

Bus Decarbonisation Taskforce

Inaugural Meeting
11 November 2020
Meeting Papers



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Agenda

All attendees are asked to join the meeting a few minutes before 11 o'clock in order that the two minute silence can be respected at 11 o'clock and the meeting begin promptly thereafter.

Item
Remembrance day 2 minute silence
1. Welcome and purpose of the taskforce and this meeting
2. Context and progress to date (<10 minutes) A short presentation from Transport Scotland
3. Agreeing the guiding vision – group discussion (Paper 1.1) (<10 minutes) The taskforce are invited to agree the guiding vision given in Paper 1.1.
4. Opportunities and hurdles – group discussion (Paper 1.2) (40 minutes) The taskforce are invited to: <ul style="list-style-type: none"> a) agree, or propose amendments to, the outline of hurdles and opportunities given b) agree that this should form the basis of the taskforce's work plan for the coming 12 months c) agree that the pathway that the taskforce will co-design by the end of its life will take the form of a set of high-level actions required to recognise the opportunities / knock-down the hurdles.
5. Summary of agreement reached and next steps

Terms of Reference

In 2019, in the context of a global climate emergency, the Scottish Parliament enacted legislation setting the world's most ambitious targets for tackling climate change. This requires emissions of carbon dioxide to be net-zero by 2040, and all greenhouse gases to be net-zero by 2045.

The transport sector is now the largest emitter of greenhouse gases in Scotland. The Scottish Government is determined to reduce emissions from transport and is committed to encouraging and supporting a transformative shift to increased active travel and public transport use. When paired with zero emission vehicles this ambition for modal shift has the ability to create significant economic and climate benefits. In terms of supporting the transition to zero emission vehicles, the Government has made commitments to phase out the need for new petrol and diesel cars and vans by 2032; phase out petrol and diesel cars from our public sector fleet by 2025, and the need for any new petrol and diesel light commercial vehicles by 2030; create Scotland's first electric highway on the A9, create at least 20 Electric Towns across Scotland by 2025; put Highlands and Islands on a path to becoming the world's first net zero aviation region by 2040; reduce emissions from Scotland's railways to zero by 2035 and more.

Emissions from buses account for 5% of road emissions (as of 2019) and across the bus sector we have seen bold commitments to zero-carbon fleet renewal with a number of operators actively engaged in projects to get battery electric and hydrogen buses on our streets. One of the challenges for the sector has been the greater upfront capital cost of new technologies and associated infrastructure, and COVID has undoubtedly elevated these challenges. Nevertheless, evidence is building that battery-electric buses are moving towards whole life cost parity with diesel vehicles, and while it is clear that support is required to manage the high

upfront costs and battery maintenance issue, this evidence shows that we are reaching a pivotal point in the transition to zero emission transport.

In this context, this taskforce will work over the period of 1 year to:

- **agree a vision for a zero-emission bus sector in Scotland;**
- **co-design the solutions for ending the bus sector's contribution to climate change;**
- **set out a collaborative pathway for achieving zero-emissions.**

Scope and Remit

The remit of the taskforce is to identify and co-design creative and practical solutions to maximising opportunities and tackling any hurdles remaining in relation to:

- Charging infrastructure (electric and hydrogen) including on-route charging
- Technology (battery-electric, hydrogen fuel-cell and other potential zero-emission technologies; on-route charging; depot considerations)
- Costs, including economies of scale, warranties
- Finance, including suitable financial structures, products and guarantees
- Knowledge and experience
- Vehicle and charging requirements in rural, island and urban areas

In designing solutions the Taskforce will consider the implications and opportunities for the decarbonisation of other large road vehicles, including school, community buses and coaches, lorries and transport more generally.

The following issues are out of scope: Encouraging modal shift, reducing congestion, bus priority infrastructure, fares, concessionary travel, bus partnerships, supported services and low-emission zones. These are all important factors that have a level of interaction with decarbonisation but are beyond the remit of this taskforce.

Organisation

The Board will sit under the auspices of the Industry Advisory Group. It will meet every 6 to 8 weeks throughout 2021 with a rotating Chair.

The deputy Chair will be Stuart Grieg (Director of Low Carbon Economy, Transport Scotland).

Secretariat, including fact-finding and provision of information, will be provided by Transport Scotland and Low-CVP.

Membership

 <p>Paul White</p>	<p>Paul is the Director of the Confederation of Passenger Transport Scotland.</p> <p>The Confederation of Passenger Transport is the industry representative for the bus and coach industry representing a range of operators both large and small. It works to enhance the reputation of bus and coach industries.</p>
 <p>Ralph Roberts</p>	<p>Ralph is the Chair of the Confederation of Passenger Transport Scotland.</p> <p>Ralph is also the CEO at McGill's Bus Services based in West Central Scotland. McGill's operate a network of routes including East Renfrewshire, Inverclyde, Glasgow city and North Ayrshire.</p>
 <p>Christine Mcglasson</p>	<p>Christine is the Vice Chair of the Confederation of Passenger Transport Scotland</p> <p>Christine is also the Managing Director at Explore Dundee, part of the National Express Group.</p>

<p>Colin Craig</p>	<p>Colin is the Managing Director at West Coast Motors and will provide a rural bus operator perspective to the taskforce.</p> <p>West Coast Motors is based in Campbeltown, Argyll running around 270 buses and coaches including city sightseeing in Glasgow and Bute, Glasgow Citybus and Scotline Tours.</p>
<p>John Dowie</p>	<p>John Dowie is Director of Strategy at First.</p> <p>First is one of the largest bus operators in the UK, operating in Edinburgh, Glasgow, Aberdeen and Stirling with a fleet of over 5,000 buses in the UK.</p>
 <p>Martin Griffiths</p>	<p>Martin Griffiths is the Chief Executive of Stagecoach.</p> <p>Stagecoach is one of the UK's multi-modal public transport companies with operations across GB including bus, coach and tram services.</p>
 <p>Colin Nicol</p>	<p>Colin Nicol is the Managing Director of Networks at Scottish and Southern Electricity (SSE).</p> <p>SSE are one of the two electricity network operators in Scotland and a generator of renewable energy.</p>

 <p>Keith Anderson</p>	<p>Keith Anderson is the Chief Executive of Scottish Power.</p> <p>Scottish Power includes Scottish Power Retail, Scottish Power Renewables and Scottish Power Energy Networks, one of Scotland’s two electricity network operators.</p> <p>Keith will be represented by Andrew Ward, CEO of Retail at Scottish Power at this meeting</p>
<p>Paul Davies</p>	<p>Paul is the Managing Director at Alexander Dennis Ltd.</p> <p>Alexander Dennis Ltd is the UK’s largest bus and coach manufacturers designing and manufacturing single and double decker buses including a range of low and zero emission vehicles.</p>
 <p>Robert Drewery</p>	<p>Robert is the Commercial Director of Sales and Marketing at Optare.</p> <p>Optare design, manufacture and sell advanced single and double decker buses to companies across the world. They have also developed a range of low carbon vehicles.</p>

<p>Buta Atwal</p>	<p>Buta is the Chief Executive of Wrightbus Wrightbus designs and manufactures buses for the British and European market. Wrightbus also provide body work for chassis manufacturers.</p>
<div data-bbox="280 555 635 904" data-label="Image"> </div> <p>Steven Meersman</p>	

 <p>Robert King</p>	<p>Robert is Head of Sustainable Finance at HSBC.</p> <p>HSBC is one of the world’s largest banking and financial services organisations. They have over 40 million customers worldwide with their network covering 64 countries in Europe, Asia, the Middle East, Africa, North and Latin America.</p>
<p>Vicky Whitehead</p>	<p>Vicky is a director in the infrastructure finance team at Lloyds Bank.</p> <p>Lloyds banking group is a financial services group focused on retail and commercial customers and the UK’s largest financial services Group with millions of UK customers.</p>
 <p>Linda Hanna</p>	<p>Linda is the interim Chief Executive of Scottish Enterprise.</p> <p>Scottish Enterprise is Scotland’s national economic development agency and a non-departmental public body of the Scottish Government. Its goal is to deliver a significant, lasting effect on the Scottish Economy by working with partners in the public and private sector to exploit the best opportunities.</p> <p>Linda is unable to attend the inaugural meeting and will be represented by with Douglas Hyslop.</p>

 <p>John Berry</p>	<p>John is a sustainable transport team leader at Dundee City Council. John will represent the Association of Transport Co-ordinating Officers at the taskforce.</p> <p>ATCO brings together local authority transport officers to ensure best practice and facilitate public transport initiatives</p>
 <p>Mark Griffin</p>	<p>Mark Griffin is the Development Manager of Transport Decarbonisation Solutions at BOC.</p> <p>BOC is the largest provider of industrial, medical and specialist gases in the UK and Ireland. BOC has a series of major production and distribution centres across the UK and Ireland and provides products and services to both countries.</p>
 <p>Laura Murdoch</p>	<p>Laura is the Director of Bus and Active Travel at Transport Scotland.</p>
<p>Stuart Greig</p>	<p>Stuart is the Director of Low Carbon Economy at Transport Scotland.</p>

Paper 1.1 Guiding Vision

The taskforce are invited to agree the following vision statement. This will be used as the guiding vision for the co-design of a pathway over the coming year.

The vision statement is limited to the remit of the taskforce which focuses on decarbonisation of the fleet, but should be understood in the context of wider decarbonisation of the transport and energy sectors and the broader vision as set out in the National Transport Strategy. Central to delivering that is a vibrant bus sector with increased bus usage as people choose to travel by bus instead of car.

In the future we are creating, bus operators are exclusively running zero-emission buses including battery-electric and hydrogen fuel-cell; people enjoy travelling on buses and knowing that doing so is one of the most climate-friendly choices they can make; some operators own their own buses and there is a vibrant leasing market which benefits operators, manufacturers and the finance sector; bus drivers enjoy competing with each other using the smart technology on buses to see who can drive in the most energy efficient way; there is a strong and diverse domestic manufacturing sector and supply-chain comprised of high-quality skilled jobs; energy networks, bus operators and Local Government are used to working together to ensure depots are well designed and local residents and businesses are able to benefit from the energy provision centred at depots, and the on-route charging infrastructure; the Government has ceased subsidising battery-electric and hydrogen fuel-cell buses, but continue to support innovation in new zero-emission fuels and technologies of the future; Scotland is recognised the world over as a leader in the design and manufacture of high quality zero-emission buses and other large road vehicles, and associated green finance solutions.

Paper 1.2 Opportunities and Hurdles

This paper sets out the opportunities presented by the guiding vision statement and/or the hurdles that need to be overcome in order to achieve that vision.

The taskforce are invited to:

- a) agree, or propose amendments to, the outline of hurdles and opportunities given here;
- b) agree that this should form the basis of the taskforce's work plan for the coming 12 months;
- c) agree that the pathway that the taskforce will co-design by the end of its life will take the form of a set of high-level actions required to recognise the opportunities / knock-down the hurdles.

Financial

Running costs of zero-emission buses are lower than those of diesel buses, but battery-electric buses have higher up-front purchase costs compared to diesel buses, and hydrogen fuel-cell buses even more so (further detail is in the Annex, section 4). This is exacerbated where charging infrastructure also has to be paid for up front. At any time this could reasonably be expected to lead to bus operators favouring diesel buses, and this is amplified by impact of COVID on bus operator finances and ability to consider fleet renewal at all at the current time.

This presents a requirement for innovation and change with respect to the products offered by the financial and manufacturing sectors; an opportunity to build on Scotland's strong finance skills and capacity; and a need to flex the support provided by Government so it both aligns with operator and manufacturer decision making processes, and enables

innovative commercial investments (further detail is in the Annex, section 3).

Energy provision, technology and infrastructure

There is a strong interplay between the different energy provision, technology and infrastructure requirements for zero-emission buses and the potential for novel and innovative financial structures to enable the transition.

Even though significant advances have been made on developing EV technology, uncertainties remain regarding the battery lifecycle and the residual value of EV buses at their point of retirement. Almost no EV buses have been operating long enough to reach their estimated decommission date, so there is currently very little information on how long they will last and how these old buses will perform. One key risk, therefore, is the continued ability of the battery in the vehicle to deliver the desired range and the need to replace parts or all of the battery during the life of the vehicle.

Whether a bus operator chooses battery-electric or hydrogen fuel-cell buses, charging infrastructure is required and opportunities for collaboration with other energy users, and providers, emerge. This may relate to other energy users in the same geographical area (reconfiguring bus depots may, in some cases, be a significant undertaking) or in relation to the technology (e.g. batteries) having value to another part of the value-chain after the value to bus operations has receded.

There is an opportunity and a need for greater information sharing and strategic planning between energy providers, technological innovators and bus operators, and there may be a need for awareness raising and knowledge sharing about infrastructure, grid and connection solutions across bus operators.

Supply-chain

There are opportunities to build on Scotland's R&D capacity, and to develop the domestic supply-chain for battery manufacturing and hydrogen generation, to drive down costs, provide high quality skilled jobs, and reduce carbon in the manufacturing and shipping of parts.

There is a requirement to understand and support the skills required.

ANNEX: Background information

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1. The fleet, operators, journeys and revenue

There are approximately 4,100 buses in Scotland of which:

~1600 are EURO V diesel

~1100 are EURO VI diesel (which meet clean air standards)

>10 are hydrogen fuel-cell

>20 are battery electric

the remainder are diesel buses older than EURO V.

Average age: 7.9 years

Typical life span: <15 years

Typical annual replacement rate: ~300 buses

There over 200 operators of which 7 (First, Stagecoach, Citylink, Lothian, Xplore Dundee , West Coast Motors / Borders Buses, McGills) are responsible for nearly 90% of bus routes in normal circumstances.

In 2018-19:

- Around 380 million passenger journeys were made by bus in Scotland

- 56% of those who used the bus the previous day lived in large urban areas compared to two per cent of users living in remote rural areas.
- Bus operators in Scotland received £694 million in revenue, an increase of 1 per cent on the previous year and a 5 per cent increase over the last 5 years.
- Almost half (£314 million, 45%) of operator revenue came from local or central government: through concessionary travel reimbursement, Bus Service Operators Grant (BSOG) or supported services.
- Passenger revenue (i.e. ticket sales to non-concessionary passengers) accounted for around 55% of operators' revenue (£380 million).
- Over the past five years operating costs per vehicle km have decreased by 8 % in real terms. Operating costs per journey over the same 5 year period have risen by 3 per cent from £1.57 per passenger journey to £1.61. Although the operating costs per vehicle km is lower than for the rest of GB (excluding London), operating costs per passenger journey remain higher in GB (£1.61 in Scotland, compared to £1.47 for GB excluding London).
- The Confederation of Passenger Transport (CPT) Cost Index shows that wages, staffing and labour accounted for around 60% of operating costs, with fuel accounting for 16%. Total costs have been above inflation for the last few years.

2. Manufacturers

Alexander Dennis Ltd

<https://www.alexander-dennis.com/about-us/who-we-are/>

“ADL is a global leader in the design and manufacture of double deck buses and is also the UK’s largest bus and coach manufacturer. ADL offers single and double deck buses under the Alexander Dennis brand as well as Plaxton coaches, with vehicles in service in the UK, Ireland, Europe, Hong Kong, Singapore, New Zealand, Mexico, Canada and the United States.

ADL's history and heritage of design, engineering and manufacturing excellence spans more than a century. As a pioneer in embracing the latest technology, ADL has brought the widest range of low and zero emission buses to market.”

BYD

<https://www.bydeurope.com/about>

“Founded in 1995 as pioneer in battery technology, BYD’s mission is to change the world by creating a complete, clean-energy ecosystem that reduces the world’s reliance on fossil fuels. In Europe BYD are dedicated to make public transport emission free.

Throughout its 25 years of high-speed growth, BYD has evolved from a small company with start-up with only 20 employees into a global company with more than 230,000 employees today. BYD has established over 30 industrial parks across six continents and has played a significant role in industries related to electronics, automobiles, new energy and rail transit.

BYD pure electric buses are already driving in over 20 countries and in 100 major European cities.”

Optare

<http://www.optare.com/about>

“Optare have over a century of expertise in using the latest technologies in bus design and manufacturing to deliver the vehicles of today and tomorrow. [Optare:]

...design, manufacture and sell advanced single deck and double deck buses for a global market place

...have developed a range of low-carbon buses using enhanced diesel technology and alternative fuel options.

...set the benchmark for fuel economy and CO2 reduction with reduced weight designs and optimised drive systems.

[Optare’s]... parent, Ashok Leyland, part of the Hinduja Group, is ranked within the top four global bus manufacturers.

Wrightbus

<http://www.wrightsgroup.com/Divisions/Wrightbus>

“Wrightbus designs and manufactures buses for the European market, including the United Kingdom and Republic of Ireland.

Wrightbus product range covers all segments of the market from small and midi-sized buses to full-size single deckers, double deckers and articulated buses and Bus Rapid Transit.

Wrightbus are capable of producing all of our vehicles with either Euro 6 diesel or alternative drivelines, including hybrid-electric, plug-in electric and induction power transfer.

As well as Wrightbus’ own complete vehicles they offer bodywork for leading chassis manufacturers including Volvo Bus.”

Yutong

<https://en.yutong.com/about/>

“Yutong Bus is a large-scale modern manufacturing company specialized in the R&D, manufacturing and sales of bus products. It has three production plants of whole vehicle that are all located in ...China.

Through conducting intelligent manufacturing, Yutong has continuously improved the degree of informatization, digitization, and intelligentization in terms of orders, planning, manufacturing, logistics, etc., and realized an efficient operation model for the information management of the entire industrial chain for orders, thus achieving unique competitiveness.

As of the end of 2019, Yutong has totally exported more than 70,000 units, and the sales volume of large and medium-sized buses has taken the leading position in the world for many consecutive years.

So far, Yutong has launched a series of new energy products such as hybrid, full electric and fuel cell buses. Yutong's self-developed new energy bus power system has become the mainstream powertrain in the industry, forming the product portfolio of 6-18m new energy buses featuring international competitiveness.”

3. Government support for bus operations

Transport Scotland is providing service stability for passengers through the payment of two financial support packages, the Covid Support Grant (CSG) and the Covid Support Grant – Restart (CSG-R). CSG maintains the value of concessionary travel and Bus Service Operators Grant (BSOG) payments at levels forecast prior to the impact of COVID, totalling over a quarter of a billion pounds a year, with operators required to continue to deliver around 30% of bus service levels. BSOG was suspended at this time. This was subsequently supplemented with additional funding (CSG-R) to enable services to be extended as Scotland moved out of lockdown. Up to £162.3 million over 30 weeks (until 17 January 2021) has been made available to support bus operators to extend services to meet increased demand whilst physical distancing requirements remain in place during the pandemic. This funding is on a non-profit cost recovery model basis.

Pre-COVID, the Bus Service Operators' Grant (BSOG) scheme was paid. This is a discretionary grant that subsidises commercial and community bus routes. BSOG core payment aims to support operators to keep fares at affordable levels and networks more extensive than would otherwise be the case. The core rate of BSOG payable is 14.4p per kilometre, BSOG payments are based on distance travelled and calculated using eligible live service kilometres x payment rate.

There is also a Low Emission Vehicle Incentive - to help with the additional running costs of low emission buses, to support their uptake by operators. The payment rates are in bands according to the certification of the bus and the extent of carbon savings delivered by that bus compared to diesel.

The Low Emission Vehicle Incentive will not be sustainable under its current terms as the fleet transitions to zero-emissions vehicles at increased pace and will be reviewed.

In summer 2020 Transport Scotland ran the first Scottish Ultra Low Emission Bus Scheme (SULEBS) – a capital grant award for up to 75% of the purchase cost difference between a diesel bus and a ultra-low emission alternative, including infrastructure costs. As currently designed, SULEBS is a stochastic programme with a maximum budget of £9 million, is restricted to bids from bus operators in Scotland, and requires the bus operator to retain ownership of the bus in its entirety.

In October 2020, Transport Scotland submitted a simplified notification to the EU Commission seeking to substantially increase the budget, and allow companies leasing buses to bus operators and local authorities to bid. As of 5 November no response had been received.

4. Whole life costs of battery-electric and diesel buses

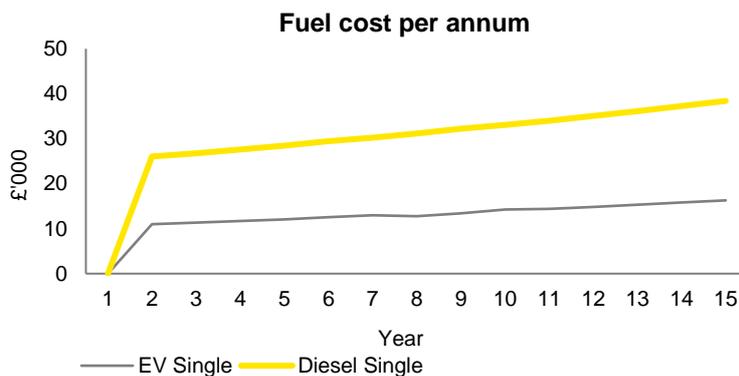
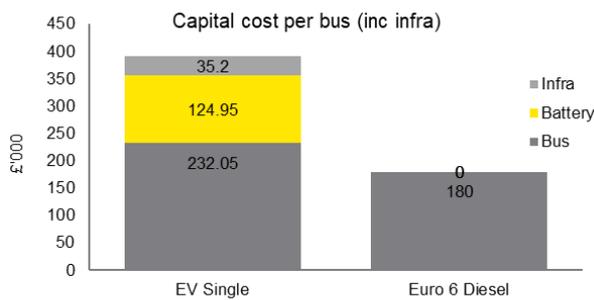
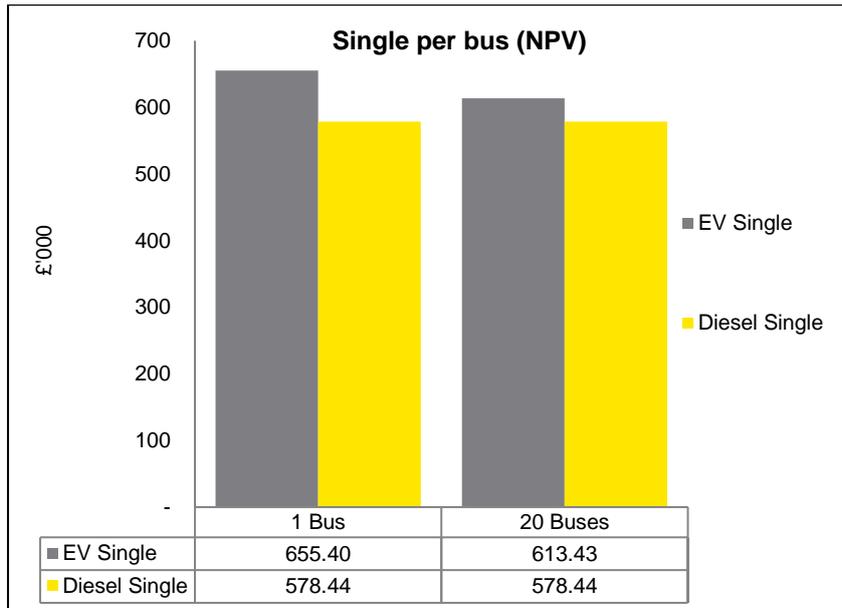
The following is taken from the Scottish Bus Electrification Commercial and Economic Context report, prepared by EY under contract to Transport Scotland and the Scottish National Investment Bank in summer 2020 (report available from Transport Scotland on request):

- In order to understand the economics of an EV bus, we compared the whole life cost (i.e. over a 15 year period) to that of an Euro 6 Diesel Bus.
- We have considered the following cost elements when undertaking this financial assessment; capital costs, operational costs and funding/financing structures.
- Our costs are based on discussions with bus manufactures and lease holders. The market has a range of products in relation to EV buses and different manufactures have different products and service offerings. We have therefore sought to provide cost ranges when explaining the assumption we have chosen to form the basis of our analysis.
- We removed all Bus Service Operator Grant (BSOG). i.e. core and LEV from the Total Cost to Operate base case.
- We have based our calculations on an operator placing an order for 1 Euro 6 Diesel Buses and 1 EV bus, based on the assumption that 90% of routes in Scotland are c110 miles and an EV bus can travel 160m per charge.
- The average life of a diesel bus is 15 years and we have used this timeline when comparing whole life costs. We have anticipated a replacement battery cost for an EV bus.

Financial Outputs (NPV)

1:1 Bus The NPV gap between 1 EV Single and 1 Diesel Single is £77k. Operational savings are not sufficient to offset the higher capital costs.

20:20 Buses Increasing the scale of bus purchases to 20 reduces the NPV gap between an EV bus and an Euro 6 Diesel bus to £30k per bus. This is due to a scaling of infrastructure costs.



5. Supply-chain and SWOT analysis

The following is taken from the Zero-emission mobility Industry Advisory Group Green Bus workshop pre-reading report, prepared by KPMG under contract to Transport Scotland in February 2020, **prior to the COVID pandemic in Scotland** (report available from Transport Scotland on request).

Some of the key elements of the Scottish green bus supply chain and infrastructure are:

- **Existing assembly supply chain:** Some home-grown Scottish players in the bus supply chain include Muirhead (an upholstery manufacturer), Scot Seats Direct (a seat manufacturer for buses, taxis and commercial vehicles) and McGregor Young (producer of bus windows and powder coating).
- **Strong electric charging infrastructure:** Scotland has one of the most extensive EV charging point networks in Europe, strong renewable energy infrastructure (e.g. Orkney Islands wind farms), and financing for EV charging points. However, electric buses require larger charging facilities (e.g. depots) and these are yet to be built at scale. Scotland's strong renewable energy sector is a key advantage for providing truly well to wheel green energy.
- **High potential for hydrogen infrastructure:** Hydrogen fuelling and development capabilities have been established in Aberdeen alongside the bus project. In addition, hydrogen fuel cell projects are delivering infrastructure in Levenmouth, Fife, Dundee, and Perth & Kinross. Scotland's strong renewable energy sector is a key advantage.
- **Lack of focus of existing battery supply chain on transport application:** The drivetrains in ADL's products are obtained outside

Scotland – hybrid drive from BAE Systems, and electric drive from BYD (China). Similarly, while some academic activities are being carried out in the Centre for Innovation in Energy Storage at St. Andrews, suppliers have noted that the volume of activity is likely to be smaller than in institutions like WMG in Warwick which have attracted more funding in battery research and commercialisation. Although 6 companies in Scotland (AGM, Denchi, Dukosi, CCPS, MEPCS, and Sunamp) are already supplying EV components and 9 others are offering battery-related technologies, they primarily supply to other sectors such as military vehicles, heating and stationary power generation. Therefore, there is a need to coordinate efforts among suppliers to start focusing on mobility applications. Initial efforts are, however, being made to coordinate suppliers' focus on mobility applications at MSIP and EDEN campus.

– ***Lack of a hydrogen fuel cell supply chain:*** There are currently no major Scottish providers of hydrogen fuel cell technology.

China is firmly in the driver's seat, having deployed 421,000 of the 425,000 electric buses worldwide, with exports to over 300 cities. There are over 10 electric bus original equipment manufacturers in China, with BYD and Yutong in the forefront. BYD manufactured over 8,000 electric buses in 2016, and benefits from also manufacturing rechargeable batteries and other electric vehicles.

European electric bus manufacturers are also proving to be competitive: Polish manufacturer Solaris has become Europe's largest electric bus company following three large orders from cities around Europe. Other competitors include VDL Bus & Coach, which has supplied 100 electric buses in the Netherlands, and Volvo Buses, which has supplied over 100 electric buses across Scandinavia and the Netherlands. Players like Irizar (the Spanish multinational company with an entire plant dedicated to electromobility), Mercedes (which began serial production in

2018), MAN (which will begin serial production in 2020) could also emerge as serious competition.

Battery supply chains are stronger in other parts of the world: The investment cost per electric bus is lowest in China with a price range of US\$ 280,000-350,000 (compared to US\$ 575,000-680,000 in Europe). This is due to the industry's easy and cheap access to raw material – China is home to 73% of global lithium cell manufacturing capacity. The UK as a whole is also falling behind the rest of Europe, with major battery cell production facilities being set up across Europe.

SWOT analysis

Strengths

Political support: The Scottish Government recognises that political support is essential for rolling out green buses because of the high upfront cost of these vehicles. The Scottish Ultra-Low Emission Bus Scheme (SULEBS) aims to accelerate the transition to the lowest-emitting buses by supporting the purchase of ultra-low and zero-emission buses (ULEB/ZEBs). Aberdeen deployed ten fuel-cell buses in 2019 supported by Innovate UK, Aberdeen City Council, the bus operators Stagecoach and First, the Scottish Government, Scottish Enterprise, Scottish Hydro Electric Power Distribution, and Scottish Gas Network for a total investment of £19 million.

Presence of Alexander Dennis Limited: ADL is one of the world's top 5 bus and coach manufacturers, and a home-grown Scottish company. Through its partnerships with BYD, Scania, and BAE Systems, it already has a sizeable presence in electric, biogas and hybrid buses respectively.

Strong off-shore wind base (with increasingly low cost): Scotland's major advantage in decarbonising transport is that 75% of its electricity is already generated from renewable sources, and 80% of this is from wind

turbines. This offshore wind base could enable the generation of electricity and production of hydrogen cheaply and sustainably.

Weaknesses

Limited supply chain: The supply chain for battery manufacturing and hydrogen generation within Scotland is weak. There are currently no battery or fuel cell manufacturers within Scotland. ADL sources most of its components from the rest of the UK and the world.

Lack of supporting infrastructure: While Scotland's EV charging network is developing rapidly, more large-scale charging facilities are required for electric buses. There is currently only one hydrogen refuelling station. Scotland has no local EV infrastructure suppliers.

Commercial constraints: Over the next ten years, commercialisation of green buses is going to be a major challenge. While battery costs are falling, the government will have to step in to a large extent (similar to China) to subsidise upfront costs. Compared to other countries, such as China, Scotland also needs to take into consideration the manufacturing cost, especially the relatively high input cost for automotive parts.

Opportunities

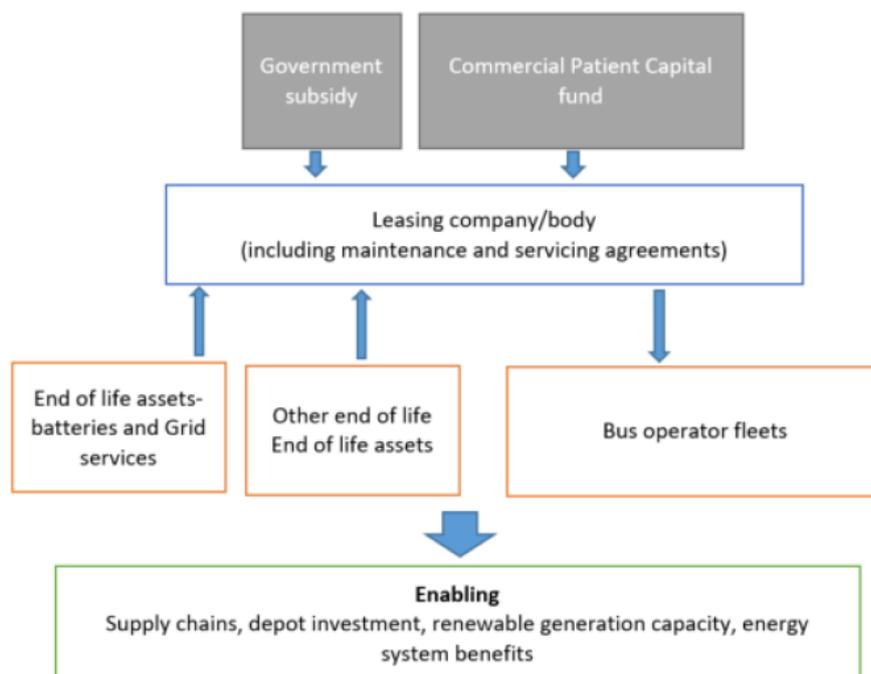
R&D: Scotland should leverage the strength of its existing research institutions and programmes – universities like St. Andrews, Edinburgh and Strathclyde, and government-funded programmes like Michelin Scotland Innovation Parc to spearhead the innovation that is required to make green bus technology commercialised and scalable.

Financing strategies: Given the commercial constraints of manufacturing green buses, seeking out public finance is critical to adoption of electric buses in the short term. SULEBS – the successor of the Green Bus Fund – can be used to finance and deploy buses that may

be more expensive to develop but are much greener and have the potential to be commercially viable in the future. Creative financing strategies like leasing of batteries/hydrogen fuel cells could also catalyse adoption. Funding frameworks for innovation can be tricky due to uncertain returns and financial risk – this can be mitigated by the following:

- The use of patient capital - innovation is highly uncertain and has long lead times, achieving smart, innovation-led growth requires not just any type of finance, but patient strategic finance. Patient capital will allow innovative companies the time and resources needed to achieve more substantial returns over a longer period of time than short-term returns
- Leasing framework – the leasing market can be used as means to remove the high barriers to uptake cost which will enable new, working technologies to be adopted with pace.
- Financing which focuses on secondary and tertiary use cases so as to maximise the potential of green economy.

A combined proposition approach of all the above can also be adopted in the manner of the following model:



Niche use cases: Given the lack of a Tier 1 supply chain, Scotland could instead focus on secondary and tertiary use cases for bus technologies like batteries and fuel cells. Another niche area to explore would be rural use cases (given Scotland's geography and potential to produce hydrogen). Although 6 companies in Scotland (AGM, Denchi, Dukosi, CCPS, MEPCS, and Sunamp) are already supplying EV components and 9 others are offering battery-related technologies, they primarily supply to other sectors such as military vehicles, heating and stationary power generation. Therefore, there is a need to coordinate efforts among suppliers to start focusing on mobility applications.

Trade strategy: Given ADL's partnerships with other manufacturers like BYD (China) and Scania (Sweden), there may be an opportunity to reduce the cost of imported components, by advocating for better terms of trade.

Localised manufacturing strategy: An assessment should be made of what policies and initiatives – e.g. skills development – would encourage Scotland's OEM's to localise a greater part of its value chain to Scotland.

Threats

International/UK competition: Other UK regions (e.g. West Midlands) and other countries (e.g. China, Poland) have already developed significant industries, supply chains, and infrastructure facilities to support the growth of their green bus industries.

Brexit: Access to both the supply chain and customers could become more cumbersome and expensive, increasing the costs of manufacturing and retail costs for vehicles. Uncertainty around UK's trade deals with other countries and regions could also reduce investor appetite to locate supply chain manufacturers in Scotland.