Urban Foresight

Highland Council

Zero Emission Bus Market Transition Scheme

STREAM 1 REPORT

Contents

Introduction

This project has been carried out with funding from Transport Scotland through stream 1 of the Zero Emission Bus Market Transition Scheme (ZEBMTS). Administered by Energy Saving Trust, the aim was to target SME bus and coach operators in Scotland. This was done through the provision of consultancy services to assist operators in understanding the requirements for transitioning to a zero-emission fleet. 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 funding looked to support SME bus and coach operators and local authorities in gauging the zero-emission technology that would best suit their needs and how this may be implemented.

To date, governmental funding such as ScotZEB1 went mostly to large bus operators, leaving smaller operators unsure of how to transition their fleets. Smaller bus operators have a vital role o play in providing fair access to transport for communities, rural locations, and schools.

Highland Council appointed Urban Foresight to complete an assessment of the in-house bus fleet and routes. This included investigating the currently available and planned sales of buses and associated infrastructure. The results of these were used to provide recommendations on the most appropriate options for transitioning to a zero-emission fleet.

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

It should be noted that all cost recommendations are high-level due to the availability of only indicative costings for vehicles and infrastructure. Highland Council has been provided with the full analysis of its fleet which can be altered following the procurement of fixed costs.

Current context

Decarbonisation

Buses have a vital role to play in a variety of sectors across Scotland. This is particularly important in areas such as the highlands, where communities are more remote and spread further apart. Due to this, there is a greater reliance on private car transport. In the UK, 73% of trips carried out in rural locations are by private transport, compared to 53% in urban areas[1].

For those who cannot or do not drive, this can lead to social isolation and a lack of access to important services. Therefore, public transport is vital in ensuring communities have fair access to necessary amenities.

Transport Scotland published a report in 2021 on the decarbonisation of road transport in Scotland[2]. There are main targets within this report which focus on bus decarbonisation in Scotland:

[1] Department for Transport (28.09.2021) Future of Transport: rural strategy – call for evidence

[2] Elemet Energy (on behalf of Transport Scotland) (23.09.2021) Decarbonising the Scottish Transport Sector

- End the sale of fossil fuel buses by **2025** and begin a retrofitting program for the installation of zero-emission technology in older buses.
- All buses manufactured from 2015 must be scrapped or repowered by **2030**.

Operational activities

Many service routes in the Highlands are less financially viable than others in Scotland. This is due to lower than average passenger numbers and longer distances travelled. This means that often when local authorities tender for these routes, they are met with high costs.

Due to this, the council's tenders were left uncontracted as they could not afford the prices submitted by operators. This has been exacerbated by recent driver shortages and fuel costs. The highland council have, therefore, recently created its own municipal bus fleet. The operations carried out by this fleet look to fill the gaps in services.

The council's fleet currently runs on the following routes:

- Foyers - Inverness
- Whitebridge – Inverness
- Fort Augustus – Glen Urquhart High School
- Tomich – Strathglass – Dingwall
- Culbokie – Dingwall Academy
- Beauly – Marybank - Inverness
- Tomich – Strathglass – Inverness
- Nairn Town Service
- Milton of Leys – Millburn Academy
- Cawdor – Nairn Academy – Cawdoe Primary School

Existing fleet requirements

The council invested in 15 buses to run services in the region, with its public and school routes having launched in January 2023. These buses range in size from 16 to 77 seats. The majority of these vehicles are 38- and 77-seaters.

Table 1 shows a breakdown of Highland Council's current operational activities.

Table 1 Highland Council's operational activities

Average daily mileage per vehicle	135 miles
Average annual mileage per vehicle	30,000 miles
Average annual fuel cost per vehicle	£12,000.00
Average lifetime cost per vehicle	£190,000.00

Technology Requirements & Availability

Available technology options

Technologies considered

Electric (EV)

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.

Consistent advancements in technology mean batteries are becoming smaller. Therefore, weight has decreased over time while the range has increased. This has increased the number of electric options entering the larger vehicle market. Refuelling an EV is another advantage as private charging infrastructure can be installed on-site.

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 tailpipe emissions. Hydrogen vehicles make use of a fuel cell in which chemical energy is converted to mechanical energy by burning hydrogen. This then powers an electric motor. Although zero emissions are produced at the tailpipe of a hydrogen vehicle, the environmental impact of hydrogen varies depending on the generation method.

- Grey hydrogen – Created through natural gas extraction which produces and emits carbon dioxide. Grey hydrogen is the most common form of generation in the UK.
- Green hydrogen –Generated through electrolysis. This process electricity (renewably generated) to split the hydrogen and oxygen from water. Green hydrogen is the cleanest production method.

Hydrogen vehicles can travel around 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 (HFCEV)

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.

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. Theoretical analysis shows that hydrogen-electric technology would be best suited to heavy goods vehicles and could extend ranges to 500 miles and over and reduce the overall vehicle weight.

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

[3] ChargePlace Scotland (2022) Accessing the network

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 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.

As this fuel is not fully zero emission and typically costs more than diesel, it has not been considered here. Additionally, although it is referred to as renewable, it is not zero-emission. Therefore, while it is a preferable to diesel, it still contributes to an increase in CO_2 emissions[4].

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 to create CNG and LNG is timely and complicated.

CNG and LNG have not been considered during this project. Current refuelling options for both CNG and LNG are low, somewhat due to the required storage temperature. LNG and CNG both need to be stored at -162 °c. Additionally, they are not zero-emission at the tailpipe.

Stakeholder engagement

In order to assess the vehicle availability and network capacity for the transition to zero-emission buses, in-depth engagement activities were carried out.

Vehicle availability

Engagement activities for this project began with a desk-based review of available zero-emission vehicles. Vehicle manufacturers and dealerships were then contacted to obtain a picture of the vehicles that may be entering the market and their suitability for Highland Council's operations.

Over 20 vehicle manufacturers and dealerships were engaged as part of this process and seven attended individual engagement sessions to detail their current and future plans for zero-emission buses and coaches. Engagement sessions were carried out with the following:

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

Manufacturers were positive about the growth of the zero-emission bus market. However, it was also noted that this sector is still in its relative infancy and not all available vehicles will suit all operator needs. For example, while there is a growing market for electric buses which can be used for service routes in cities there is a lack of availability in the zero-emission coach market, particularly midi-coaches.

[4] Sarah Moore – AZO Clean Tech (27.08.2019) Are Biofuels Renewable Energy?

Additionally, electric vehicles appear to be the preferred option for vehicle manufacturers at present. This may be due to the unavailability of widespread hydrogen refuelling infrastructure compared to electric. There are currently three hydrogen refuelling stations in Scotland – located in Orkney, Aberdeen, and Edinburgh – and over 2,400 public charge points[5]. Due to this, vehicle manufacturers are still hesitant to produce vehicles as they do not see the demand at this time.

However, the longer ranges and lighter vehicle weights associated with hydrogen could be ideal for application within the larger bus and coach market. The highlands are far-reaching and mileage on some routes can be high. Hydrogen could be beneficial in this market 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 Highland Council's local distribution network operator (DNO), SSEN, was carried out.

SSEN's open portal data review showed that the grid supplying Highland Council's depot is currently constrained in both the upstream and downstream. Therefore, it is very likely that grid or substation upgrades will need to take place in order to install charging infrastructure.

Engagement outcomes for Highland Council

As noted by the Green Finance Institute and Confederation of Passenger Transport, there are four main challenges associated with transitioning a bus or coach fleet:

- High up-front costs associated with vehicle and infrastructure
- Residual value risks for both financiers and vehicle operators
- Insufficient real-world operational data on the costs
- Lack of policies associated with coaches

This project has investigated the above challenges to give operators such as Highland Council a real-world perspective on what transitioning means to them and their operations.

There are additional challenges faced by public bodies that may add a degree of complexity to transitioning fleets. Councils and other public bodies must abide by strict procurement and capital expenditure procedures that may affect the amount they can spend on vehicles. This may lead to them taking longer than other operators to transition.

As Highland Council's various services are carried out in rural locations with smaller roads and longer distances, its fleet requires different vehicle types. The unavailability of suitable vehicles for the council's fleet will likely mean that it needs to continue using diesel vehicles until appropriate options become available. This will have a detrimental impact on reducing overall emissions within the Highlands and Scotland.

The short-term solution may be to transition the vehicles which currently have the most feasibility and similarity to the existing fleet. The operational savings could then be used to transition the rest of the fleet when vehicles become available. This will depend on the total financial savings from the initial transitions and the vehicle replacement periods.

[5] ChargePlace Scotland (2022) Accessing the network

The Road to an Electric Fleet

Vehicle and infrastructure analysis

Vehicles

The following vehicles were used in the financial analysis of the council's fleet:

Diesel	Zero-emission
• Volvo Evora • Scania Omnicity • Alexander Dennis Enviro 300 • Ford Transit	• Switch Mobility e3/Metrocity • Wrightbus StreetDeck Electroliner • ADL Enviro 100 • ADL Enviro 400 • EVM Atlas E-Cityline

These were used to carry out a total cost of ownership (see financial analysis section below) of Highland Council's fleet. All zero-emission replacement vehicles a Zemo certified[6].

Infrastructure

To transition all 15 of the vehicles within Highland Counsil's fleet, it has been established that this would require the installation of fully at least one charge point per vehicle at the council's depot plus an ultra-rapid charger for emergency top-ups if required.

Therefore, the council will likely require eight 22kW chargers and up to two 150kW chargers to support a full transition.

This installation would provide the council with the appropriate infrastructure to ensure a full charge for each vehicle before a service. The council also has the opportunity to install publicly available charging infrastructure at strategic locations throughout the region to support their own activities as well as those of other operators.

Financial analysis

A total cost of ownersip (TCO) analysis was carried out for each of Highland Council's existing fleet vehicles in order to compare them to electric vehicle costs. This was followed by two 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.

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

The findings from this analysis were used to assess the financial savings of transitioning to a zero-emission fleet. Calculations have been carried out with and without potential funding. The results of this show the need for funding to kickstart the transition. The savings made over the life of the fleet could then be used to replace vehicles when required.

Feasible transition

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. Table 2 shows the maximum potential savings from transitioning the older vehicles first.

Table 2 initial transition analysis

No. of vehicles	Years of ownership	TCO	Cost to Highland Council without price parity of vehicles	Max potential savings with price parity of vehicles
7	5	£970,000	£460,000	£100,000

Transitioning these vehicles would require installation of four charge points at the depot. Table 3 shows the split of required infrastructure and the indicative costs for this.

Table 3 Feasible transition analysis

No. of chargers	Total charge points	Indicitive install cost (without funding)	Indicitive install cost (with funding)
5	9	£49,000	£12,000

Full transition

Transitioning the remaining vehicles could be carried out at a later date by the council when vehicles reach their end of life or end of ownership timeframe. Table 4 shows the potential savings a full fleet transition could offer Highland Council.

Table 4 Full fleet transition analysis

No. of vehicles	Years of ownership	TCO	Cost to Highland Council without price parity of vehicles	Max potential savings with price parity of vehicles
15	5	£2.1 million	£650,000	£550,000

Without funding to support the purchase of vehicles, it is likely Highland Council will be unable to transition its fleet in time to meet net-zero targets. A full transition will also depend on the total financial savings from the initial transition and the vehicle replacement periods.

Transitioning all 15 of Highland Council'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 Full fleet transition analysis

No. of chargers	Total charge points	Indicitive install cost (without funding)	Indicitive install cost (with funding)
10	18	£98,000	£24,500

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 a high-level zero-emission TCO analysis has been carried out for Highland Council's fleet vehicles, it is likely that a phased transition is the most suitable approach.

It is recommended that Highland Council look to transition its older vehicles first as the newer vehicles have not yet reached the end of their ownership cycle. Without additional capital funding to assist in the purchase of vehicles, a transition of feasible vehicles would cost Highland Council £2.5 million more than the cost of purchasing diesel vehicles.

Infrastructure

Transitioning the seven oldest fleet vehicles would require the installation of five private chargers within the existing depot. High-level figures provided by charge point providers suggest that this will likely cost an additional £49,000 to Highland Council (without the addition of funding).

Collaboration opportunities

Carrying out a collaborative approach with other bus operators in the Highland region will allow for a regional transition. Recent Transport Scotland statistics present a reduction in the number of bus journeys taken in Scotland. Compared to pre-covid levels, there has been a 12% reduction in bus journeys in Scotland and an increase in fare costs.

Public transport is vital in areas such as the Highlands where the distance to amenities is much larger than in towns and cities. Highland Council has set up its own municipal bus fleet to cover the areas in the region with current public transport gaps. This puts them in a unique position to offer SME operators service contracts with a zero-emission vehicle.

Highland Council has therefore carried out a Stream 2 project for the ZEBMTS to investigate the options.

Next steps required

In order to carry out a successful fleet transition, there are three main steps to take focused on vehicles, infrastructure, and people.

Vehicles

To ensure an increasing number of bus operators can transition to zero-emission vehicles, manufacturers must release additional vehicle models. This will be particularly significant for operators that have a range of vehicle types and sizes. Additionally, the release of additional vehicles will create a more widespread availability in the market and likely reduce costs.

To begin its zero-emission fleet transition, Urban Foresight recommends that Highland Council looks to transition the oldest vehicles within its fleet. To achieve this, 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 seven vehicles are transitioned within Highland Council's existing fleet. High-level costs suggest that the purchase of vehicles would require £2.8 million in capital finance. This is between £2.5 million more than the cost of its existing diesel vehicles.

Infrastructure

If Highland Council decides to transition the oldest vehicles within its fleet, private charging infrastructure should be installed at the depot to ensure vehicles are fully charged prior to service.

It is recommended that Highland Council 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 parking and planning teams within the council and private businesses to have suitable public charging infrastructure installed along main service routes.

Recommended next steps:
Urban Foresight recommends that Highland council install the following configuration at its depot:
- Four 22kW chargers with two connection points
- One 150kW charger for top-up charging

High-level costs suggest that this will require £49k in capital finance.

People

Zero-emission vehicles have fewer moving parts than their internal combustion engine (ICE) equivalent. The maintenance and servicing costs of zero-emission vehicles are, therefore, often lower. However, there are also unique components which need to be considered. For example, although electric vehicles 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.

Training will be required for those who are maintaining, servicing, and driving vehicles. 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. 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.

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 anf maintenance
    a. 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

Urban Foresight

The Catalyst, 3 Science Square, Newcastle Helix,
Newcastle upon Tyne, NE4 5TG

Flour Mill, 34 Commercial Street,
Dundee, DD1 3EJ

E: info@urbanforesight.org

T: +44 191 814 2210

W: http://urbanforesight.org

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VAT No. 179 2207 93