2023/02/21/kleanbus-completes-first-re-power-prototype/
30: Sustainable Bus (2020), *e-troFit plans 8,000 buses to be converted to electric drives until 2030*. Available at: https://www.sustainable-bus.com/news/e-trofit-plans-8000-buses-to-be-converted-to-electric-drives-until-2030/

Retrofitting

Examples for hydrogen buses

Ricardo (UK)

Seeking customers to invest in the production for sustainable shared mobility future

- Repowered a diesel double deck bus with a hydrogen fuel cell propulsion system **as a demonstrator for UK's first hydrogen transport hub** in Tees Valley (Stagecoach North East, part funded by DfT)[31]

SAFRA (France)

Set to unveil its first hydrogen retrofit kit H2-PACK dedicated to coaches

- Launched the marketing of the h2 retrofit kit in October 2022 and currently in the process of certification[32]

31: Ricardo (2022), *Ricardo repowers double decker diesel bus with hydrogen fuel cells ready for zero emission demonstration on Teesside*. Available at: https://www.ricardo.com/en/news-and-insights/press-releases/2022/ricardo-repowers-double-decker-diesel-bus-with-hydrogen-fuel-cells-ready-for-zero-emission-demonstration-on-teesside
32: Sustainable Bus (2023), *Soon to be approved Safra's first hydrogen retrofit kit*. Available at: https://www.sustainable-bus.com/fuel-cell-bus/soon-to-be-approved-safras-first-hydrogen-retrofit-kit/

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Transition support mechanisms

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Transition support mechanisms

Deregulation and commercial barriers

1.

Deregulated bus market structure limits how LTAs can lead on transition.

2.

Bus operations are a commercial business and there is frequently a commercial viability gap for ZEBs.

3.

Maturing technologies for ZEBs means that operators are uncertain of operating performance and costs.

4.

No visibility of future pipeline of new ZEBs to allow industry to develop relevant manufacturing and servicing capacity.

Transition support mechanisms

Opportunities for policy and market development

1.

Opportunities to change the regulatory environment.

2.

Sale of diesel buses to be phased out between 2025 and 2032.

3.

Capital and operating costs will reduce and stabilise to a sustainable level but the trajectory of this is uncertain.

4.

Central government financial support is increasingly available.

Transition support mechanisms

Subsidy Control (formerly State aid) risks

Post Brexit, the issue of State aid or subsidy remains an important factor for the public sector when considering providing financial assistance to commercial businesses.

Subsidy Control Act 2022[33]

A subsidy is where a public authority provides support to a business in a way that gives them advantage over a competitor. Without controls, subsidies could give an unfair advantage to some business over their competitors.

LTAs need to assess subsidies against a set of principles to determine if a subsidy is allowed (*Statutory Guidance for the United Kingdom Subsidy Control Regime*). As long as the rules are followed, subsidies can be awarded. However, competitors could challenge a subsidy in the courts and if the rules weren't followed, the subsidy may need to be recovered from the business.

A key consideration is the extent to which any subsidy/aid can be competed so as not to **'favour certain undertakings'** or the extent to which the **services of general economic interest (SGEI)** exemption applies.

SGEI are economic activities which **deliver outcomes in the overall public good that would not be supplied by the market without public intervention.**

Specifically, this relates to any commercial interfaces between LTAs and operators that include grants or contracts on non-commercial terms such as leases, access agreements, fuel supply contracts and purchase agreements.

33: UK Government (2022) *Subsidy Control Act 2022.* Available at: https://www.legislation.gov.uk/ukpga/2022/23/enacted

Procurement models

Overview[34]

Existing

Buy:
Operator buys the buses direct from the manufacturer and carries all the risks and rewards of ownership. This may be paid for from existing cash resources or from loan (either commercial loans or concessional loans, e.g. from UKIB).

Operating leases:
Operator leases the buses from the owner, and pays for rent, taxes, and insurance. Maintenance is usually dependent on the provisions agreed in the lease agreement. Generally shorter leases where the risks and rewards of ownership remain with the asset owner.

Finance leases:
Operator pays a regular lease payment to the vehicle owner. The difference is the expectation of (or opportunity for) the operator to purchase the asset at the end of the lease term. Generally longer leases where the risks and rewards of ownership transfer to the lessee.

Sale-and-leaseback (refinancing):
Using the traditional form of this model, the operator would be assumed to already own the asset which it would then sell to a buyer, to free up capital and then lease the very same asset from the buyer.

Emerging

Component (battery) leases:
Operator purchases the actual vehicle but leases the most expensive/technologically risky part of the vehicle, for example electric batteries, hydrogen fuel cells or even charging infrastructure.

Integrated end-to-end financing:
An integrated financing package / solution, providing all necessary assets to the operator via a service model, where the operator only pays a fee for the availability and use of the asset(s), on a per mile / km basis. The integration provider “bundles” the vehicle, battery (or fuel cell) and infrastructure into one package, and the operators pays a regular fee for use and access. This is effectively a form of enhanced lease arrangement, but is an evolving market.

Note: Additional information on each of these is provided in Appendix A

34: Transport Scotland (2021) *Zero Emission Bus Financing Ideas Pack*. Available at: https://www.cpt-uk.org/media/yo2du40i/ze-bus-financing-information-and-ideas-pack.pdf

Procurement models

The challenge for LTAs is **how to support transition within the current regulatory environment?**

This will require **close cooperation with key stakeholders to develop a suite of mutually acceptable commercial arrangements.** At this stage in the transition, LTAs are best placed to support operators through these financial support mechanisms, subject to Subsidy Control assessment:

Public Capital or Revenue Grants to Private Sector (Gap Funding):
LTAs fund all or part of the costs of the body in receipt of the grant (e.g. operator or fuelling/charging provider) to support the commercial viability case.

Direct Asset Investment:
LTAs directly invest and owns assets – buses and/or infrastructure – and makes these available to operators at a discount to support the commercial viability case, e.g. leasing the buses or granting access to fuelling /charging infrastructure. LTAs would carry the risks of asset stewardship and asset usage.

Procurement models

Local examples

Brighton & Hove Private sector direct investment	Cardiff Public sector capital grant funding as owner of bus operator	Aberdeen Public sector capital grant funding	Liverpool Public sector direct asset investment and public sector capital and revenue grant	West Sussex Public private partnership
• 54 extended range hybrid electric buses for the Ultra Low Emission Zones. • £18m funded by Brighton and Hove Buses Limited. • A natural market response with no public intervention. • Charging is regenerative braking rather than from investing in chargers.	• 36 electric buses ordered by Cardiff Bus (wholly owned by Cardiff Council). • Funded through £5.6m from DfT and £8.4m from Cardiff City Council as the owner of Cardiff Bus. • A £8m grant from Cardiff Council in October 2022 to help further increase the number of electric buses.	• £19m package of public sector grant funding to develop a hydrogen refuelling station demonstration project in 2015. • 15 double deck hydrogen buses operated by First Bus (£8.3m funding secured). • 22 electric buses operated by Stagecoach and funded by Scottish Government grant awarded through competitive tendering.	• 20 hydrogen buses directly purchased by Liverpool City Region for £12.5m and leased to bus operators at a diesel equivalent (not commercial) rate. • Ongoing revenue subsidy for the incremental operating costs through the discounted lease rate (covered internally from devolved BSOG allocations). • A public grant to the hydrogen fuelling provider.	• A contract was tendered for a private partner to deliver a major electric vehicle charging programme across the region. • Aspiration to provide charging points to residents, businesses and visitors. • A comparator for funding the roll out of charging infrastructure for open access.

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Decarbonising a region

31 March 2023

Steps to transition to alternative and low emission fuels

Transport for the South East · Transport East · England's Economic Heartland

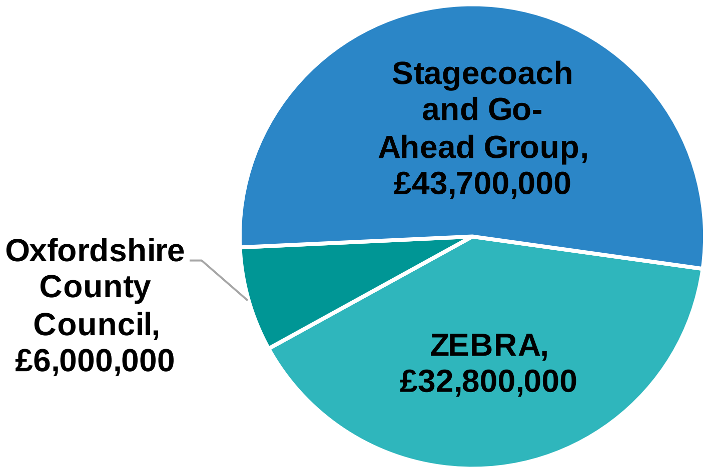
Supported by Mott MacDonald · Arup

1. Understand local operators' plans
2. Conduct a route and depot analysis
3. Identify major energy constraints
4. Consider local economic growth strategies
5. Prepare for future funding rounds e.g. ZEBRA 2
6. Account for worker reskilling
7. Consider additional uses for the charging/fuelling infrastructure

Decarbonising a region

Case Study: Oxford All Electric Bus City

- Oxford is due to become one of the UK's all-electric bus cities
- Funding from various sources:



- Bus operator funding is dependent on delivery of bus priority measures by OCC
- Proposed complementary measures include a Zero-Emission Zone and Workplace Parking Levy in Oxford.

36: Oxford Bus Company (2022) *Electric bus on trial in Oxford as city prepares for low carbon future*. Available from: https://www.oxfordbus.co.uk/electric-bus-trial-oxford-city-prepares-low-carbon-future

35: Plans for £82.5 million electric bus network in Oxford Available at: https://www.oxfordshirelive.co.uk/news/oxfordshire-news/plans-825-million-electric-bus-6879772

Role of LTAs in supporting the transition

Financial support

- Procure zero emission vehicles directly
- Deliver match-funding through tender contracts for operators investing directly themselves
- Lease at equivalent cost to diesel buses
- Review tender framework to ensure longer payback investment can be modelled to spread the cost of financing
- Unlock grants for infrastructure - capital purchase, depot conversion and provision of shared infrastructure
- Support development of low-emission vehicle and component markets
- Mitigate against potential skills gaps by investing in education and training to support the upskilling of the workforce to be able to support delivery of the new technology fleets

Support the roll-out of supporting infrastructure

- Direct support on land access, planning and engagement with utilities to ease the friction related to roll out of supporting infrastructure
- Consider the needs of bus providers as part of local EV charging infrastructure or energy plans to ensure future-proofed provision
- Identify grid constraints and infrastructure upgrade needed to ensure long-term adoption

Q & A

Next steps

Completed

Webinar

Coming Up

FAQ and Advice Document

Support Package materials made available online

Please send any additional questions to Sophie.Zachulski@arup.com and Patrick.Noonan@mottmac.com by COB 5th April 2023

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Appendix A

Additional information

31 March 2023

Procurement models

Comparison – existing

Model	Key strengths	Key weaknesses	Opportunities
Buy	• Operators own the asset – resale opportunities. • Not locked into lease term.	• High upfront capital required.	• Grants available to assist with this.
Operating leases	• Operators get to spread the high upfront cost over the lease term, with an additional financing cost. • Lease terms are typically short and therefore provide operators with the option at the end of lease term to transition to other technologies. • Maintenance and service is usually provided. Asset owners may also offer training.	• If owner is the LTA, subject to subsidy control eligibility compliance assessment. • The cost for using the asset will be greater than the equivalent if the operator bought the asset (due to the financing cost). • Doesn't necessarily resolve a commercial viability gap.	• Marketing/PR opportunities for LTAs (e.g. Merseytravel). • LTAs can work with the leasing operator to introduce KPIs into lease terms, such that operators could be financially rewarded / penalised, depending on level of service quality provided (or even condition of battery / fuel cell upheld).
Finance leases	• Reduces the high upfront cost of acquiring assets, with an additional financing cost. • Lease terms are typically longer for significantly the useful economic life of the vehicle. • Maintenance and service is usually responsibility for the lessee.	• If owner is the LTA, subject to subsidy control eligibility compliance assessment. • The cost for using the asset will be greater than the equivalent if the operator bought the asset (due to the financing cost). • Operators bear the residual value risk at the end of the lease term. • Operators are usually left to maintain the asset, including the replacement of batteries. • Doesn't necessarily resolve a commercial viability gap.	• Work with finance lease providers to identify and establish a channel to secondary markets.
Sale-and-leaseback (refinancing)	• Opportunity to free up capital for other uses (e.g. new bus purchase) and shift residual value risk to a third party.	• Lifetime cost of leasing is ultimately still going to be higher than lifetime cost of ownership. Hence, there should be a strong business case of an alternative investment, in which the 'released capital' is allocated towards, generating a higher return for the operator.	• Greater flexibility provided to operators in selecting, or switching to, technology types most suited to meet the requirements of a particular region / area / bus route – particularly if the technology types, or route requirements, are constantly evolving or changing.

Procurement models

Comparison – emerging

Model	Key strengths	Key weaknesses
Component leases	• Batteries can be financed over a contract length. • Removes technology risk from operators. • Zenobe, for example, discount the residual value of the battery from the total cost of the contract.[aa]	• The total lifetime cost of the battery / fuel cell can be more through this model than if operators purchased both the vehicle and component outright up front. • Some leasing contracts can have stipulations which limit the total use of the assets e.g. with mileage limits in some instances to preserve lifespan of batteries.
Integrated end-to-end financing	• Enables operators to overcome the complexity of technology and infrastructure transitions.	• Operators likely pay a premium to access and use such a solution (the premium being to incentivise service providers to build and offer this service).

Steps to transition to alternative and low emission fuels: additional text

Understand local operators' plans

Some, particularly those owned by a larger group, may already have policies for transitioning

Conduct a route and depot analysis

Understand which routes and depots are good early candidates for ZEBs. Key factors include route length (for electric buses) and local air quality hotspots. The volume and shape of space available in depots may also affect their suitability for conversion to ZEBs

Identify major energy constraints

These include the available grid capacity in your area, which may necessitate upgrades that add to lead-in times and project costs. Note that, from 1st April 2023, the way grid upgrades are paid for is changing, which in many cases will significantly reduce the direct cost to the customer requesting the upgrade

Consider local economic growth strategies

•Are there any emerging industries that your choice of fuel type could support, (for example, if your area is aiming to develop a hydrogen cluster)

Prepare for future funding rounds e.g. ZEBRA 2

These may be able to support your scheme, although not all new ZEBs will be funded by direct government grants as the transition to ZEBs accelerates

Account for worker reskilling

Electric and Hydrogen vehicle maintenance requires different skills to those for diesel buses. There may be a role for the authority to support local operators in making this skills transition and/or an opportunity for the operator to offer new skilled jobs, or training opportunities such as apprenticeships

Consider additional uses for the charging/fuelling infrastructure

When buses are not using this infrastructure, enabling use by other vehicles can generate an ongoing revenue stream while supporting wider decarbonisation goals. Potential users include municipal vehicles and private fleets (see Caledonia case study)

Decarbonising a region

Key points to consider

Negotiations with operators are key as, in addition to fleet funding, they must be willing to adapt their depots to ZEBs

Most major UK bus groups aim to have a fully zero-emission fleet by 2035 or earlier and so may part-fund the costs of transition

Operators may make their investment in ZEBs conditional on local policy changes to favour buses - see Oxford example (next slide)

BSOG reform is expected to reduce the operating costs of ZEBs, making them more commercially attractive

Under current networks, a mix of hydrogen and electric buses will be the best solution for many areas. See Liverpool City Region example. However, it may be possible to redesign networks to facilitate electric bus operation by splitting the longest routes and making interchange easier. Franchising or partnerships may offer opportunities for such route redesign

Sharing or monetising charging/fuelling infrastructure (for example, allowing municipal vehicles to charge in bus depots during the day) can generate additional income streams, making the transition to ZEBs more financially viable. See Caledonia Case Study

Appendix B

Q&A

31 March 2023

Q&A

TRANSPORT FOR THE South East
TRANSPORT EAST
ENGLAND'S ECONOMIC HEARTLAND
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The following is a record of the questions and responses from the webinar held on 31st March 2023.

Question	Response
At what geographical scale does the government commitment of 'supporting the delivery of 4,000 new zero emission buses' apply? (as mentioned in the *Decarbonising Transport* report)	This is a UK commitment.
Is there potential for sharing of infrastructure between third parties and Local Authorities?	There is definitely opportunity to share charging infrastructure at bus depots. The most likely scenario is the charging of public sector vehicles during the day while buses are in use. It is theoretically possible to share the infrastructure with the general public, however security concerns may limit the feasibility of this. It is also possible to place the infrastructure at publicly accessible locations, such as the hydrogen refuelling facility in Aberdeen (see slide 31). Grid connection sharing could present more opportunities, as grid connection cost is a major determinant of project feasibility. Spreading the cost across users through this approach could make schemes more viable. Pivot Power's business model (on the outskirts of Oxford) looks at doing a range of things with a large connection around energy balancing and private wiring to certain types of EV charging – showing how EV charging across modes can be optimised.