Urban Foresight

Rabbies Tours

Zero Emission Bus Market Transition Scheme

STREAM 1 REPORT

Contents

Introduction

This project has been completed as part of stream 1 of the Zero Emission Bus Market Transition Scheme (ZEBMTS) which is funded by Transport Scotland and administered by Energy Saving Trust. The scheme aims to assist SME bus and coach operators understand the steps required in transitioning to zero-emission vehicles. The overarching goal is to provide SME bus and coach operators with the required information to apply for potential ScotZEB Phase 2 funding in Spring 2023. There were three funding streams available for ZEBMTS - this report focuses on stream 1.

Stream 1 of the scheme is aimed at supporting individual bus and coach operators in assessing the zero-emission technology that would best suit their business and how this may be implemented. Support has been provided to Rabbies in assessing the zero-emission technology that would best suit its business and operational needs.

Government policies in recent years have focused solely on the bus market. Additionally, governmental funding such as ScotZEB1 went mostly to large bus operators, leaving the coach market underdeveloped. However, the coach sector provides many vital services for people and communities across Scotland, including community transport, tourism, and recreation activities.

This report aims to outline potential options for Rabbies to 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. Rabbies has been provided with the full analysis of its fleet which can be altered following the acquisition of fixed costs.

Current Context

Operational activities

Rabbies offers small and private tours across the UK and Europe. The tours carried out within Scotland consist of 1-17 day tours visiting iconic landmarks such as Loch Ness, the Highlands, and Skye. To take customers further off the beaten track, Rabbies make use of smaller, 16-passenger coaches. This ensures that tours can help the economies of the little out-of-reach villages and communities.

Private tours are also available through the Rabbies website, making the tour more personal, and covering the areas of Scotland that interest the client the most. Tours can be booked from most of the main cities in Scotland with pick up and drop off in Edinburgh, Glasgow, Inverness, and Aberdeen.

The routes below are the main areas Rabbies cover but there are more tours on offer.

- Isle of Skye
- Loch Ness
- Scottish Islands
- Scottish Borders
- Whisky Tours
- Scottish Highlands
- Loch Lomond
- Outland Tours

At present, Rabbies coaches are refuelled at public petrol stations along tour routes with a fuel card. A transition to zero-emission vehicles could reduce additional time at fuel stations by having provisions located on-site for recharging/refuelling.

Over 70% of Rabbies' coaches are stored, maintained, and fuelled at their facility in Granton, on the outskirts of Edinburgh. This facility would be an ideal charging hub for their fleet of vehicles in line with their current refuelling strategy. The rest of the vehicles are stored in Inverness, Aberdeen, or Glasgow.

Existing fleet requirements

Rabbies' current vehicle fleet is made up of 79 Mercedes Sprinter internal combustion engine (ICE) coaches which seat up to 16 passengers.

The coaches are typically interchanged on the tours with no specific coach used per route. The 16-seater coaches make the experience for the customer more personal due to the smaller groups and the guides being able to interact with facts about the scenery or answer questions as they drive.

Table 1 shows a breakdown of Rabbies' current operational activities.

Table 1: Rabbies Small Group Tours operational activities

Average mileage per trip	139 miles
Average annual tours per vehicle	229 tours
Average fuel cost of a trip per vehicle	£46.00
Average lifetime cost per vehicle	£105,000.00

Due to the nature of the tours and size of the coach, 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 manufacturer's requirements & availability.

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

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 and luggage capacity compared to ICE • Expensive grid upgrades may be needed • Increased vehicle weight due to battery

Hydrogen

Hydrogen is an alternative fuel option for vehicles and, unlike traditional petrol or diesel, produces zero emissions at the tailpipe. 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.

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

An in-depth engagement activity was conducted with industry stakeholders to assess the vehicle availability and network capacity for the transition to zero-emission buses.

Vehicle availability

This engagement began with desk-based research of the zero-emission bus and coach market and 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 Rabbies Small Group Tours. Seven attended individual engagement sessions to detail their current and future plans for

[2] ChargePlace Scotland (2022) Accessing the network

zero-emission buses and coaches. Through the engagement activity, it was identified only one large coach is currently available on the market compared to the widespread availability of buses.

Engagement 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. There is currently a lack of vehicle availability within the coach market, particularly for midi-coaches[3], despite the growing market for electric service buses. As a result, there is a low number of available vehicles that will suit operator needs.

Through the engagement, manufacturers had a positive attitude towards electric and this seems to be the favoured alternative fuel option at present. This may be due to a lack of widespread hydrogen refuelling stations compared to electric.

However, if the appropriate provisions were made available, hydrogen could be beneficial for this market. The extended ranges and lighter overall vehicle weights may lend themselves to tours where mileage is great and there is the added complexity of luggage.

Infrastructure

In parallel with the engagement regarding vehicles, Rabbies' 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 the depot.

SPENs desk-based review noted that the transformer supplying power to Rabbies' depot is heavily loaded but there is capacity in neighbouring cables. Installation of the infrastructure required for Rabbies' fleet is likely to require a substation upgrade.

> "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 Rabbies

In line with findings from the Green Finance Institute and Confederation of Passenger Transport, Rabbies is faced with four main challenges when transitioning:

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

Challenge four is particularly complicated for organisations such as Rabbies. A lack of policy measures surrounding the transition of coaches means less drive for manufacturers to create new vehicles.

Rabbies' operations are often in rural locations with smaller roads. As Rabbies operates on a single-vehicle type business model, they could feasibly transition all vehicles when a replacement enters the market. However, this may come at a risk to Rabbies as any delays to vehicle delivery

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

could impact the day-to-day business. Therefore, it is recommended that Rabbies transition ten of its vehicles in the coming years and use the operational savings from this to transition the others. 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

At present, Rabbies makes use of a single-vehicle model which they operate across the entirety of tours – An EVM-converted Mercedes Sprinter. As such, a transition vehicle must meet this specification. The closest option is the EVM Atlas E-Cityline (coach) which is due to be released in the coming years.

Infrastructure

To fully transition Rabbies' fleet of vehicles, it has been established that this would require at least one charge point per vehicle and an ultra-rapid charger for emergency top-ups if required.

It is suggested that, for a complete fleet transition, this is made up of 40 double connection 43kW chargers and seven 120kW chargers split across two depot locations. Additionally, mobile charging units could be utilised if required.

Public charging infrastructure provisions are equally important along Rabbies' tour routes.

Financial analysis

A total cost of ownership (TCO) analysis was carried out for each of the existing vehicles in Rabbies' fleet to compare ICE to e-coach costs. The findings were used to assess the financial savings of transitioning to an electric fleet. This was followed by an analysis of 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[4].
- **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 fuel cost of 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.

The objective of this TCO analysis is to use potential savings made over the lifetime of the fleet to replace vehicles. The calculations include different scenarios: with and without potential funding.

[4] Note: since time of writing, the prices for the purchase of ICE coaches have increased by 10%.

Feasible transition

Due to the lack of availability of suitable transition options and the number of vehicles in Rabbies fleet, it is suggested that 10 vehicles are transitioned initially. 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 Rabbies without price parity of vehicles	Max potential savings with price parity of vehicles
10	5	£630,000	£170,000	£250,000

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 for this.

Table 3 Charge points required for feasible transition

No. of chargers	Total charge points	Indicative install cost (without funding)	Indicative install cost (with funding)
7	12	£78,000	£20,000

Full transition

Transitioning the remaining vehicles could be carried out at a later date by Rabbies when additional vehicle models are released and savings are made from the initial transitions. Table 4 shows the potential savings a full fleet transition could offer Rabbies Tours.

Table 4 Full fleet transition analysis

No. of vehicles	Years of ownership	TCO	Cost to Rabbies without price parity of vehicles	Max potential savings with price parity of vehicles
79	5	£6 million	£4 million	£2 million

Funding will, therefore, 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 69 of Rabbies vehicles would require up to 48 chargers at the depot and one mobile charger. 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)	Indicative install cost (with funding)
49	89	£450,000	£113,000

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 future transition options for Rabbies utilises a vehicle which is due to come into the market in the next few years. There is no specified date for the release of this vehicle at present.

As Rabbies operates on a single-vehicle type business model, they could feasibly transition all vehicles when a replacement enters the market. However, this may come at a risk to Rabbies as any delays to vehicle delivery could impact the day-to-day business. Therefore, it is recommended that Rabbies transition ten of its vehicles in the coming years and use the operational savings from this to transition the others. The options to transition the remaining 69 vehicles would be to:

1. Group several tours of smaller vehicles into a larger vehicle.
    a. This would lead to an increased mileage across vehicles and a reduced number of tours. As tours are currently carried out on smaller vehicles, this could limit the places they can visit and will impact Rabbies' business through reduced revenue.
2. Transition the remaining vehicles in groups as more vehicles become available.
    a. Due to the uncertainty around the release of suitable vehicles, this will likely mean Rabbies is left at a disadvantage compared to other operators with a variety of coach sizes in their fleet.

Infrastructure

To support the transition of the ten feasible vehicles in Rabbies' fleet, six private chargers would likely need to be installed at the existing depot with an additional mobile unit for during tours. High-level figures from charge point providers suggest this may cost in the region of £78k for Rabbies.

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.

Rabbies 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.

Rabbies 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 transition to a zero-emission fleet, there are a number of steps to take and considerations to be made. These have been 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 Rabbies 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 recommends that Rabbies begin their transition by replacing eight vehicles with zero-emission alternatives in the coming years as availability of suitable options increases. High-level costs suggest that the purchase of vehicles would require £2.4 million in capital finance. This is £1.5 million more than the cost of existing diesel vehicles.

Infrastructure

If Rabbies decides to purchase the recommended zero-emission vehicles to kickstart a 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 Rabbies install the following charge point configuration at its depot:

- Five 43kW chargers with two connection points
- One 120kW charger for top-up charging
- One mobile charger

High-level costs suggest that this will require £78k in capital finance.

People

Zero-emission vehicles have fewer moving parts than their internal combustion engine (ICE) equivalent, therefore, the maintenance and servicing costs are often lower. However, there are also unique components associated with zero-emission vehicles which need to be considered. For example, maintenance and servicing of an electric vehicle will not be needed on oil, spark plugs, or drive belts but will be required on battery packs, electric motors, and regenerative braking systems.

Despite these differences, the cost of maintaining a zero-emission vehicle is still typically lower than an ICE vehicle.

In addition, 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

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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