Urban Foresight

Radical Travel Group Limited

Zero Emission Bus Market Transition Scheme

STREAM 1 REPORT

Executive Summary

In light of ScotZEB Phase 2 funding, a review of Radical Travel's existing fleet was carried out to determine the most suitable zero-emission transition options.

This report has been created to detail the findings of this review and provide recommendations on the best options available to Radical Travel and how a transition may be achieved. This includes information on the following:

- Suitable zero-emission vehicles
- High-level costs to carry out the transition
- Infrastructure requirements for a transitioned fleet
- Summary of the current transition options

It was established through this project that the most suitable transition technology at present is electric. However, through research and engagement, it became clear that, despite advancements in electric vehicles, there is a current lack of vehicle availability in the zero-emission coach market. At present, there is only one suitable Zemo-approved coach on the market. Therefore, this report focuses on the five vehicles within Radical Travel's existing fleet that could be transitioned in the next few years.

Additionally, due to the longer distances travelled on tours, the transition of any vehicles within the fleet will be heavily dependent on the availability of suitable private and public charging infrastructure. As such, this report provides indicative requirements and costs of private charge point installation at Radical Travel's depot.

The findings of research, engagement, and analysis established the following summary of likely transition costs for Radical Travel:

Feasible vehicles (**within the next few years**)

Item	Number of items	Total purchase cost (without ScotZEB grant)
Vehicles (coaches)	5	£1.3 million (+£800k on current fleet)
Infrastructure (chargers)	5	£52,000
Total	10	£1.82 million

All vehicles (**using the closest suitable vehicle costs**)

Item	Number of items	Total purchase cost (without ScotZEB grant)
Vehicles (coaches)	16	£3.6 million (+£1.65 million on current fleet)
Infrastructure (chargers)	10	£70,000
Total	26	£4.3 million

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 in understanding the steps required in transitioning to zero-emission vehicles.

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.

To date, governmental funding such as ScotZEB1 went mostly to large bus operators, leaving the coach market underdeveloped. The coach sector provides many vital services, from community transport to tourism and recreation activities.

In preparation for ScotZEB Phase 2, Radical Travel approached Urban Foresight to conduct a full fleet and route assessment for stream 1 of the ZEBMTS. This included investigating the currently available and planned sales of vehicles and associated infrastructure. The results of these assessments were used to establish recommendations on the most suitable options for transitioning to a zero-emission fleet.

This report presents the available options for Radical Travel to transition to a zero-emission fleet and the associated high-level costs. A total cost of ownership (TCO) has been carried out on Radical Travel's fleet to be compared to a zero-emission alternative and determine lifetime financial savings. The results have been provided to Radical Travel to allow for further evaluation of vehicle feasibility.

The costs included in the report have been gathered from engagement with stakeholders and should be treated as guidance only. Official quotations from all parties should be gathered before any financial decisions are made.

Current context

Operational activities

Radical Travel Group offers a range of award-winning tours across Scotland. Their mission is to provide tours which exceed guests' expectations and deliver an authentic experience of Scotland.

Unique tours are provided through HAGGiS Adventures and Highland Explorer Tours. These include single and multi-day public and private group tours on the following main routes:

- Loch Ness
- Edinburgh Tattoo
- Stirling
- Alnwick
- Highland Games
- Harry Potter

Of these, the most popular tour is Loch Ness which accounts for 76% of the annual tours noted above. Due to the popularity of the six tours detailed above, these have been used as a baseline for the feasibility of transitioning to a zero-emission fleet.

Radical Travel's vehicles are refuelled at public petrol stations along tour routes with a fuel card. A transition to zero-emission vehicles could reduce the refuelling activities required by having provisions located on-site for recharging/refuelling.

Radical Travel's vehicle depot is currently located at a vehicle storage space in Edinburgh. The site is, therefore, not owned by Radical Travel and a warehouse is rented.

Existing fleet requirements

Radical Travel's vehicle fleet is composed of 16 internal combustion engine (ICE) coaches of varying sizes. These vehicles range from 16 to 41 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 Harry Potter tours as these are the most popular and, therefore, have the largest passenger numbers. Table 1 shows a breakdown of Radical Travel's current operational activities.

Table 1 Radical Travel's operational activities

Average mileage per trip	330 miles
Average annual tours per vehicle	45 tours
Average fuel cost of a trip per vehicle	£170.00
Average lifetime cost per vehicle	£120,000.00

Due to the nature of the tours, luggage capacity in the vehicles is vital, particularly for the multi-day tours increasing the vehicle's total weight. Considerations regarding luggage weight need to be made regarding the transition to zero-emission.

New draft legislation published by the UK Government states a two-tonne increase for electric heavy goods vehicles (EHGV) and a one-tonne increase for other alternatively fuelled vehicles[1]. This has been implemented to minimise the impact on payloads due to the weight of batteries.

If these recent updates to legislation are applied to buses and coaches, it would likely mean that creating suitable passenger and luggage vehicles 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.

[1] 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, 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.

[2] ChargePlace Scotland (2022) Accessing the network

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 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

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 Radical. Seven attended individual engagement sessions to detail their current and future plans for zero-emission buses and coaches. 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

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

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

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.

Infrastructure

In parallel with the engagement regarding vehicles, Radical Travel's local distribution network operator (DNO), Scottish Power Energy Network (SPEN), was contacted. As part of this, SPEN agreed to conduct a desk review of the power availability at Radical Travel's depot.

The results of this engagement and the desk review by SPEN noted existing capacity in the neighbouring cables of Radical Travel's depot. However, an upgrade may be required if the entire fleet was to be electrified.

"Local transformer does not appear heavily loaded and there is capacity within the neighbouring cables, however due to size of connection there is the potential for the need for a substation upgrade." - SPEN

Engagement outcomes for Radical Travel

Radical Travel 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

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

Radical Travel's operations are often in rural locations with smaller roads. Their business relies on small and mid-sized vehicles for tours. The lack of availability of these vehicles means that Radical Travel, 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.

Considering the low availability of suitable vehicles on the market, the short-term solution may be to transition the vehicles with the most feasibility and similarity to the existing fleet. For Radical Travel, the most feasible vehicles to transition are 16-seater Mercedes Sprinters and 41-seater Mercedes Ategos. The potential operational savings could then be used to transition the rest of the fleet when vehicles become available.

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 Radical Travel's fleet:

Diesel	Zero-emission
• Mercedes Sprinter 516 CDI Paramount • Mercedes Atego 1527 Unvi Touring • Mercedes Atego 1024 Unvi Touring	• Pelican Yutong • EVM Atlas E-Cityline (coach specification) • Switch Mobility EiV7

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

Infrastructure

To fully transition Radical Travel's fleet of 16 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 eight 43kW chargers and one 120kW charger. Installing this configuration would provide Radical Travel with the required infrastructure to charge their vehicles in preparation for tour departures fully.

Public charging infrastructure provisions are equally important along Radical Travel's tour routes.

Financial analysis

A total cost of ownership (TCO) analysis was carried out for each of the existing vehicles in Radical Travel's 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 three analyses 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.
- **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.

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

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.

Feasible transition

Due to the lack of availability in suitable transition options, only five of Radical Travel's coaches are suitable for replacement within the next few years this has been assumed to be a Mercedes Sprinter 516 CDI Paramount and Mercedes Atego 1527 Unvi Touring. 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 ZEB (inc. ScotZEB grant)	TCO ZEB (no ScotZEB grant)	TCO (existing ICE fleet)	Total cost of transition	Max savings to Radical Travel (inc ScotZEB)
5	5	£430,000	£730,000	£520,000	£210,000	£90,000

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 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)
5	8	£52,000	£17,000

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 the UK market due to the closeness of specifications – Switch Mobility EiV7.

Table 4 shows the potential savings a full fleet transition could offer Radical Travel.

Table 4 Full fleet transition analysis

No. of vehicles	Years of ownership	TCO ZEB (inc. ScotZEB grant)	TCO ZEB (no ScotZEB grant)	TCO (existing ICE fleet)	Total cost of transition	Max savings to Radical Travel (inc ScotZEB)
16	5	£1 million	£2.2 million	£1.9 million	£310,000	£800,000

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 16 of Radical Travel's vehicles would require up to nine 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)	Indicative install cost (with funding)
10	18	£70,000	£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

Although high-level zero-emission TCO analyses have been carried out for all vehicles in Radical Travel's fleet, there is a clear disparity in the availability of mid-sized zero-emission coaches.

Radical Travel could feasibly transition up to five of its vehicles without altering the existing business model. The options to transition the remaining 11 vehicles would be to:

1. Group several tours of smaller vehicles into a larger vehicle.
    a. This would lead to increased mileage across vehicles and reduced tours. As not all tours are carried out at full capacity, this could greatly impact Radical Travel's business and lead to a loss in revenue.
2. Purchase a greater number of smaller vehicles in place of larger ones.
    a. This would come at an increased cost as Radical Travel's fleet would grow to 26 vehicles. This would require guarantees that customer numbers remained the same to avoid increasing customer costs.

Infrastructure

Transitioning the five feasible vehicles in Radical Travel's fleet would require the installation of four private chargers within the existing depot. High-level figures provided by charge point providers suggest that this will likely cost an additional £70k to Radical Travel.

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.

Radical Travel 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.

Radical Travel is one of four SDMA members who have undertaken similar ZEBMTS stream 1 work to establish options for transitioning their coach fleets. 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, several steps must be taken and considerations to be made. These can be broken down into a three-step process focusing on vehicles, infrastructure, and people.

Vehicles

To ensure the availability of vehicles for as many operators as possible, it will also become increasingly important for manufacturers to release additional zero-emission vehicle options. This is particularly important for small and mid-size coaches, as noted previously.

We recommend that Radical Travel transition the most feasible vehicles within their fleet over the next few years to kickstart the transition journey. To carry out this transition, the following steps should be completed:

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

Options for hydrogen should not be overlooked but are likely to happen in the long term when the industry will propose a suited model and infrastructure is widespread.

Recommended next steps:
Urban Foresight has identified five vehicles that are feasible to transition within Radical Travel's existing fleet. High-level costs suggest that the purchase of vehicles would require £1.3 million in capital finance. This is £850k more than the cost of existing diesel vehicles.

Infrastructure

It is recommended that if Radical Travel chooses to purchase the existing feasible vehicles for its fleet, private charge points are installed at their depot for overnight charging before a tour departure. Top-ups could then be made if necessary, along a route, such as at destinations.

We recommend that Radical Travel carry out the following steps for the installation of 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 Radical Travel install the following configuration at its depot:

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

High-level costs suggest that this will require £70,000 in capital finance.

People

Zero-emission vehicles have fewer moving parts than their internal combustion engine (ICE) equivalent, reducing maintenance and servicing costs. However, there are also unique components which need to be considered. For example, although EVs do not have oil, spark plugs, or drive belts that need maintenance, they do have 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:

[5] Zemo (10.2022) Zero Emission Bus Guide

- **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.

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 (up to £80,000) 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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