Urban Foresight

Timberbush Tours

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 assist 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.

Stream 1 of the scheme sought to support individual bus and coach operators to assess the zero-emission technology that would best suit their business and how it may be implemented.

Existing government policies centre around the transition of the bus market. Additionally, governmental funding, such as ScotZEB1 went mostly to large bus operators, leaving the coach market underdeveloped. 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 Timberbush Tours in the transition to a zero-emission fleet. The recommendations have been established by completing 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.

The costs included in this report for vehicles and infrastructure are indicative and should be treated as guidance only. Timberbush Tours has been provided with the full analysis of its fleet, which can be altered following the acquisition of fixed costs.

Current context

Operational activities

Timberbush Tours is a family-owned coach tour operator based in Edinburgh, established in 1998. The business provides guided tours across Scotland with departures from Edinburgh, Glasgow, Inverness, and the North of England. The tours vary from 1, 2 & 3 days depending on available options.

These include single and multi-day group tours on the following main routes:

- Loch Ness
- Isle of Skye
- Mallaig
- The Highlands
- Loch Lomond
- Oban
- Glenfinnan

The tours listed above have been used as a baseline for the feasibility of transitioning to a zero-emission fleet. Of these tours, the Loch Ness day tour from Edinburgh is the most popular. This tour currently departs daily and is run year-round. This is due to the high number of tours carried out on them and the variances in the distance.

Timberbush Tours' depot is located in an industrial estate in Edinburgh. After each tour, vehicles are refuelled at a local public petrol station when returning to the depot. Extended, multi-day tours utilise nearby service stations. Having refuelling infrastructure at the depo for zero-emission vehicles could reduce refuelling time.

Existing fleet requirements

There are 25 coaches in Timberbush Tours' fleet, which range in size from 16 to 53 seats. Tours are sold to listings of main interest points, but drivers have a degree of flexibility with this[1].

Each coach is deployed on a tour, depending on the group size. This allows for the optimisation of load factors, increased efficiency, and maximum sales. For example, if 130 tickets were sold for a specific tour, the passengers can be spread across a 53-seater coach, a 47-seater coach, and a 32-seater coach. This provides a 98.5% load factor and maximises the available space. By operating this way, Timberbush Tours can align vehicle size to meet demand on a day-to-day basis. Table 1 shows a breakdown of Timberbush Tours' current operational activities.

Table 1 Timberbush Tours' operational activities

Average mileage per trip	250 miles
Average annual tours per vehicle	330 tours
Average fuel cost of a trip per vehicle	£120.00
Average lifetime cost per vehicle	£190,000.00

Luggage capacity within the fleets vehicles is vital as there are multi-day tours taking place and must be considered in the transition to zero-emission vehicles.

The UK Government has recently published new guidance for electric and alternatively fuelled heavy goods vehicles. This states a two-tonne increase for electric vehicles and a one-tonne increase for other alternatively fuelled vehicles[2]. If this guidance is further employed for buses and coaches, this could equate to a boost in the manufacture of better-suited passenger vehicles with luggage capacity.

Technology requirements & availability

Available technology options

Technologies considered

Electric

Plug-in electric vehicles make use of batteries to power a motor. They, therefore, produce zero tailpipe emissions. Electric vehicles are 'refuelled' similar to other battery-powered devices through a charging cable. Charging capability ranges from 3.6kW up to 350+kW.

Electric vehicles have become increasingly prevalent in the zero-emission market in recent years. There are three types of electric vehicles for purchase at present – battery electric, hybrid, and plug-in hybrid. Hybrid vehicles utilise petrol to power the electric motor rather than electricity.

With consistent technological advancements, battery weight has decreased, and range has 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.

[1] Note: the information and data used within this report represent what was available and correct at the tine of writing (January 2023).

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

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

Hydrogen

Hydrogen is an alternative fuel option for vehicles and produces zero emissions at the tailpipe, unlike traditional petrol or diesel. 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, producing and emitting 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 vehicles use a combination of hydrogen and electric technology in a single vehicle. This is done 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.

The technology is similar to a hybrid electric vehicle where petrol or diesel is used to produce electricity. 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.

There are currently three hydrogen refuelling stations in Scotland – in Orkney, Aberdeen, and Edinburgh – and over 2,400 public charge points[3]. 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 variety of diesel fuel which is derived from plants or animals. It is typically manufactured from domestic vegetable oils, animal fat, or recycled oil from restaurant cooking. The most common type of biofuel is hydrotreated vegetable oil (HVO). This type utilises

[3] ChargePlace Scotland (2022) Accessing the network

hydrogen at high temperatures and pressures to treat vegetable oil and create a fuel similar to diesel. This type of fuel is only a suitable replacement for diesel vehicles.

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 CO_2 emissions.

CNG and LNG

Compressed natural gas (CNG) is currently the cleanest fossil fuel on the market and, like biodiesel, is an eco-friendly alternative to diesel. CNG is typically generated by compressing methane to less than 1% of its original volume.

Liquified natural gas (LNG) is the liquid form of CNG. LNG also takes up less storage space than CNG. For example, after processing, $1m^3$ of fuel equates to $100m^3$ of CNG and $600m^3$ of LNG. However, at present, the process of creating CNG and LNG is timely and complicated.

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 as they need to be stored at -162°c.

Engagement with stakeholders

To evaluate vehicle availability and network capacity, in-depth engagement was completed.

Vehicle availability

Vehicle engagement activities for this project began with a desk-based research period. This involved reviewing sources to build a baseline of suitable vehicles on the market. Vehicle manufacturers and dealerships were then contacted to gain further insight into the vehicles established in the desk-based review and understand the potential future market.

Over 20 vehicle manufacturers and dealerships were contacted in this process, and seven attended individual engagement sessions. They detailed their existing and future plans for the bus and coach markets.

This engagement showed a widespread availability of buses on the market but only one large coach. Engagement sessions were carried out with the following:

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

The majority of vehicle manufacturers noted that they were positive about the growth of the zero-emission bus and coach markets. However, they also noted that technology is still in its infancy compared to other vehicle markets, such as cars and vans. Due to this, it may take time to see the release of vehicles that suit all operators' needs. One market in which manufacturers noted a lack of availability at present was the coach market, with only one large vehicle on the market.

Battery electric technology currently appears to be the favoured option for vehicle manufacturers. This may be due to the availability of widespread recharging infrastructure and the ease of installation compared to the likes of hydrogen infrastructure.

Despite this, hydrogen could be an ideal technology for use in coaches due to the lighter weight of fuel and associated longer ranges. Coach drivers face heavier-than-average loads due to factors such as vehicle size, luggage requirements, and passenger numbers. Battery technology only adds to this weight at present. Vehicle weight can be especially challenging for tour operators who travel on smaller, less maintained, 'off the beaten track' roads. Hydrogen could be beneficial for these operators and, with the appropriate provisions for refuelling infrastructure, could increase opportunities for all operators.

Infrastructure

While engagement activities were underway with vehicle manufacturers and dealerships, a review of Timberbush Tours' local distribution network operator (DNO), SPEN, was carried out. SPEN agreed to undertake a desk review of the power availability at Timberbush Tours' depot.

SPENs desk-based review noted that the transformer serving Timberbush Tours' depot is currently heavily loaded but neighbouring cables have capacity. To install the charging infrastructure required for Timberbush Tours' 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 Timberbush Tours

A roundtable summary from the Green Finance Institute and Confederation of Passenger Transport noted that there are four central challenges in transitioning to zero-emission coaches. Timberbush Tours has also noted these barriers:

1. The high up-front cost of zero-emission coaches and charging infrastructure
2. Residual value risks for both financiers and coach operators
3. Insufficient data available on real-world operational costs
4. Lack of zero-emission coach-specific policy measures to stimulate demand

One of the key challenges from those noted above is the lack of coach-specific policy measures. Policy introduction is typically a crucial motivator to change in any industry. As such, policy measures in the coach market could drive change and increase the generation of new vehicles to meet demand.

As Timberbush Tours' operations are carried out across a variety of locations in Scotland and the north of England, they rely on a range of different vehicle sizes. The lack of availability of suitable vehicles means that Timberbush Tours, and other similar tour operators, may need to change their business model to an increased number of smaller coaches or change their routes to accommodate larger vehicles. Both options require a complete rethink of how their business operates and may cost more in the long term.

The Road to an Electric Fleet

Vehicle and infrastructure analysis

Vehicles

Due to the low Due to the low market availability of zero-emission coaches, 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 Timberbush Tours' fleet:

Diesel	Zero-emission
• MAN Neoplan • MAN Baribi Galileo • MAN Mobipeople • Mercedes Sprinter 516	• Pelican Yutong • EVM Atlas E-Cityline (coach)

Of the zero-emission vehicles above, only one is currently Zemo certified – the Pelican Yutong[4]. This means that it may take longer for Timbebush Tours to be able to transition its fleet.

Infrastructure

For a full transition of Timberbush Tours' vehicles, it has been assumed 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 Timberbush Tours install up to 13 double connection 22kW chargers and two 150kW chargers. This would provide the suitable infrastructure to ensure each vehicle can be fully charged in preparation for departing tours.

Additionally, public charge point provisions must 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 transitioning.

Financial analysis

A high-level total cost of ownership analysis (TCO) was completed for the vehicles in Timberbush Tours' fleet. The findings were used to assess the financial savings of transitioning to an electric fleet. Two subsequent analyses were then carried out for the potential transition options.

The TCO analysis takes the following information into account:

- **Vehicle costs**: including the total purchase price, 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**: including 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.

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

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

The results of the analyses conducted were used to compare the financial savings of transitioning to a zero-emission fleet – with and without potential funding.

Feasible transition

Timberbush Tours could feasibly transition eight of its vehicles in the next few years without having to significantly alter its current operations. This is predominantly due to the lack of available vehicles currently on the market. The vehicles for transition have been assumed to be the MAN Neoplan and Mercedes Sprinter 516. 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 Timberbush Tours without price parity of vehicles	Max potential savings with price parity of vehicles
8	3-5	£2.1 million	£260,000	£380,000

Transitioning these vehicles would require the installation of four charge points at the depot. 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 shows the split of required infrastructure and the indicative costs.

Table 3 Charge points required for feasible transition

No. of chargers	Total charge points	Indicative install cost (without funding)	Indicative install cost (with funding)
6	10	£55,000	£18,000

Full transition

A transition of the remaining 17 vehicles would require the release of appropriate vehicles. For this analysis, unfeasible vehicles were analysed by grouping mid-sized vehicles into a larger vehicle – Pelican Yutong . Table 4 shows the potential savings a full fleet transition could offer Timberbush Tours.

Table 4 Full fleet transition analysis

No. of vehicles	Years of ownership	TCO	Cost to Timberbush Tours without price parity of vehicles	Max potential savings with price parity of vehicles
23	3-5	£3.4 million	£400,000	800,000

Funding will be required to kickstart this due to the higher cost of alternatively fuelled vehicles compared to petrol and diesel. A full transition will also depend on the total financial savings from the initial transition and the vehicle replacement periods.

Transitioning all 25 of Timberbush Tours' vehicles would require up to 15 charge points at the depot. Table 5 shows the split of required infrastructure and the indicative costs for this.

Table 5 Charge points required for a full transition

No. of chargers	Total charge points	Indicative install cost (without funding)	Indicitive install cost (with funding)
15	38	£139,000	£45,000

Due to commercial sensitivity, a complete TCO analysis can be provided to EST and Transport Scotland upon request.

Feasibility of a step-by-step transition

Conditions

Vehicles

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

Timberbush Tours could feasibly transition eight of its vehicles in the next few years without having to significantly alter its current operations. The options for transitioning the remaining 17 vehicles would be to:

1. Group tours of smaller vehicles into one.
    a. This would lead to an increased mileage across these vehicles and a reduced number of tours. As not all tours are guaranteed to be carried out at full capacity, this could greatly impact business and lead to a loss in revenue.
2. Purchase additional smaller vehicles in place of larger ones.
    a. This would come at an increased cost as Timberbush Tours' fleet would grow to 30 vehicles. This in turn would require guarantees that customer numbers remained the same to avoid increasing customer costs.

Infrastructure

To support the transition of the eight feasible vehicles in Timberbush Tours' 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 £138k for Timberbush Tours.

Collaboration Opportunities

A collaborative approach to transitioning fleet vehicles could allow operators to share the costs and risks associated with the purchase of vehicles and associated infrastructure. This will then assist in achieving a just transition across several operators in the same space. Additionally, findings and methods could be replicated across other businesses to assist with their transition.

Timberbush Tours is currently 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.

Timberbush Tours is one of four SDMA members who have carried out ZEBMTS stream 1 work to determine their options for transitioning their coaches to zero-emission. As such, these operators came together to carry out research through ZEBMTS stream 2 funding.

The stream 2 project looks to explore the potential of a collaboration between SME tour bus operators, local authorities, bus manufacturers and charge point operators. This work has been carried out alongside the individual analysis for stream 1.

Next steps required

In order to successfully and feasible transition to a zero-emission fleet, there are several steps to take and considerations to be made. These can be carried out through a three-step process focused on vehicles, infrastructure, and people.

Vehicles | Infrastructure | 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 Timberbush Tours 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 eight vehicles that are feasible to transition within Timberbush Tours' existing fleet. High-level costs suggest that the purchase of vehicles would require £2.3 million in capital finance. This is £950k more than the cost of existing diesel vehicles.

Infrastructure

If Timberbush Tours 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 that Timberbush Tours 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 £138k 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. training will be required for mechanics and drivers[5]. 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

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)[6].
    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
    a. Determined to be between £0.03 and £0.10 per km from real-world data[7].

[6] Fleet News (03.2023) Regional fuel prices

[7] Ember Buses Dundee

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