Urban Foresight

TA Scotland Ltd

Zero Emission Bus Market Transition Scheme

STREAM 1 REPORT

Contents

Introduction

This project has been completed as part of a transport Scotland funded project. Administered by Energy Saving Trust, the Zero Emission Bus Market Transition Scheme (ZEBMTS) aimed to provide assistance to SME bus and coach operators to establish the steps required in transitioning to zero-emission vehicles. This would provide a basis for the application of potential ScotZEB Phase 2 application in Spring 2023. There were three streams of funding available for ZEBMTS - this report focuses on stream 1.

Stream 1 of the scheme looked to support individual bus and coach operators by providing funding for consultancy expertise. Support was provided to assess the zero-emission technology that would best suit the operator's business model.

Existing government policies centre around the transition of the bus market. This has resulted in an underdeveloped coach market in Scotland and the UK. However, the coach market provides a number of essential services that must be considered. This includes community transport operations, tourism, and recreational activities.

This report presents the options available to TA Scotland in the transition to a zero-emission fleet. The recommendations have been established through the completion of a high-level total cost of ownership (TCO) analysis of the existing fleet and the most suitable transition options. The results of this will provide a baseline of potential operational savings of transitioning.

Due to the availability of indicative costings for vehicles and infrastructure, all cost recommendations are high-level. TA Scotland has been provided with the full analysis of its fleet which can be altered following the acquisition of fixed costs.

Current context

Operational activities

Since 2009, TA Scotland has been providing Scotland tours in Spanish, Italian, and English through their organisation Viajar por Escocia. They offer a variety of group tours over the course of one or multiple days.

The tours can be personalised depending on the preference of the customer. Tours pass through some of Scotland's most iconic landmarks such as the Highlands, Loch ness and the Isle of Skye.

A tailored private tour can also be arranged using the TA Scotland website, covering the areas of Scotland that are of interest to the customer.

The meeting point for the tours is in central Edinburgh, meaning it is accessible for those staying in and around the city. This makes the tours more convenient for those flying into the country.

The routes below are the main areas TA Scotland cover but there are more specific tours available.

- Loch Lomond
- Isle of Skye
- Stirling & St.Andrews
- Loch Ness
- Highlands

TA Scotland buses refuel while out on tours at publicly available fuel stations using a fuel card. By transitioning to zero-emission vehicles, TA Scotland could save time finding fuelling stations if they have pre-determined locations to charge their vehicles.

Existing fleet requirements

TA Scotland's vehicle fleet is made up of 13 coaches of varying sizes. These vehicles range from 16 to 55 seaters.

The vehicles are typically used interchangeably on the tours, depending on passenger numbers and demand. However, the larger vehicles are most often operated on the Loch Ness and Loch Lomond tours as these are the most popular and, therefore, have the largest passenger numbers. Table 1 shows a breakdown of TA Scotland's current operational activities.

Table 1 TA Sctoland's operational activities

Average mileage per trip	310 miles
Average annual tours per vehicle	115 tours
Average fuel cost of a trip per vehicle	£130.00
Average lifetime cost per vehicle	£160,000.00

Due to the nature of the tours, luggage capacity in the vehicles is vital, particularly for the multi-day tours. However, as this adds to the total weight of the vehicle, considerations need to be made for this in the transition to zero-emission.

New draft legislation published by the UK Government states a two-tonne increase for electric vehicles and a one-tonne increase for other alternatively fuelled vehicles[1]. These recent updates to legislation may mean a suitable passenger and luggage vehicle is more feasible for manufacturers.

Technology requirements & availability

Available technology options

Technologies considered

Electric

Plug-in electric vehicles are powered by a central battery and are zero-emission at the tailpipe. The vehicle is plugged into an electrical power source to recharge. This can be accomplished through a single-or three-phase electricity supply.

Electric vehicles (EVs) have become increasingly prevalent in the zero-emission market. Vehicles have evolved from hybrid models to full battery electric and have arguably been most popular for domestic travel.

With consistent technological advancements, battery weight has decreased, and range increased. This has made electric technology possible on bigger vehicles. Another advantage of EVs is refuelling. With current technology, it is more feasible to have on-site refuelling solutions for EVs compared to other alternative fuels.

Pros	Cons
• Widespread public charging is available • Zero emissions at the tailpipe • An increasing number of models available • Lower maintenance costs than ICE	• Increased refuelling time • More expensive than ICE vehicles • Reduced mileage range compared to ICE • Expensive grid upgrades may be needed

[1] GreenFleet 2023. Weight-limit increase for alternatively-fueled and electric HGVs

Hydrogen

Hydrogen is an alternative fuel option for vehicles that produce zero tailpipe emissions. Vehicles are fitted with a fuel cell where chemical energy is converted to mechanical energy by burning hydrogen to power an electric motor. Although zero emissions are produced at the tailpipe of a hydrogen vehicle, the environmental impact of hydrogen production can vary.

- Grey hydrogen – most common in the UK- is derived through natural gas extraction, which also produces and emits carbon dioxide.
- Green hydrogen – the cleanest form of hydrogen production- is produced through electrolysis, which uses electricity (renewably generated) to split the hydrogen and oxygen from water.

Vehicles running on hydrogen can travel 300+ miles on a single tank. However, refuelling stations are not readily available in the UK and the technology is expensive.

Hydrogen fuel cell electric

As the name states, hydrogen-electric combines both hydrogen and electric technologies to reduce vehicle weight and increase mileage. Theoretical analysis shows that hydrogen-electric technology would be best suited to heavy goods vehicles and could extend ranges to 500+ miles.

HFCEVs can be refuelled using hydrogen facilities. This type of fuel is in its infancy at present and only a small number of trials are being carried out, primarily by energy companies. The technology is similar to a hybrid electric vehicle where petrol or diesel is used to produce electricity.

There are currently three hydrogen refuelling stations in Scotland – in Orkney, Aberdeen, and Edinburgh – and over 2,400 public charge points[2]. Due to the limited infrastructure, vehicle manufacturers still hesitate to produce vehicles at scale as they do not see the demand.

Pros	Cons
• Mileage range comparative with ICE • Only water vapour emitted • Weight load is lighter than electric and 14 times lighter than traditional petrol	• Refuelling infrastructure availability • More expensive than ICE and electric • Fewer vehicle options are available • Expensive and not as easily installed as electric • A variance in hydrogen production methods

Technologies not considered

Biodiesel

Biodiesel is a cleaner form of diesel fuel derived from plants or animals. It is typically manufactured from domestic vegetable oils, animal fat, or recycled oil from restaurant cooking. The most commonly noted type of biofuel is hydrotreated vegetable oil (HVO). This method utilises hydrogen at high temperatures and pressures to treat vegetable oil and create a fuel similar to diesel.

This fuel has not been considered due to its higher cost than traditional diesel and because it is not a zero-emission fuel. Emissions are still produced by burning biofuel. It is, a preferable alternative to conventional diesel but can still contribute to emitting CO2 emissions.

[2] ChargePlace Scotland (2022) Accessing the network

CNG and LNG

Compressed natural gas (CNG) is the cleanest fossil fuel currently on the market and is used as an eco-friendly alternative to diesel. It is usually made by compressing methane to less than 1% of its original volume.

Liquified natural gas (LNG) is the same as CNG but in liquid form. LNG takes up less storage space than the equivalent amount of CNG. One hundred cubic meters of CNG equates to 1 cubic meter after processing, whereas 600 cubic meters of LNG equates to 1 cubic meter after processing. Nonetheless, the process of creating CNG and LNG is timely and complex.

CNG and LNG have not been considered part of this project as they are not fully zero-emission at the tailpipe. Moreover, refuelling options for both CNG and LNG are low. This may partially be due to the temperatures they need to be stored at, -162°c.

Engagement with stakeholders

To assess the vehicle availability and network capacity for the transition to zero-emission buses, in-depth engagement activities were carried out with industry stakeholders.

Vehicle availability

A desk-based research of the zero-emission bus and coach market was carried out to assess the vehicles available to purchase.

Over 20 vehicle manufacturers and dealerships were engaged as part of this process to understand better the vehicles that may be entering the market and their suitability for TA Scotland. This engagement showed a widespread availability of buses on the market but only one large coach through the seven industry bodies interviewed. Sessions were carried out with the following:

- ADL (Alexander Dennis)
- Daimler (Mercedes)
- EVM UK
- Pelican (Yutong)
- Stanford Coachworks
- Switch Mobility
- Wrightbus

Although manufacturers are positive about the growth of the ZEB market, the sector is still in its relative infancy. A low number of available vehicles will suit all operator needs. While there is a growing market for electric service buses, there is a significant lack of availability in the zero-emission coach market, particularly midi-coaches[3].

Amongst the different zero-emission fuels, electric appears to be the favoured option for vehicle manufacturers at present. This may be due to the unavailability of widespread hydrogen refuelling infrastructure compared to electric.

However, the longer ranges and lighter vehicle weights associated with hydrogen could be ideal for application within the coach market. Coach drivers already face heavier than average loads due to luggage loads which batteries only add to. This is especially challenging when coaches are travelling on smaller, less maintained roads in Scotland. Hydrogen could be beneficial in this market and, with the appropriate provisions for refuelling infrastructure, could increase opportunities for all operators.

[3] A midi coach is a coach between 15 to 40 seaters

Infrastructure

In parallel with the engagement regarding vehicles, TA Scotland's local distribution network operator (DNO), SPEN, was contacted. As part of this engagement, SPEN agreed to carry out a desk review of the power availability at TA Scotland's depot.

SPENs desk-based review noted that the transformer serving TA Scotland's depot is currently heavily loaded but neighbouring cables have capacity. To install the charging infrastructure required for TA Scotland's fleet, it is very likely a substation upgrade would be needed.

> "Local transformer is heavily loaded and whilst there is capacity within the neighbouring cables due to the size of the required connection it is almost certain a substation upgrade will be required."

Engagement outcomes for TA Scotland

TA Scotland is faced with four main challenges associated with transitioning:

1. High up-front vehicle and infrastructure costs
2. Residual value risks for both financiers and coach operators
3. Lack of real-world operational cost data
4. Little to no coach-specific zero-emission policy measures

These challenges align with the outcomes of the round table discussion from the Green Finance Institute and Confederation of Passenger Transport. Challenge four is particularly complicated for organisations such as TA Scotland. With no policy backing the transition of coaches may mean there's little incentive for manufacturers to introduce new vehicles.

As TA Scotland's operations are carried out across a variety of locations in Scotland, they rely on a range of different vehicle sizes. A lack of available vehicles, mainly in the midi-coach range, is likely to result in missed opportunities for coach operators. This may mean that operators need to greatly adapt their existing business models to fit the availability of vehicles. Increased time, resources, and capital would be required to conduct this change and, may need to be carried out again when vehicles become available, costing the business in the short and long term.

The Road to an Electric Fleet

Vehicle and infrastructure analysis

Vehicles

Due to the low availability of zero-emission coaches on the market, the following vehicles have been identified and were used to carry out a total cost of ownership (TCO) analysis (see financial analysis section below) of TA Scotland's' fleet:

Diesel	Zero-emission
• Mercedes Tourismo (O35) • Mercedes Sprinter • Mercedes Atego • Tesma MD9	• Pelican Yutong TCe12 • EVM Atlas Cityline (Coach)

Of these vehicles, only one is currently Zemo certified – the Pelican Yutong[4]. This means that it may take longer for TA Scotland to be able to transition its fleet.

[4] Zemo (updated 23.01.2023) Zero Emission Bus Certificates

Infrastructure

For a full transition of TA Scotland's vehicles, it has been determined that the installation of at least one charge point per vehicle would be required, plus one ultra-rapid charger for every 10 vehicles for emergency top-ups if required.

It is therefore recommended that TA Scotland install seven double connection 43kW chargers and one 120kW charger at its depot. Additionally, mobile charging units could be utilised if required.

Public charge point provisions must also be considered along key tour routes. Local authorities and private organisations must consider larger vehicle needs when installing public infrastructure. This will increase the likelihood of bus, coach, and HGV operators being able to transition.

Financial analysis

As part of this project, a total cost of ownership (TCO) analysis was carried out for each of the existing vehicles in TA Scotland's fleet – with and without funding. This was followed by an analysis of the potential transition options.

The TCO analysis takes the following information into account:

- **Vehicle costs**: the total purchase price minus the potential disposal price and high-level funding. This is used to assess the potential annual cost of the fleet and compare the cost between diesel and zero-emission vehicles.
- **Operation and maintenance**: annual cost of maintenance, servicing, MOT, and tax.
- **Fuel cost**: utilises information on vehicle efficiency and tour mileage to determine the typical cost to carry out each tour.
- **Funding**: assumes the availability of funding for vehicles is up to £80,000 to reach diesel price parity and 75% of the cost of charging infrastructure, including installation and connection costs.

For a full description of the methodology used, please see appendix 1.

Feasible transition

The TCO analysis carried out on a potential zero-emission fleet utilises vehicles that are currently on the market (or are soon to enter). Not all vehicles are feasible to transition at present.

TA Scotland could feasibly transition seven of its vehicles in the next few years without having to significantly alter its current operations. Suitable vehicles for this transition have been assumed to be a Pelican Yutong Tce 12 and EVM Atlas E-Cityline (coach). Table 2 shows the maximum potential savings from transitioning the most feasible vehicles.

Table 2 Feasible transition analysis

No. of vehicles	Years of ownership	TCO	Cost to TA Scotland without price parity of vehicles	Max potential savings with price parity of vehicles
7	5	£1 million	£410,000	£142,000

Transitioning these vehicles would require the installation of five charge points at the depot. Table 3 shows the split of required infrastructure and the indicative costs for this. Due to the low availability of public infrastructure at present, the purchase of a mobile charging unit may be appropriate for on-the-go charging. The purchase of one mobile unit has been factored into the charging cost.

Table 3 Charge points required for feasible transition

No. of chargers	Total charge points	Indicative install cost (without funding)	Indicative install cost (without funding)
5	9	£74,000	£18,000

Full transition

A transition of the remaining vehicles would require the release of appropriate vehicles. For this analysis, unfeasible vehicles were analysed with a vehicle that is yet to enter, and larger vehicles were split into smaller ones with a similar specification – EVM Atlas E-Cityline (coach).

Table 4 shows the potential savings a full fleet transition could offer TA Scotland.

able 4 Full fleet transition analysis

No. of vehicles	Years of ownership	TCO	Cost to TA Scotland without price parity of vehicles	Max potential savings with price parity of vehicles
15	5	£1.8 million	£800,000	£325,000

A full transition of TA Scotland's fleet will depend on two main factors: funding and saving incurred from transitioning. Funding would be required to elevate the high up-front cost associated with EVs. Also, transitioning the full fleet would likely require the savings incurred from the partial transition.

In terms of infrastructure, TA Scotland's vehicles would require up to nine charge points at the depot to fully electrify the fleet and an optional mobile charging unit. Table 5 shows the split of required infrastructure and the indicative costs for this.

Table 5 Charge points required for full transition

No. of chargers	Total charge points	Indicative install cost (without funding)	Indicative install cost (without funding)
10	18	£92,000	£23,000

Due to commercial sensitivity, full TCO analysis can be provided to Transport Scotland upon request.

Feasibility of a step-by-step transition

Conditions

Vehicles

The TCO analysis carried out on the potential zero-emission fleet transition options utilises the vehicles that are currently on the market (or are soon to enter). For example, several vehicles are in the production stages at present and will not be available to purchase right away.

Urban Foresight recommends that TA Scotland transition seven of its vehicles in the next few years to begin the transition to a zero-emission fleet. As stated prior, the operational savings from these transitions could then be used to subsidise the transition of the remaining vehicles.

Infrastructure

To support the transition of the seven feasible vehicles in TA Scotland's fleet, five private chargers would likely need to be installed at the existing depot. High-level figures from charge point providers suggest this may cost in the region of £92k for TA Scotland.

Collaboration Opportunities

Taking a collaborative approach with other operators allows for sharing costs and risks associated with the purchase of vehicles and associated infrastructure. This will, in turn, assist in achieving a just transition of a range of operators.

TA Scotland is part of the Scottish Destination Management Association (SDMA). This association is made up of a wider group of tour operators and destination management companies in Scotland.

TA Scotland is one of four SDMA members who have undertaken similar ZEBMTS stream 1 work to establish options for transitioning their coach fleets to electric. As such, these operators came together with another SDMA member to carry out research through ZEBMTS stream 2 funding.

This stream 2 project explores the potential of a collaboration between SME tour bus operators, local authorities, bus manufacturers and charge point operators.

Next steps required

To successfully to a zero-emission fleet, there are several steps to take an considerations to be made. This can be broken down into a three-step process focused on vehicles, infrastructure, and people.

Vehicles

To ensure more operators are able to transition their vehicles to zero-emission, it will become increasingly important that manufacturers release additional options. This is particularly important for operators that have a range of vehicle types and sizes.

To kickstart the transition to zero-emission vehicles, Urban Foresight recommends that TA Scotland looks to first transition the most feasible vehicles over the next few years. To achieve this first step of the transition, it is important to carry out the following steps:

1. Further engagement with vehicle manufacturers of feasible replacements as outlined in the TCO tool to fully assess feasibility.
2. Obtain direct quotes from manufacturers for vehicle purchases

Recommended next steps:
Urban Foresight has identified seven vehicles that are feasible to transition within TA Scotland's existing fleet. High-level costs suggest that the purchase of vehicles would require £2 million in capital finance. This is £970k more than the cost of existing diesel vehicles.

Infrastructure

If TA Scotland decides to purchase the recommended zero-emission vehicles to kickstart the transition of its fleet, private charging infrastructure should be installed at the depot for overnight charging before tour departures. Top-up charging locations should also be considered along tour routes, such as at destinations.

It is recommended that the following steps are carried out to assist in the installation of suitable electric vehicle charging infrastructure:

1. Engage with charge point providers to obtain a full site assessment and quotation to have charging infrastructure installed at the depot.
2. Work with local authorities and private businesses to have suitable public charging infrastructure installed along main tour routes.

Recommended next steps:
Urban Foresight recommends TA Scotland install the following charge point configuration at its depot:

- four 22kW chargers with two connection points
- One 150kW charger for top-up charging
- One mobile charging unit

High-level costs suggest that this will require £74k in capital finance.

People

As zero-emission vehicles have fewer moving parts than their internal combustion engine (ICE) equivalent. Therefore, the maintenance and servicing costs of zero-emission vehicles are often lower. However, the unique components associated with zero-emission vehicles must also be considered. For example, during maintenance and servicing of electric vehicles, work on oil, spark plugs and drive belts is not necessary, but battery packs, electric motors, and regenerative braking systems will require work.

Training will likely be required for those who are maintaining and servicing vehicles as well as for drivers. As zero-emission vehicles are relatively unfamiliar to many, particularly for larger vehicles such as buses and coaches, it is important to provide training for staff members. Table 2[5] shows the required training for electric and hydrogen buses and coaches.

In addition, training will be required for mechanics and drivers[6]. The following training is required for electric coaches:

- **Drivers**
  - Ensuring drivers are aware of how to efficiently use the vehicle, making use of regenerative braking to conserve energy.
- **Maintenance**
  - Upskilling staff by providing training on the maintenance of electric-specific components. This can be carried out by vehicle OEMs.
- **Depot management**
  - Providing training on safely and efficiently recharging vehicles.
  - Training is required for staff to work with high-voltage systems.
- **Operation**
  - Ensuring staff are aware of locations for opportunity charging where necessary.
  - Telematics can support this in the long term by assessing routes and mileage.

[5] Zemo (10.2022) Zero Emission Bus Guide

[6] Zemo (10.2022) Zero Emission Bus Guide

Appendix 1 TCO Methodology

TCO Methodology

Urban Foresight's Electric Mobility team has designed its own in-house total cost of ownership tool. This is used to assess and compare the cost of a fleet of vehicles across a variety of fuel types.

The tool allows an analysis to first be carried out on the existing vehicles within a fleet to determine the total cost of ownership before a potential transition to zero emissions. Fleet replacement options can then be established and a TCO analysis can be carried out on these vehicles using operational data from the existing fleet.

Information required

Existing fleet

To carry out the initial fleet analysis, the following information was requested from the operator:

1. Vehicle details
    a. Vehicle type, number of seats, purchase cost, residual value (where known), average age of vehicles
2. Operation and maintenance data
    a. Servicing and maintenance schedules and costs, MOT and road tax rates
3. Fuel usage data
    a. Annual vehicle mileage (or mileage per trip), vehicle efficiency (MPG), and/or litres of fuel consumed annually or per trip
4. Trip information (optional)
    a. Number of trips carried out annually (for those who provided fuel data per trip)

Zero-emission fleet

For zero-emission vehicles, the following data was gathered to compare to the existing fleet:

1. Purchase price of vehicle
    a. Including available grants and residual value
2. Maintenance and servicing costs
    a. Price per kilometre or mile of travel based on real-world data where available
3. Fuel costs
    a. Miles/kWh or kWh/km
    b. Electricity cost – split between required use of private and public infrastructure

Results of analysis

Analysis of the information provided by operators and gathered on zero-emission options allows the following conclusions to be drawn:

1. Total annual ownership cost of each vehicle (and overall fleet)
    a. Vehicle cost
    b. Operational and maintenance costs
    c. Fuel costs
2. Total lifetime ownership of each vehicle (and overall fleet)
    a. Vehicle cost
    b. Operational and maintenance costs
    c. Fuel costs

Assumptions:

The following assumptions have been made in the TCO analysis for this project:

1. Fuel costs
    a. Diesel cost determined by the average cost at the time of analysis (£1.69 per litre at time of writing)[7].
    b. Electricity cost determined to be 35p per kWh for private infrastructure and 55p per kWh for public infrastructure.
2. Private vs public infrastructure use
    a. Established through the range of the alternative vehicle option and required range per trip (e.g a vehicle travelling 300 miles with 200 miles of range will require 34% public charging).
3. Servicing and maintenance

Determined to be between £0.03 and £0.10 per km from real-world data[8].

[7] Fleet News (03.2023) Regional fuel prices

[8] Ember Buses Dundee

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