Low Carbon Investment - Scottish Bus Electrification commercial and economic content

Scottish Government

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1

Executive Summary

1 Executive Summary

The switch to EV buses has the potential to reduce carbon savings by c300,000 tonnes per annum

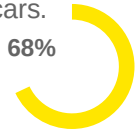
Purpose

We have been asked by the SG to provide an understanding of the electrification of buses in Scotland, including the current economics and what cost reduction and/or additional revenue needs to be achieved for this sector to be commercially viable.

This report provides an overview of the market for illustrative purposes and all further work and contracts would be on a commercial case by case basis.

SG Low Carbon Economy

Transport is a Key Target area in Scotland's ambitions to creating a low carbon economy, with over 68% of greenhouse gases coming from buses, trains and cars.

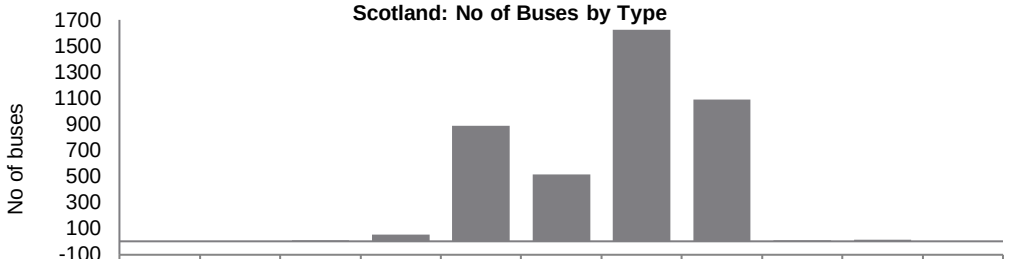


The SG's ambition is to ensure that 75% of Scotland's heat, transport, and electricity consumption is supplied from renewable sources by 2030.

A Scotland-wide bus decarbonisation scheme is being considered, however, due to the unregulated nature of Scotland's Bus market, any options considered would need to be commercially viable for an operator.

Bus Market Overview

- There are currently c4,200 buses servicing Scotland's bus routes with an average age of 7 years.
- Of this 4,200, only 23 are low carbon (i.e. EV Buses and Hydrogen fuel cell).



Bus type	Pre Euro	Euro 0	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI	Hydrogen Fuel Cell	Electric	Total (By Operator)
Bus type	0	0	6	52	890	515	1624	1092	10	13	4202

Bus Type	Average Age (years)	% of bus type
Euro 2	15.93	1%
Euro 3	12.71	21%
Euro 4	9.59	12%
Euro 5	5.76	39%
Euro 6	2.83	26%
Total fleet average age	**7.07**	

- Scottish bus orders amount to c400 buses per annum. Based on this assumption, it would take 10 years to replace Scotland's current fleet with EV buses.
- However, given both the current economic climate, and the potential barriers to purchasing an EV bus, it is likely that it will take considerably longer before Scotland's bus fleet is fully electric.

Scottish Bus Fleet

383,000

Tonnes of carbon emissions annually

Euro 6 v Euro 5 Diesel

1.4%

Carbon savings generated by using a Euro 6 bus to a Euro 5 Bus

Change to EV buses

8,109

Tonnes of carbon emissions

1 Executive Summary

An EV bus TCO is higher than a Euro 6 Diesel Bus over 15 years if subsidy is excluded – but the difference is small

Total Cost to Operate – 1 Bus and 20 Buses (No subsidy)

Key Assumptions

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.
- We have assumed:
  - Diesel buses retired have reached the end of their useful life and have not therefore included an residual value element
  - All buses would be purchased in the year FY20, coming into operation FY21
  - We have made the assumption of 3.1% inflation throughout the project
- When calculating the Net Present Value (NPV) we have used HM Green Book Guidance recommended discount rate of 3.5%
- We reviewed the costs for the purchase of 1 and 20 Buses.

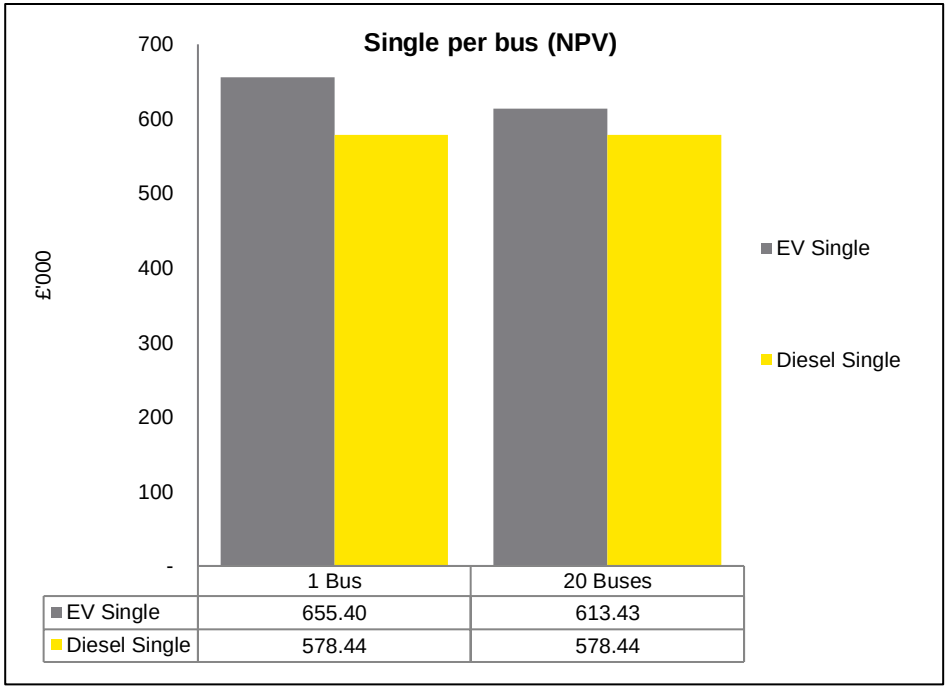
Financial Outputs (NPV)

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.



	1 Bus	20 Buses
EV Single	655.40	613.43
Diesel Single	578.44	578.44

1 Executive Summary

The greater confidence that can be given on farebox, the more likely operators are to invest in a substantial shift in technology.

COVID-19 Impact

COVID-19 has had a devastating impact on the Scottish Bus Sector.

Farebox

Farebox revenue has fallen significantly, and with social distancing expected to continue until a vaccination is found (predicted for the second half of FY21) it is unlikely to recover to normal levels for some time.

The SG has put in place temporary financial support packages that will help bus operators to maintain and increase essential services.

Current conditions mean there is less need to purchase new vehicles and programmes can be paused. Any new investment for bus operators is risky as the pace and extent of the return of farebox is uncertain.

Social Impact

A potential fall in patronage due to a mix of working practices and unemployment will make a number of routes in the Scottish Market unprofitable. As the vast majority of bus patrons earn below the medium national household income of £29,600pa, it is not unfair to say that any changes to the Scottish bus market will disproportionately

Barriers

Take up of EV Bus has been low to date, (0.4% across the EU). The main reasons for this is due to the barriers faced by implementing a new technology into the existing bus network.

Tech risk	A critical risk to take-up is the need for assurance that performance will continue to be at right level, particularly in terms of the range that the bus. This is not a risk bus operators are enabled to take. There are also differing views about the range of different products in different circumstances and an insufficient track record to put the issue beyond debate.
Range risk and batteries	Any proposal will need to be clear how this works in terms of how this risk is covered – through warranties or leasing – and how this interacts with battery replacement costs. .
Scale of capex and cashflow	This is an obvious problem given the high cost of vehicles and the need for infrastructure investment. There are established methods for dealing with this issue through HP and leasing agreements. These are unlikely to provide balance sheet relief for operators unless the term of the lease is shorter than the period over which the debt is expected to be amortised. However the barrier to this is the willingness of finance providers to support leasing companies or operators in purchase
RV risk	Third party finance and leasing can offer solutions to the issue of high capex, but are vulnerable to issue of residual value. This issue affects all vehicles but electric vehicles have two characteristics that make this more difficult – the issue of technology and battery risk, and secondly the current lack of a market for second hand vehicles and barriers to deployment which mean it is more difficult for smaller firms to establish themselves and provide such a market. This issue affects direct financing of vehicles as well as the potential for current lease companies to become more involved in electric vehicles.

Leasing

Regardless of how it is set up and owned, a new leasing operation could help overcome some of the problems that make it difficult for operators and for current leasing companies to support EV Buses in their operations, as well as providing certainty for manufacturers.

Risk		Leasing
Vehicle capital cost	✓	Leasing avoids the need for companies to find the cash to spend on new vehicles as this requirement is spread over the term of the lease.
Charging capital cost	✓	Would only be some ability to reduce upfront costs if this was also leased; there are options in the market to bring this type of service to the market and currently available leasing options (e.g. from SSE). OEMs / third parties would offer such a service.
Battery performance risk	✓	From an operator point of view can manage this risk as the lessor can take on some of the responsibility for this. However, the battery / vehicle manufacturer is in control of this risk, so the risk should be backed onto those parties in order to be managed. This can be done through warranties and agreements between the purchaser of the vehicle and the OEM.
Residual Value	✓	If the lease is shorter than the expected life of the vehicle and the lessor is taking the risk of the residual value, then the operator is insulated from that risk. As long as they return the vehicle in the condition stipulated in the lease contract, they have fulfilled their obligation.

2

Introduction

2 Introduction

Accelerating the take-up of electric buses

Introduction

- In 2017 the SG launched the Scottish Energy Strategy (the Strategy), which sets out a vision that by 2050 Scotland will have “a flourishing, competitive local and national energy sector delivering secure, affordable, clean energy for Scotland's households, communities and businesses.”
- A key priority identified within the Strategy is to continue advocating and supporting the transition to renewable and low carbon energy sources. As a result, SG established a 2030 ‘all energy’ renewables target which sets out an ambitious challenge to deliver the equivalent of half of Scotland’s heat, transport and electricity needs from renewable sources.
- One the SG’s key target areas is Transport, with over 68% of greenhouse gases coming from buses, trains and cars. As well as exploring methods of encouraging a change in vehicle ownership behaviour, the SG is exploring ways of reducing emissions from public transport vehicles through the adoption of new technological solutions.
- A Scotland-wide bus decarbonisation scheme is being considered which potentially involves an EV bus leasing body that will lease buses to bus operators, and a number of charging infrastructure owner/operators that will charge the bus operator and potentially other users to access to services.

Purpose

- We have been asked by the SG to provide an understanding of the electrification of buses in Scotland including the current economics and what cost reduction and/or additional revenue needs to be achieved for this sector to be commercially viable without subsidy. This assessment will include a review of:
  - **Key costs** including the capital cost of EV buses and charging infrastructure, and operational costs including any potential cost saving.
  - **Key revenue** items supporting this sector during roll out and over the full operating life of the bus, including BSOG payments, and its implication for electric buses.
  - **Commercial structures** including the differentiated vehicle ownership models such as leasing, public-private partnership mechanisms and other potential capex reduction methods, and an overview of any public sector accounting implications.
  - **Policy / Subsidy impacts** including the effects of future government policies, e.g. increased bus prioritisation measures; work place parking levies; low-emission zone regulations etc. and the types of subsidy that could be introduced.

Structure

This report includes the following:

1. Scotland’s key targets for a low carbon economy and how transport can play a vital role in meeting them.
2. An overview of Scotland’s Bus network including the age of the fleet, daily mileage, and the split between urban and rural routes.
3. A review of the economics of an electric bus compared to a diesel bus over the whole life of the asset including capex, infrastructure costs and opex.
4. An overview of the barriers operators face when introducing EV buses to their bus networks.
5. A review of patronage and social impact of COVID-19

This report provides an overview of the market for illustrative purposes and all further work and contracts would be on a commercial case by case basis.

3

SG - Low Carbon Objectives

3 SG - Low Carbon Objectives
Emissions, targets and policies

Introduction

This section sets out:

- the SG's low carbon objectives
- key transport targets
- key mechanisms for the bus sector
- COVID-19 impact

Scottish Government: Low Carbon Ambitions

In December 2017 the SG issued the Scottish Energy Strategy, "the Future of Energy in Scotland" setting out its energy vision and targets to 2030.

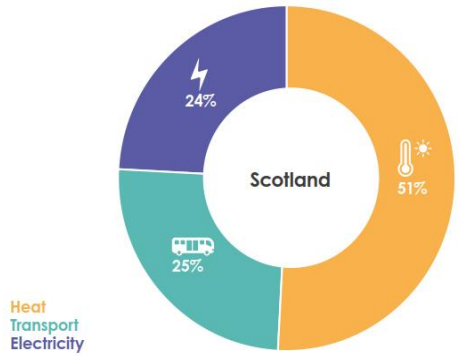
When developing its future targets, the SG ensured that all areas of energy consumption - that is electricity, heat and transport - were part of its targets and initiatives to 2030. The strategy includes the following targets:

- The equivalent of 50% of the energy for Scotland's heat, transport and electricity consumption to be supplied from renewable sources
- An increase by 30% in the productivity of energy use across the Scottish Economy

Transport: Key Targets

Transport represents 25% of Scotland's energy demand and has been identified by the SG as a key objective in meeting its energy ambitions.

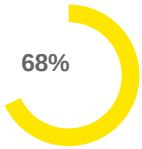
On Scotland's railway, the SG's policy of electrification is reducing the need for diesel rolling stock.



Source https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level

However, road transport contributes the largest portion of overall emissions (68%) and is therefore a priority for action.

Transport GHG Emissions



SG has identified a number of actions to accelerate the decarbonisation of road transport, including expanding electric charging infrastructure between now and 2022; developing Scotland's 'Electric A9'; accelerating the procurement of ULEVs in the public and private sectors; introducing large scale pilots across the country; and providing financial support for local solutions and small scale R&D.

Key Mechanisms

The SG has introduced a number of concepts, aimed at Scottish bus operators, as part of its concepts to improve Scotland's air quality. These concepts fall into two categories, 1. financial penalties imposed and 2. financial incentives.

Financial Penalties

- Low Emission Zones (LEZs) have been introduced / have plans to be introduced across Scotland's largest Cities.
- A LEZ was introduced in Glasgow in 2018 – further developments for LEZs are planned for Edinburgh, Dundee, and Aberdeen, however this has been delayed due to COVID-19.
- A Low Emission Zone is a road space with an environmental limit on the types of vehicles that are allowed to access that road space.
- The standards for vehicles allowed within LEZs are set out below:

Vehicle type	Euro Emission Standard
Petrol (car, taxi, minibus, van, HGV)	Euro 4
Diesel (car, taxi, minibus, van, HGV)	Euro 6
Motor cycle	Euro 3

3 SG - Low Carbon Objectives
Emissions, targets and policies

Financial Penalties (cont.)

- Scotland's Low Emission Zones is not a 'charging' scheme, i.e. non-compliant vehicles will not be able to pay a small daily charge to enter restricted zones.
- Non-compliant vehicles entering restricted zones will be issued a penalty (base penalty of £60 currently proposed, in alignment with current charges on parking and bus lane violations).
- In reference to the current LEZ in place (Glasgow City Centre), enforcement of penalties is currently limited to service buses only.

Financial Incentives

- The Bus Service Operators' Grant (BSOG) scheme is a discretionary grant that subsidises commercial and community bus routes across Scotland. It is an annual subsidy comprising of a core payment and an incentive for the operation of green, environmentally friendly buses.
- The green incentive helps with the additional running costs of low emission buses to support their uptake by operators.
- Entitlement for the BSOG LEV incentive is capped at a maximum period of 5 years starting from the date that the vehicle came into operation.

The COVID-19 Impact

- Pre-COVID-19, due to both the incentives available and advances in the EV bus Market Technology, EV buses were beginning to look like a viable option as the higher capital costs were close to being offset by lower operating costs and the low emission BSOG supplement.
- The Scottish National Investment Bank (SNIB) - on behalf of the SG - was exploring the options to finance the roll out of EV buses across Scotland.
- The financing for the project was subject to a detailed business plan but the intention was for SNIB to co-finance the capital spend, chargers and buses with private sector banks.

COVID-19 has had a devastating impact on the Scottish Bus Sector

- Farebox revenue has fallen significantly, and with social distancing expected to continue until a vaccination is found (predicted for the second half of F21) it is unlikely to recover to normal levels for some time.
- The sector is on government life support with the timing and shape of the recovery impossible to predict.
- The impact on the Balance Sheet of bus operators has been significant and their financiers have indicated that they will not extend further credit to the sector at this time.
- The combined impact is that planning for capital investment is difficult and operators have been cutting or cancelling order for new buses.
- Scottish bus manufacturers and supply chain have also been impacted.
- Falling patronage will affect the overall transition targets.

There is an opportunity for a cross-sector response to the crisis to underpin the viability of the sector and accelerate the drive towards decarbonisation in Scotland

It requires all of the key parties to play a role

Bus operators to co-invest with public sector partners

Bus manufacturers to accelerate their delivery of EV buses and increase local content

SNIB to lead the provision of capital financing and attract the support of private sector co-financiers

TS to provide the required revenue or capital support required to deliver zero carbon transport

4

Scotland Bus Market Overview

4 Scotland Bus Market Overview

Composition of the Scottish bus fleet

Introduction

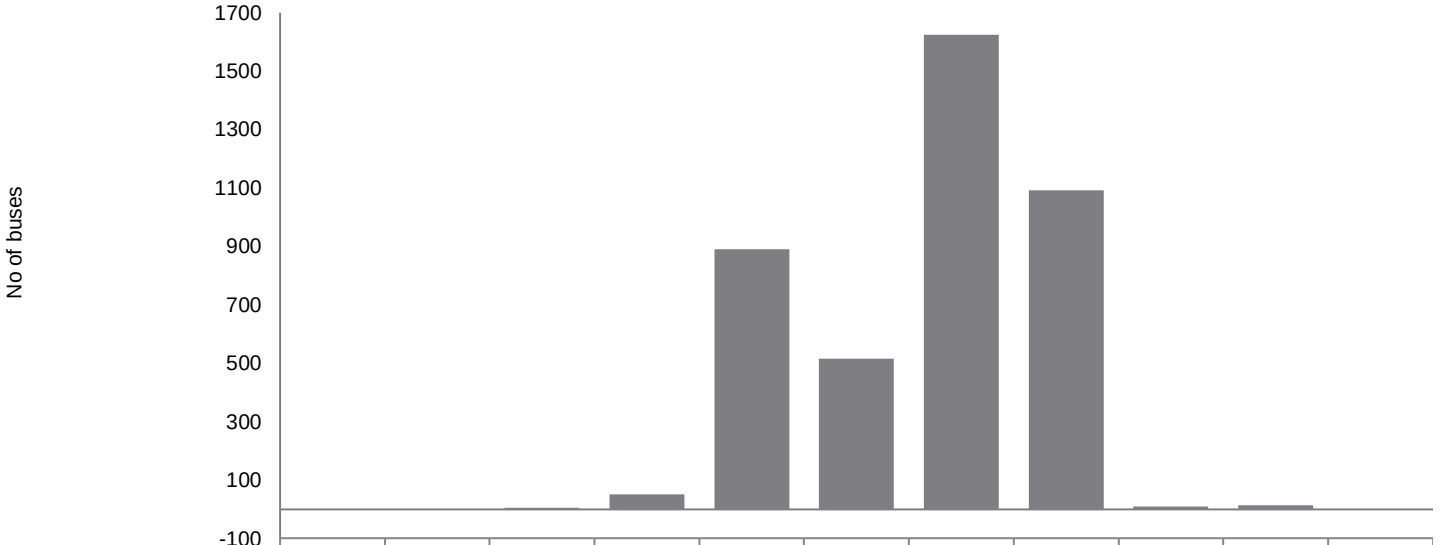
This section sets out a summary of the current Scottish Bus market in order to understand:

1. The types of buses currently in operation
2. The age of these buses and the likely replacement profile
3. The CO2 emissions per bus type
4. The largest operators and their share of the market

Scotland: Bus Type

- The average Scottish bus daily mileage is c130 miles which is the equivalent to c50,000 miles per year.
- There are currently c4,200 buses servicing Scotland's bus routes.
- Euro V and Euro VI Diesel buses represent the largest share with 39% and 25% of the total number of operational buses.

Scotland: No of Buses by Type



	Pre Euro	Euro 0	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI	Hydrogen Fuel Cell	Electric	Total (By Operator)
Total (By Engine Type)	0	0	6	52	890	515	1624	1092	10	13	4202

- Hydrogen Fuel Cell and EV buses represent the lowest share cumulatively - representing less than 1% of the total number of operational buses in Scotland.
- This is consistent with the profile of EV buses across Europe where EV buses account for 0.2% of operational buses.
- The largest EV bus fleet in the world is currently in China, with 14% of its total fleet (400,000 Buses) electric.
- However, it is widely recognised that there will be a shift to EV buses in the coming years as cities across the world strive to meet their green agenda.

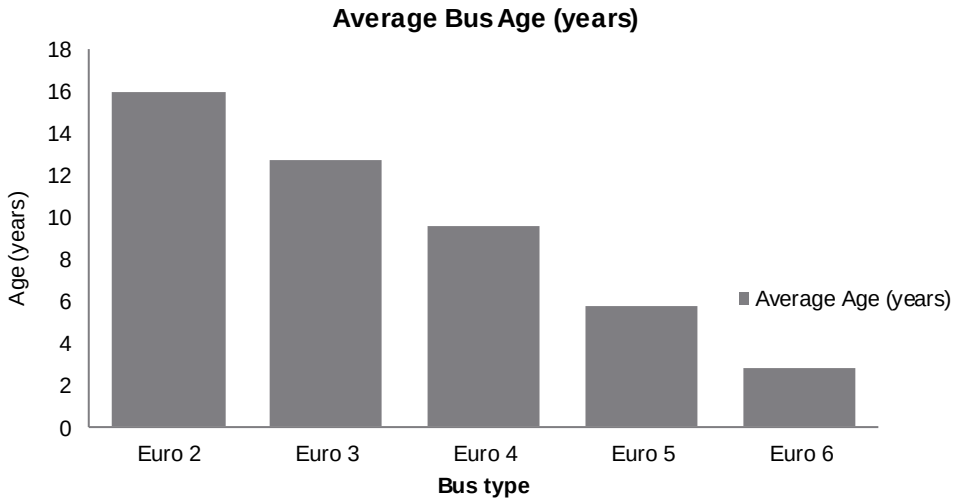
4 Scotland Bus Market Overview
Bus age and replacement

Average Bus Age

- The average Scottish fleet age is 7 years.
- The current average age profile of the current Euro V and Euro VI buses is approximately 4 years - in comparison to 9.5 years and 12.5 years for Euro IV and Euro III buses, respectively.

Bus Type	Average Age (years)	% of bus type	No of buses
Euro 2	15.93	1%	52
Euro 3	12.71	21%	890
Euro 4	9.59	12%	515
Euro 5	5.76	39%	1624
Euro 6	2.83	26%	1092
Total fleet average age	**7.07**		

- Euro 6 buses are the latest Diesel offering and amount to 26% of the fleet.
- However, due to the low carbon targets set by Scottish Government, operators are reluctant to continue to purchase diesel buses.
- Based on the current needs and the ageing profile of Euro IV and Euro III buses, c900 buses may need to be replaced within the next four years if we assume the average useful life of a bus is 15 years.
- From discussions with bus manufacturers, Scottish bus orders amount to c400 buses per annum.
- Based on this assumption, it would take c10 years to replace Scotland's current fleet with EV buses.
- However, given both the current economic climate, and the potential barriers to purchasing an EV, it is likely that it will take considerably longer before Scotland's bus fleet is fully electric.



- Operators are likely to continue to use aging fleet increasing their life. The table below includes an overview of the useful life of a Diesel Bus.

Useful Life	Years
Expected	12 to 15
Average	15.1
Optimum	12 to 14
Minimum	12

- An electric bus could potentially have a longer life depending on battery life.
- Furthermore, there is evidence in the industry that (pre-COVID-19) patronage numbers were continuing to fall. It may be the case that when a bus has reached the end of its useful life it will, therefore, not be replaced.

4 Scotland Bus Market Overview

Carbon emissions of diesel vs electric

Carbon Emissions

- Electrification of the transport sector represents a key challenge for the SG in its attempts to ensure that 50% of Scotland's heat, transport, and electricity needs are supplied through renewable energy sources.
- Although net emissions reduced significantly between 1990 and 2017, emissions from road transport have increased by 11.1% over the same period.
- The entire Scottish bus fleet contributes c383,000 tonnes of carbon emissions annually, therefore electrification would represent a significant step toward achieving the SG's ambitious targets.

Impact assessment: Diesel Buses

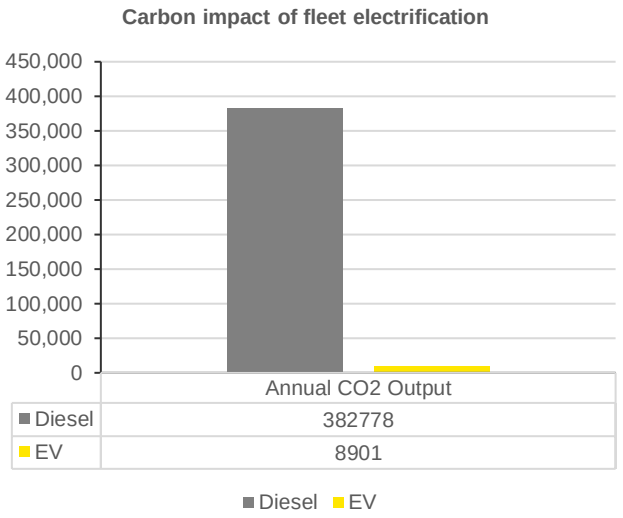
The table below shows the approximate carbon output (g/km) of different bus types and the quantity of each. The fleet composition (single to double deck buses) is assumed to be 55/45% based on the data from the largest operators on slide 19. An annual distance of 80,500km per bus has been assumed.

Bus	Single (55%) (g/km)	Double (45%) (g/km)	No of buses	Total emissions (tonnes)
Euro III	1,130	1,430	890	90,631
Euro IV	975	1,370	515	47,790
Euro V	942	1,326	1,624	145,740
Euro VI	936	1,349	1,092	98,617
Total			4,121	382,778

Impact Assessment: EV buses

A high-level estimate of emissions of a fully electrified fleet has been outlined below. A grid carbon intensity of has been assumed 24g/kwh based on most recent SG guidance.

Carbon intensity of the Scottish grid	24 g/kwh
Kwh per annum per bus	90,000
High level output	8,901 tonnes



Introducing EV buses to the Scottish fleet will significantly reduce carbon emissions contributing to the SG's low carbon targets.

Scottish Bus Fleet

383,000

Tonnes of carbon emissions annually based on Scottish fleet of c4,100

EV buses

8,109

Tonnes of carbon emissions annually based on Scottish Bus fleet of c4,100

Euro 6 v Euro 5 Diesel

1.4%

Carbon savings generated by using a Euro 6 bus to a Euro 5 Bus

4 Scotland Bus Market Overview

Scottish Operators

- The table below includes an overview of number of buses split across operators.

Buses by operator	No of Buses	Single	Double	%
First	1195	58%	34%	28%
Stagecoach	1,081	70%	26%	26%
Lothian	746	16%	83%	18%
Total	**3347**	**47%**	**53%**	**72%**
Remaining 13 operators	1180			28%
Total	**4202**			**100%**

Operators in Scotland have not yet introduced EV buses to their fleet on a large scale (EV's represent less than 0.5% of the Scottish Bus market).

Changing the Bus Landscape in Scotland will require a commitment from all operators if the SG is to meet its 2030 target of 50% reduction in emissions.

Overview

- Scotland's bus market is largely dominated by three operators; First Bus, Lothian Buses and Stagecoach.
- The top three operators own 72% of the buses currently operating in Scotland.
- At present, Scottish bus operators only operate a small number of EV/Low Carbon buses in their fleet.
- Without the backing of these operators, the SG will not meet its 2030 emissions targets.

Investment Considerations

When considering the replacement of its fleet of buses with EV buses, an operator will consider the following:

1. The age of its existing vehicles, i.e. how many vehicles are coming to the end of their useful lives.
2. A comparisons of the capital and operating costs involved in purchasing either an EV bus or a Euro 6 Diesel Bus.
3. The infrastructure required to bring an EV bus to operation and the capital cost of this.
4. The average daily mileage per route, and whether an EV bus has the capacity to service this route.
5. Incentives available for purchasing an EV bus.
6. Future patronage forecasts and the requirement to replace the fleet, or whether a reduced fleet will be more efficient.
7. Risks of introducing new technology including reliability/ training/ maintenance etc.

5

Total Cost to Operate

5 Total Cost to Operate

Banner name

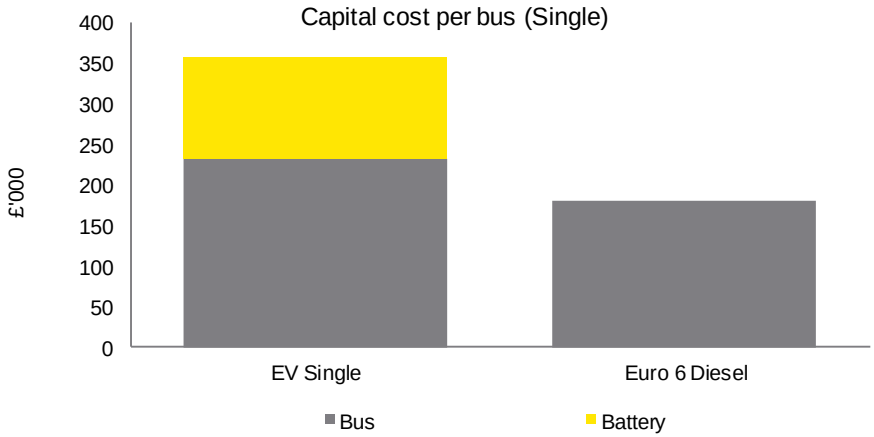
Capital Costs - Bus

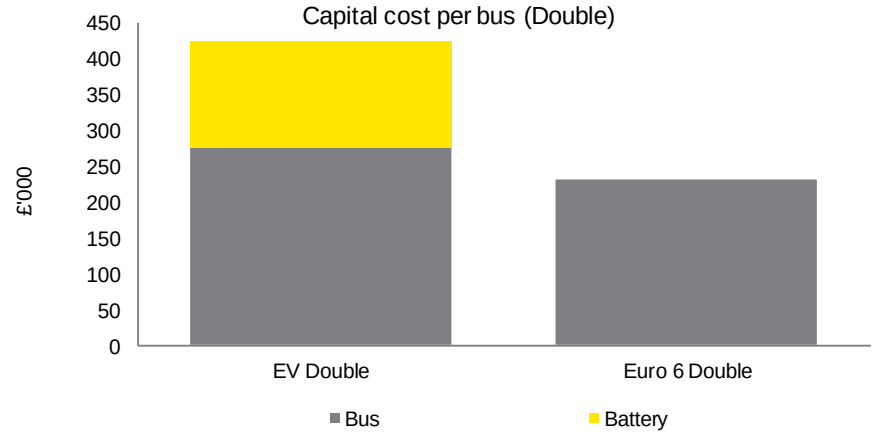
- Capital costs include both the cost of a bus and the cost of any infrastructure required.
- The main assumptions made when calculating the cost of an EV bus are around the battery warranty manufacturers can offer. Battery warranty costs can vary across different manufacturers. We have reviewed capital costs across manufacturers which include 5/7/8 year warranties as standard, as well as extensions of up to 10 years. The length of the warranty will also have an impact on any battery replacement costs the operator will incur.
- Single decker buses ranged in price from £355k and £360k, we therefore took an average capital cost in our capex assumption. However, we have also assumed that the capital cost range will widen further if bulk orders are placed.
- A battery life is assumed to be 7 years, manufacturers also differ in their assumption around what happens after 7 years, i.e. will the full battery need to be replaced at year 8 versus various cells being swapped out as and when needed. We have assumed a battery maintenance programme once the battery warranty runs out.

We have made the following assumptions with regards to an EV bus:

- Capital cost includes a 7 year warranty
- Battery accounts for c. 35% of the overall bus price
- The graphs opposite reflect the capital cost per bus.

Capital cost per bus		EV (Single)	Diesel (singe)	EV Double	Diesel Double
Bus	£'000	357	180	425	230
Bus	%	65	100	65	100
Battery	%	35	0	35	0
Warranty 7 years	£'000	included	included	included	included





5 Total Cost to Operate

Capital Cost - Infrastructure

The bus operator will need to ensure that the correct infrastructure is installed to charge EV buses. Infrastructure costs includes:

1. The cost to ensure that the bus depot is connected to the distribution network
2. Chargers can be installed at the depot to charge the buses
3. Any upgrades to the depot are made as required, to accommodate the EV buses.

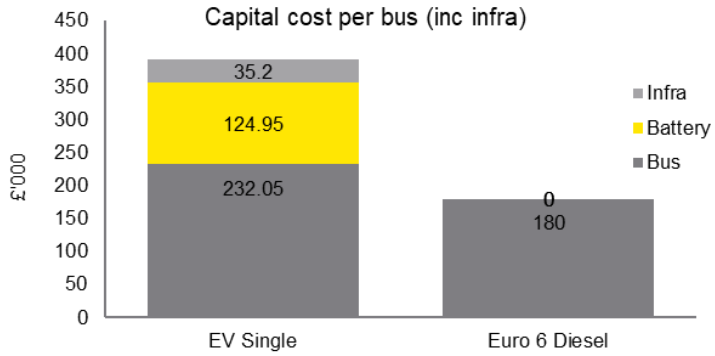
The cost range for each point above can vary significantly depending on:

1. How easy it is to connect to the grid. Grid connections vary depending on location/grid capacity etc.
2. What type of charger the bus operator chooses. Bus operators have the choice of either AC charging or DC Charging to charge an EV bus. AC charging can take longer (6 hours) compared to a DC Charger (3 hours). However, the costs of installing DC chargers vary significantly from a AC charger. DC chargers range in cost approx. £30-45k per charger. AC chargers are £1.5k per bus.
3. The size / layout of the existing depot, i.e. does the depot need to be reconfigured to install chargers, etc.

Based on the above, we assumed the following costs:

- Infrastructure costs - will be the same for EV Single and EV Double Buses.
- AC charging stations - we have assumed that each bus will have its own AC charging station at the depot to minimise reorganisation of the fleet at night. AC charging stations are c£1-1.5k, and it typically takes 5 hours to charge a single decker and 6 hours to charge a double decker.
- DC charging stations are more expensive than AC stations (c£45k), however buses can be charged quicker. It is likely there would be 1 or 2 DC charging stations per 20 vehicles to ensure full charging as a back up to the AC charging.
- Grid connection per vehicle of £25k. However, this will vary depending on the location of the Depot, and the number of buses this is spread across.
- Depot alterations per vehicle of £1k. We have not assumed additional land required
- Contingency cost of 10% as standard HM Green Book Guidance for capital projects.
- We have therefore assumed that the cost per bus of installing infrastructure is £35.2k (if 10 buses are installed) bringing the total estimated capital cost of an EV Single Decker to £392.2k (Double decker £460k).

Infrastructure costs		EV bus (Single and double)
Cost per charging point AC	£'000	1.5
Cost per charging point DC	£'000	45
Buses charged per AC	no	1
Buses charged by DC	no	10
Grid connection and cabling per vehicle	£'000	25
Depot expansion per vehicle	£'000	1
Contingency	%	10%
Average infra cost per bus	£'000	35.7
Charger life	Years	15



5 Total Cost to Operate

Banner name

Operational Costs

Fuel – EV buses

When calculating the fuel cost per bus type, we have assumed:

- that the average bus travels c140miles per day, equating to c50,000 miles (80,500 km) per annum.
- EV bus manufacturers will guarantee that a battery will perform at 160miles per day for the first 7 years of operation.
- A Single Decker bus will require 1.8kwh for every mile travelled (2.3km double).
- The following equation:

$$no\ of\ miles\ x\ kwh\ per\ mile\ x\ price\ per\ kwh$$

- The price of electricity will differ between peak/non-peak hours.
- Buses will be charged 20% at peak and 80% at non-peak.
- Pricing is based on current electricity pricing and inflated using the BEIS electricity inflation factor.
- It is likely that electricity costs will fluctuate over the life of the bus and an operator may put in place a PPA to fix electric costs on an annual basis.

Fuel Costs per bus		EV Single	EV Double
Miles per annum	000	50	50
pence per kwh (Day)	p	15	15
pence per kwh (Night)	p	11	11
Fleet charged by day %	%	20	-
Fleet charged by night %	%	80	-
kwh required for 1 mile Single Decker	kwh	1.8	2.3

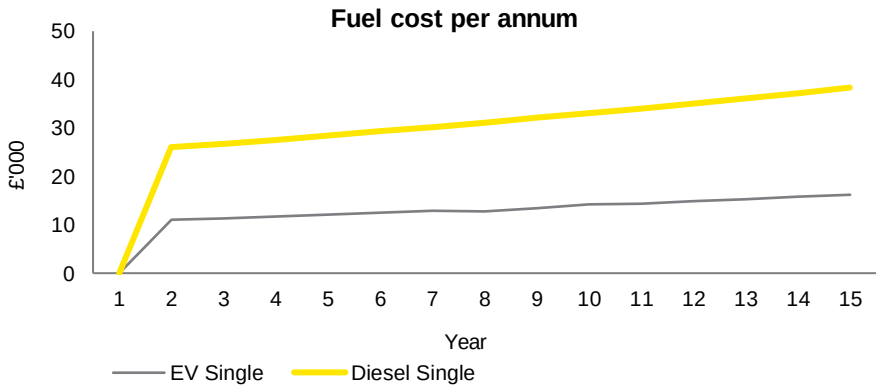
Fuel – Diesel

We have assumed the following:

- Diesel buses perform the same annual mileage as an electric bus using UK averages.
- A single decker's average consumption rate is 9.1mpg (double 7.8mpg).
- Fuel pricing is based on the current cost of diesel, however it is likely that fuel costs will fluctuate over the life of the bus and an operator is likely to put hedging agreements in place. We have assumed fuel prices change using the BEIS index for transport modelling.

Fuel Costs per bus		Diesel Single	Diesel Double
Miles per annum	000	50	50
Miles per gallon	no	9.1	7.8
Litres per gallon	No	4.55	4.55
Fuel cost per litre	P	100	100

The graph below shows the difference in fuel costs over the life of the bus (single decker).



5 Total Cost to Operate

Banner name

Maintenance Costs

EV buses

- Annual maintenance costs per bus have been assumed to include labour, parts and upkeep.
- In addition, for EV buses we have assumed costs in the first year around staff training / re hiring of £5k per bus.

The table below includes an overview of the cost per bus.

Maintenance costs (per annum)		EV Single	EV Double
Parts	£'000	6.15	7.15
Charger upkeep	£'000	0.27	0.27
Labour	£'000	3.08	3.58

Maintenance costs (per annum)		Diesel Single	Diesel Double
Parts	£'000	7.59	7.89
Charger upkeep	£'000	-	-
Labour	£'000	4.48	4.60

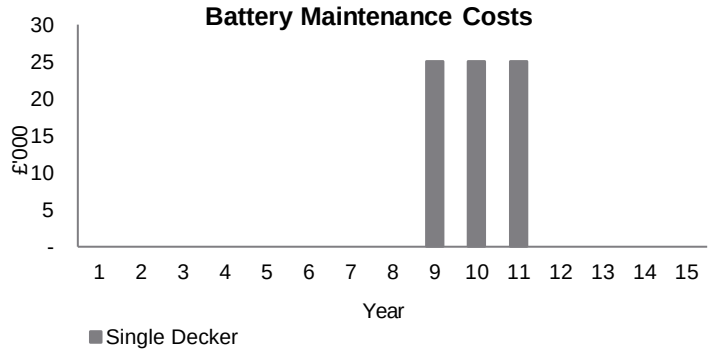
This gives an annual figure of 9.5k vs 12.07k for a single bus.

Battery Maintenance Costs

- Battery costs will be dependent on both the condition of the battery at the end of the 7 years, and the type of warranty the operator has in place with the manufacturer.
- Furthermore, EV Batteries have continued to come down in price over the last 10 years (battery costs have reduced by about 30% in this period) and their range has improved.

Our assumptions include:

- EV batteries are manufactured to operate at 75% capacity (at least c160miles per charge) for 7 years.
- Each battery has a number of fuel cells which will all need to be replaced during the buses useful life if it is to continue in operation until year 15.
- As we have included a 7 year warranty in our base case, we have assumed a £25k per year maintenance programme from year 9 to year 11 for fuel cells.
- We have assumed the same profile for an EV Double Decker at an increased cost of £30k.



5 Total Cost to Operate

Banner name

Incentive Schemes

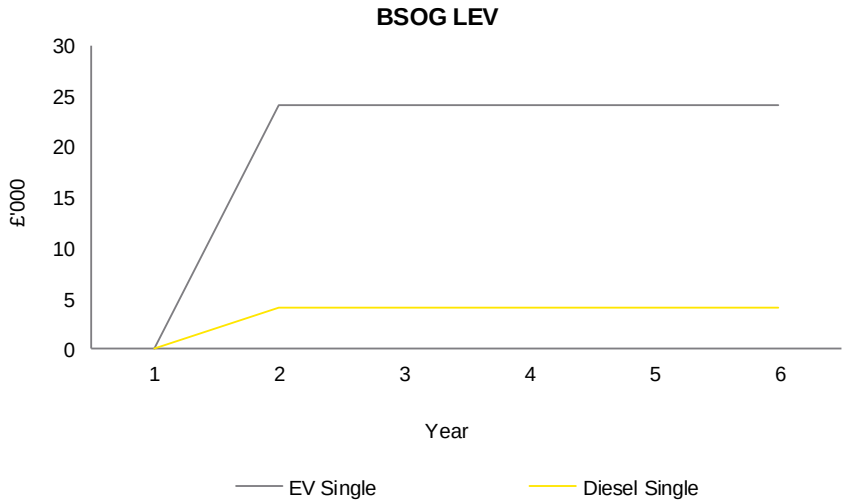
BSOG

BSOG is a discretionary grant that subsidises commercial and community bus routes across Scotland. It is an annual subsidy comprising of a core payment and an incentive for the operation of green, environmentally friendly buses.

- The core rate of BSOG payable is 14.4p per km throughout the life of the bus.
- The LEV buses element is capped at a maximum period of 5 years starting from the date that the vehicle came into operation.

	EV	Diesel	No of years
BSOG All	14.4p	14.4p	life of bus
BSOG LEV	30p	5p	5 years

- A Euro 6 diesel bus is considered to be a Low Emission Vehicle and therefore receives 5p per km for 5 years.
- A EV bus is considered to be a Zero Emission Bus and receives 30p for 5 years.



The graph opposite includes an overview of the BSOG Grant differences in the first 5 years of operation, contributing to £20k additional income for an EV bus per annum.

Capital incentives

At present there is no capital incentive for the purchase of an EV bus in Scotland, however, previously Transport Scotland has offered operators 40% of the difference of an EV bus and a Diesel Bus. We have not therefore included an element within our base case, but have included options within our sensitivity analysis.

Potential additional revenue

It has been suggested that operators could allow other EV bus users to charge their vehicles on site at their depots. We have not included this as a potential revenue stream due to the low take up of EV buses currently.

5 Total Cost to Operate

Banner name

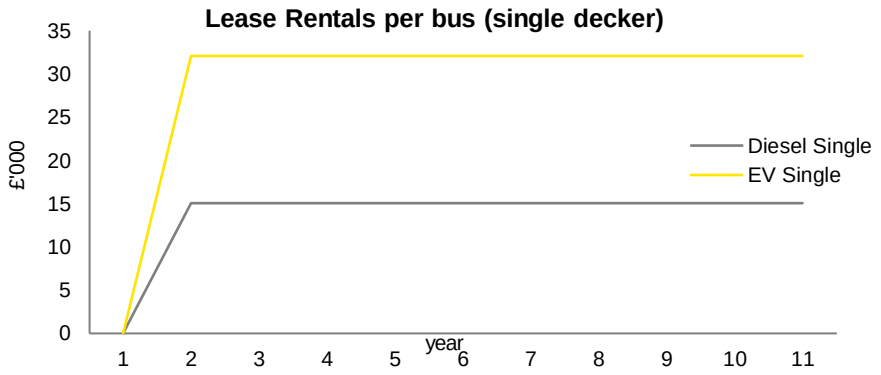
Funding / Financing

EV bus Funding

- Financing is an important element of the cost of an EV bus.
- From discussions with lease providers, the current lease term offered on an EV bus is 7 years (with the option of a 3 year extension). This would be in the form of an operating lease, with the leaseholder taking the residual value risk.
- For our base case, we have assumed a 10 year lease, and the bus would have five years useful life remaining.
- We have assumed an interest rate of 4% is payable as finance would be secured against an asset. This is lower than the average WACC for a UK bus operator.

Diesel Bus Funding

- Lease providers tend to value a diesel bus as having a useful life of 15 years, and take residual value risk on any lease term shorter than this.
- For our base case, we have assumed a 10 year lease, and the bus would have 5 years useful life remaining at the end of the lease period.
- We have assumed an interest rate of 4% is payable.

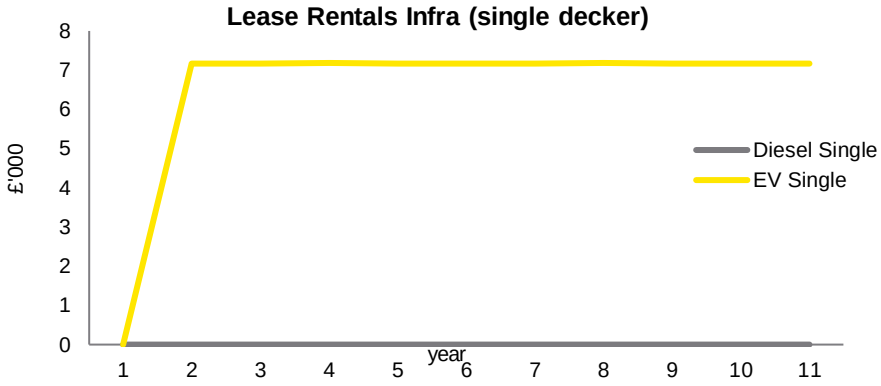


Infrastructure Funding

Infrastructure tends to be financed in one of two ways:

1. Operator installs and operates the infrastructure themselves incurring a high capital payment and a yearly operating charge.
2. Operator leases the infrastructure and pays the provider an annual maintenance amount to operate the charging infrastructure.

We have assumed that the bus operator in this instance would maintain its own fleet (included in opex).

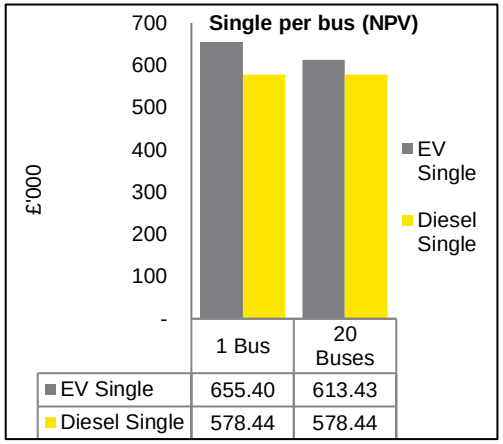


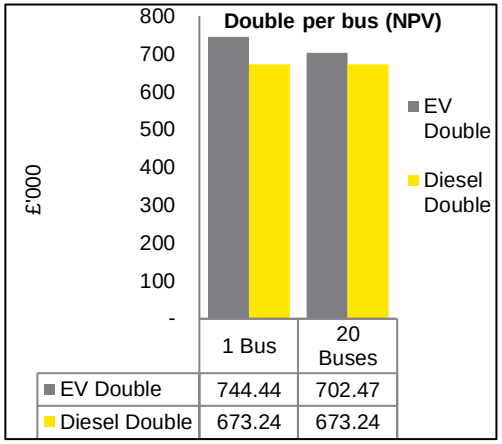
5 Total Cost to Operate

BASE CASE: No BSOG – Core Rate and LEV Rate Removed

1:1 Bus - The 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 gap between an EV bus and an Euro 6 Diesel bus to £30k per bus. This is due to a scaling of infrastructure costs.





Nominal	1 Bus				20 Buses (cost per bus)			
£'000	**EV Single**	**Diesel Single**	**EV Double**	**Diesel Double**	**EV Single**	**Diesel Single**	**EV Double**	**Diesel Double**
Total bus acquisition cost	357.0	180.0	425.0	230.0	357.0	180.0	425.0	230.0
Total infrastructure cost	79.8	-	79.8	-	35.2	-	35.2	-
Total operating costs	491.7	718.1	545.8	807.2	486.5	718.1	540.7	807.2
BSOG	0	0	0	0	0	0	0	0
Loan capital	(357.0)	(180.0)	(425.0)	(230.0)	(357.0)	(180.0)	(425.0)	(230.0)
Interest Charge	124.4	62.7	148.1	80.1	124.4	62.7	148.1	80.1
Principal Repayment	357.0	180.0	425.0	230.0	357.0	180.0	425.0	230.0
Loan capital	(79.8)	-	(79.8)	-	(35.2)	-	(35.2)	-
Interest Charge	27.8	-	27.8	-	12.3	-	12.3	-
Principal Repayment	79.8	-	79.8	-	35.2	-	35.2	-
Net Cash Flow	1,080.7	960.8	1,226.5	1,117.3	1,015.4	960.8	1,161.2	1,117.3
Project life NPV	**655.4**	**578.4**	**744.4**	**673.2**	**613.4**	**578.4**	**702.5**	**673.2**
Net cash flow per vehicle mile (£)	21.61	19.22	24.53	22.35	20.31	19.22	23.22	22.35

6

EV buses

Barriers to operation

6 EV buses

Introduction

Changing the Bus Landscape in Scotland will require a commitment from all operators if the SG is to meet its 2030 target of a 50% reduction in emissions.

EV buses have zero emissions, lower operational costs, and could help the SG meet these targets - however, take up has been slow to date.

The main barriers facing EV buses include:

1. High capital costs
2. Technology risk
3. Performance risk
4. Infrastructure
5. Operational maintenance
6. Grid connection
7. Product cost risk

We have included an overview of the potential barriers to operation below.

Capital Costs

The high up-front cost associated with EV buses is often cited as the primary challenge to EV bus procurement. EV buses cost two times more than conventional diesel buses.

EV buses have a high initial cost for several reasons, mostly related to their status as a new technology with unknown risks and an emerging market place. As a result, EV buses have a much higher price, which can make their procurement difficult to justify in economic terms. The single-largest contributor to the cost of an EV bus is the price of its battery (around 35 percent of the total vehicle price).

Due to these high up-front capital costs, many operators must secure financing for EV buses, which can be difficult. Financing constructs for EV buses had historically fallen into two primary categories: capital leases and operating leases. As illustrated in the modelling, interest charges can make the difference in viability between diesel and electric.

However, recent changes in accounting standards for operating leases have rendered this construct generally non-viable. In a capital lease, the operator or transit agency buys (and owns) the EV bus up front but pays for it over time.

Under the prior construct for an operating lease, the operator or transit agency never buys the EV bus, but pays a certain price each month for the rights to use it. This allowed for 'off-balance sheet' accounting for bus operators.

The updated accounting standards generally place the balance sheet burden on the entity that directly operates the vehicles, which makes such an arrangement difficult to execute.

Since a capital lease typically also requires an operator to report the entire value of an EV bus as a liability on its balance sheet, capital lease structures limit not only the financial risk to the manufacturer but also the benefit to the operators. Thus, depending on the operators budgeting rules, capital leasing may offer no benefit over a direct purchase.

While some EV bus manufacturers do offer leasing options (which eliminates residual value risk for the bus operators), the terms of these leases can vary dramatically and these leases are typically only available for pilot programs or small order sizes.

Technology Risk

- 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 (15 years).

6 EV buses

Technology (cont.)

There are commercial arrangements that can help mitigate this risk – warranties that manufacturers can give. These can either:

- guarantee either the battery will remain effective for its anticipated working life (e.g. 7 years). This would require a different mechanism for replacement of the battery and certainty that such replacement can be made at appropriate cost; or
- Guarantee that the battery will be available at sufficient capacity for a longer period (e.g. 12 years) so that it is guarantees to last effectively as long as the vehicle. This would be more likely than the shorter guarantee to involve some degree of continuous replacement of cells of the battery as they individually fall below capacity.

Each of these options would depend on the willingness of manufacturers to enter into such agreements and also crucially on the track record and confidence in manufacturers given that the operator would require confidence that the manufacturer would continue to have the financial capability to stand behind any warranty or guarantee.

There has not been a track record yet of large scale deployment and the battery issues that may arise – for instance battery issues in 5% of vehicles could be debilitating for a bus operation given the slim margins they work on operationally. Neither is there a long-term track record of battery manufacturers supporting their products for the lifetime of a vehicles.

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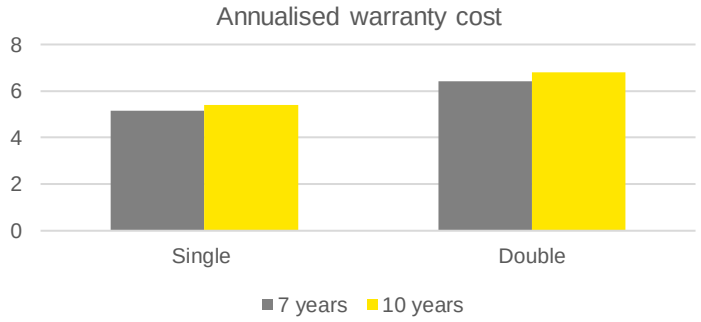


Performance

Operators will be concerned to ensure the continued availability of vehicles. The risks around diesel vehicles are well known and effectively managed by operators currently. However EV buses presents a new set of risks that operators will need to understand how they can manage and be certain that operations will not be interrupted.

Despite gains in the range and ability of EV buses over the past several years, there are still performance limitations. Most manufactures will guarantee performance of 160km per charge for the first 5 years. Despite these advances, there are still limitations around the range and power of EV buses. Temperatures can also affect the range travelled as power required to heat or cool the bus reduces the range of the bus per charge.

If we assume an average length of service of 140km, it's highly likely that a proportion of routes would be greater in length than a single charge. This presents a challenge operationally.

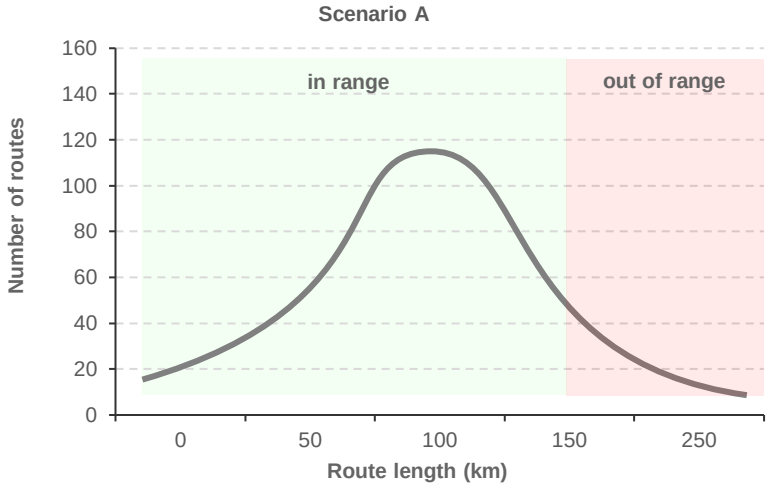
The exact distribution of lengths of service is not currently known, however, we have charted two potential scenarios (A and B) on the following page.

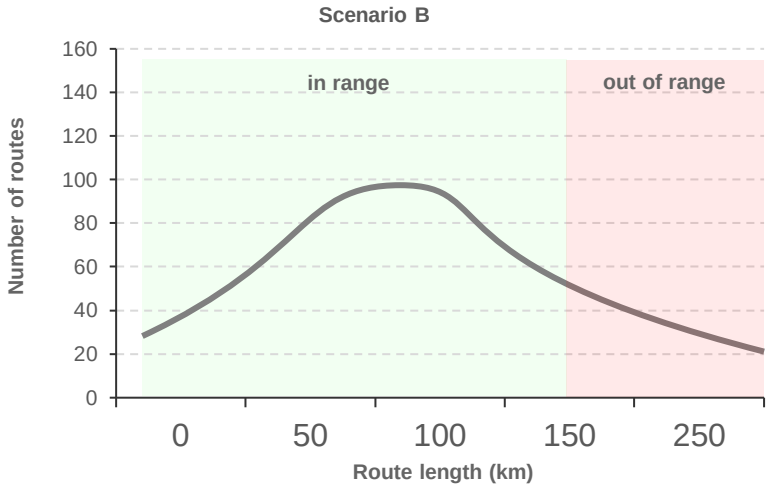
*Scenario A (*thin tail) – this presents a normal distribution whereby the vast majority of lengths of service are within one standard deviation of the average. Under these conditions an EV bus would be able to fulfil the daily service requirements of most routes on one single charge. There would be a small number of routes.

Scenario B (fat tail) – this presents a distribution whereby the majority of lengths of service would still fall within the applicable EV bus range, however the 'fat tail' represents a larger number of routes which would not be serviceable on a single charge.

6 EV buses

Performance (cont)





Challenges

- *Rural routes may not currently be viable for electrification* – As shown in scenario B, there may be a significant proportion of routes that require daily mileage that exceeds the EV bus range from a single charge. This may be particularly problematic for rural routes.
- *A phased approach to electrification may be necessary* – Given the above, it may be necessary to roll-out an EV bus fleet gradually, focussing first on those where the length of service is comfortably below the EV bus single charge range
- *Structuring depots may be difficult with a blended fleet* – There may be additional operational challenges to consider when running a fleet comprising both diesel and EV buses.

Infrastructure

Operators will need to have some additional capex in the depot in terms of the DNO connections, charging equipment, and any layout changes required as set out above. In terms of commercial decision, operators will need to understand how to approach this expenditure.

Furthermore, bus operators do not usually have technical expertise in electricity infrastructure and often struggle to fully grasp what electrical upgrades are needed to facilitate EV buses, including how charging stations are installed and what kind of grid upgrades will be required.

In addition to the physical infrastructure requirements, operators often also do not understand the importance of, and requirements for smart charging. Smart charging is the generic name for an electricity pricing and distribution scheme that uses computer algorithms to ensure efficient, flexible, and economical charging.

While enabling smart charging is a relatively small expense compared to other infrastructure requirements, it does require forward thinking to ensure that appropriate communication infrastructure is in place (such as ethernet connections and hardware to protect security).

6 EV buses

Operational Maintenance

The operational restructuring required to address the different maintenance duties of EV buses is considered to be another barrier.

- If EV bus maintenance will be the duty of the operator, then measures need to be taken to ensure the manufacturer (or other qualified group) provides training and continued guidance.
- If maintenance will be partially or fully contracted to a third party, then the duties and responsibilities of each stakeholder need to be well defined.
- In either scenario, a lack of coordination can lead to low EV bus availability rates.

Grid Capacity

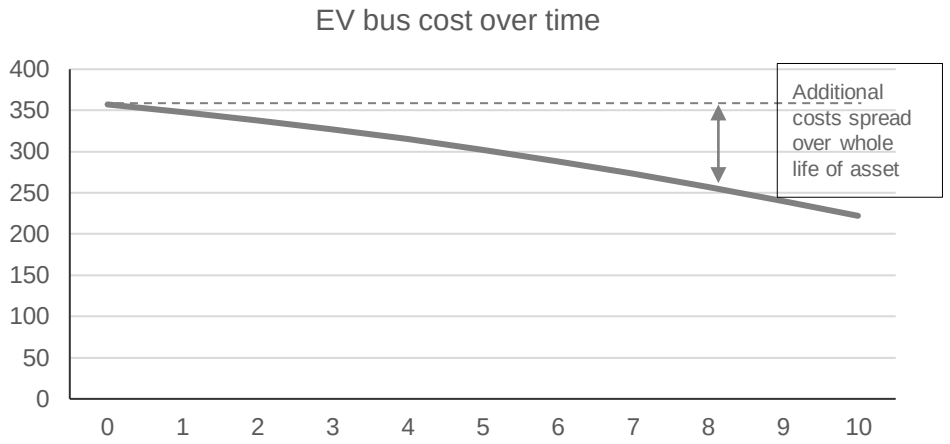
While this issue may not apply at the moment - with take up still low - as EV buses fleets are established and expanded, grid instability at the local level will likely become increasingly important.

Grid capacity is likely to be sufficient for a small number of EV buses but large scale change could mean that depot connection reinforcement is necessary. This can be both expensive (for some depots this could cost c. £5m) and also time consuming.

Product Cost Risk

New technologies tend to reduce in cost over time and with increasing scale of manufacture. This is likely to be the case with EV buses, although this is not an absolutely new technology and the extent of such changes is open to debate.

The commercial risk faced by operators is that in a relatively short period of time cheaper vehicles become available and that therefore they are running more expansive vehicles (on a whole life / depreciated basis) than they could have done or than potential rivals might be doing.



Much of the vehicle is unlikely to change in cost as the technology is well established – for instance the vehicle body, steering, brakes etc. Electric motors are also a well-established technology and unlikely to be changed a great deal.

Overall the cost shift may not be very large, but would still become a commercial consideration for a bus operator considering a purchase decisions, in effect creating a first mover disadvantage.

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7

COVID-19 Impact

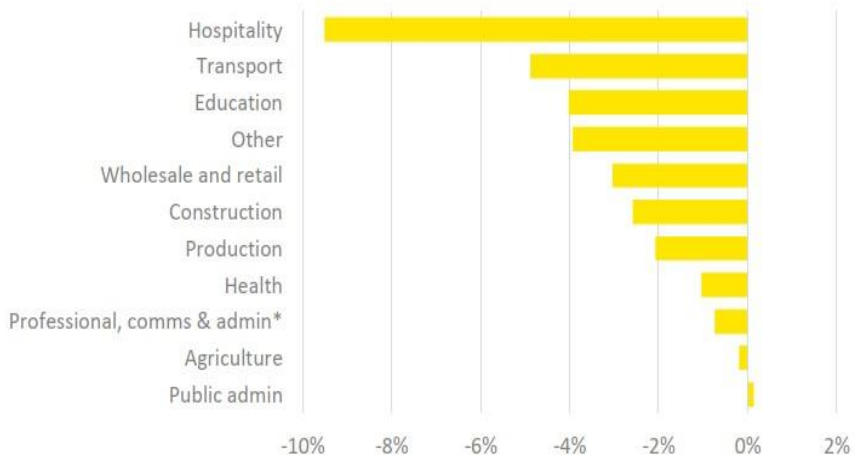
7 COVID-19 Impact
Patronage and revenue

Introduction

In the wake of COVID-19, this section looks at the level of protection the SG has put in place for operators and the likely social impact.

COVID-19 Impact

- Q1 2020 impacts highlight sectors most affected: hospitality, travel and tourism, education and non-food retail



Scotland bus passenger number fallen by 80% since June 2019.

The SG has put in place temporary financial support packages that will help bus operators to maintain and increase essential services which has been outlined below, but it is unclear when, or if, passenger numbers will return to pre-COVID-19 levels.

COVID-19 Grant

Payments are being made to operators on a monthly basis and individual operator's payments are based on:

- the estimated level of NCTS lost due to COVID-19; plus
- the pre-COVID expected level of BSOG

The grant terms require operators to:

- continue to deliver around 30% (25-35%) of bus service levels for the period of the scheme to maintain core services (unless otherwise agreed with Transport Scotland); and
- continue engagement with relevant local authorities and health boards to determine what bus services should be operated, when and on which routes

The grant was initially put in place for a three month period with a review planned for June but with physical distancing requirements continuing it is being maintained for the time being and supplemented with additional funding (COVID-19 Support Grant - Restart) to enable services to be extended as Scotland moves out of lockdown. Certainty around grant support and timelines of when it may run out should therefore been provided by Transport Scotland.

Change in employment practices

- In 2019 only 5% of the 32.6 million UK workforce mainly worked from home (WFH), less than 30% had WFH at some point during that year (ONS).
- In April 2020, 50% of the UK workforce was working from home.

There is likely to be a higher proportion of the population working from home compared to the pre-COVID scenario, mainly as a result of businesses realising that their employees are able to work effectively from home without compromising on productivity. The impact of social distancing:

- An ONS survey suggests that post lockdown, 33% of the UK population are expect to increase WFH by at least 3 days a week and up to 81% would like to work at least 1 day a week.
- There will always be a need for a space that brings employees together as there are roles that cannot be delivered remotely and organisations will need to be careful they do not lose the innovation that comes from ideas being generated through in person conversations. However, most organisations will be reviewing their property portfolio to understand what their 'future of work' looks like.

7 COVID-19 Impact
Social Impact

Unemployment

There is also likely to be a spike in unemployment when the Government's furlough scheme ends. Companies will be reviewing their operating models and looking to become more efficient and effective to deal with the reduction of revenue since the start of Covid-19.

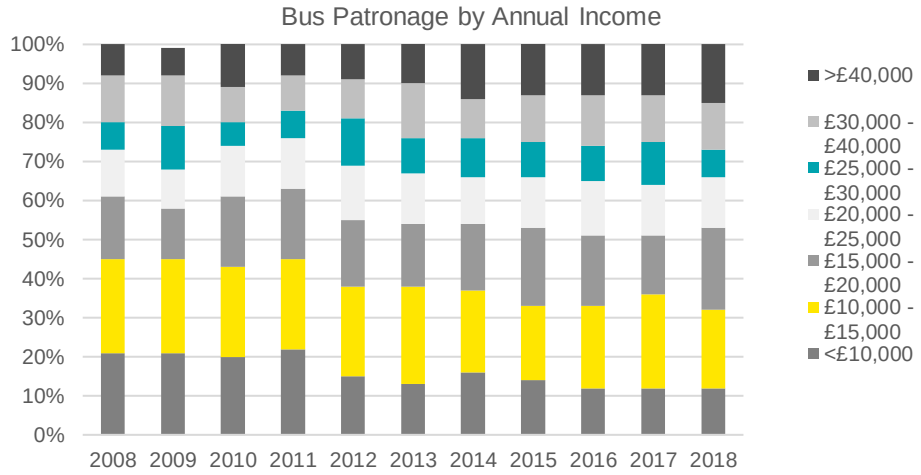
With less people using public transport, due to less jobs, there is likely to be a spiral of service cuts and fare rises by commercial operators. This will create challenges around providing people with the means to access new employment opportunities. There will still be a need for public transport as not all roles will be remote, all the time.

Social Impact

A falling in patronage due to a mix of working practices and unemployment will make a number of routes in the Scottish market unprofitable. Throughout the UK a drop in patronage has a direct correlation with a drop in bus mileage as bus operators reduce services if patronage falls.

Unprofitable routes, that likely link areas of deprivation to economic hubs, will therefore be hit hardest and this could create a cycle of economic hardship as people who are in the lower socio economic bracket suddenly find it harder to access employment.

The chart opposite illustrates bus patronage by annual income from 2008 to 2018.



The chart shows that the vast majority of bus patrons earn below the medium national household income (£29,600).

A large proportion of bus patrons (30%-45%) earn below £15,000 per year. This may be influenced in part by the high proportion who are permanently retired from work (27% in 2018), however, given that only 15% of patrons earn £40,000 or above, it is not unfair to say that any changes to Scottish bus market will disproportionately affect those on the lower end of the income scale.

Appendix A

Model Assumptions

Appendix A
Assumption – Base Case

General	EV single	EV Double	Diesel Single	Diesel Double
Bus life	15 Years	15 years	15 years	15 years
Diesel Buses Purchased	1/20/100	1/20/100	1/20/100	1/20/100
Purchased	FY20	FY20	FY20	FY20
Operation	June 21	June 21	June 21	June 21
Inflation rate	3.1%	3.1%	3.1%	3.1%
Discount rate	3.5%	3.5%	3.5%	3.5%

Capital Cost	EV single	EV Double	Diesel Single	Diesel Double
Bus	357	425	180	230
Mileage	50	50	50	50
Battery as % of cost	35	35	N/A	N/A
Charging point (AC)	1.50	1.50	N/A	N/A
Charging point (DC)	45.00	45.00	N/A	N/A
Buses charged per point (AC)	1.00	1.00	N/A	N/A
Buses charged per point (DC)	10.00	10.00	N/A	N/A
Grid connection per vehicle	25.00	25.00	N/A	N/A
Depot expansion per vehicle	1.00	1.00	N/A	N/A

Maintenance	EV single	EV Double	Diesel Single	Diesel Double
Parts	6.15	7.15	7.59	7.89
Charger up-keep	0.27	0.27	N/A	N/A
Labour	3.08	3.58	4.48	4.60

Appendix A
Assumptions – Base Case

Electricity / Fuel assumptions	EV single	EV Double	Diesel Single	Diesel Double
Electricity p pence per kwh (day)	15	15	N/A	N/A
Electricity p pence per kwh (night)	11	11	N/A	N/A
Fleet charged by day	20	20	N/A	N/A
Fleet charged by night	80	80	N/A	N/A
Kwh required for 1 mile	1.8	2.3	N/A	N/A
Diesel – miles per gallon	N/A	N/A	9.10	9.10
Diesel – Litres per gallon	N/A	N/A	7.80	7.80
Cost per litre	N/A	N/A	100.00	100.00

Appendix A
Assumptions – Base Case

Warranty	EV single	EV Double	Diesel Single	Diesel Double
Base cost – 5 year	inc.	inc.	N/A	N/A
Base cost – 7 year	inc.	inc.	N/A	N/A
Base cost – 10 year	50	50	N/A	N/A

A 7-year warranty is included within the capital costs of an EV bus. The cost to extend the warranty out to ten years in assumed to be £50k

Financing	All
Loan term	15
Interest	4