ENERGY SAVINGS TRUST ZERO EMISSION BUS MARKET TRANSITION SCHEME 2022/2023

MacPhails Coaches

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Content

1 - Introduction

MacPhails Coaches is a family run Coach Operator based out Salsburgh, Lanarkshire.

MacPhails run 15 vehicles a day out of Salsburgh servicing a variety of private hire, holiday, contract and school work.

The fleet comprises a mix of vehicles, with most of the fleet equipped to perform tours and some sprinters for local work

The main fleet are fitted with GPS devices that provide detailed telematics information.

An analysis of the 2022 telematics data shows:

> Drove **630,475 KM** producing approx. 524 **tonnes of CO2** which would require planting 20,952 **trees to offset**.

This study aims to understand how operations are currently run and then to model, using the technology available today, what percentage of journeys could instead be performed with Zero Emission vehicles.

As the only ZE coach on the market is the electric Yutong TCe12 the study also investigates electrical power needs and feasibility as well as the price difference between replacing vehicles with Electric versus Diesel.

This has been achieved by performing analytical models using the telematics data to understand:

1. **The percentage of journeys that can be perfomed by the Yutong TCe12 if the Buckie depot is electrified;**

2

The percentage of journeys that can be performed by the Yutong TCe12 if all depots are electrified;

3

The power required to electrify the main Buckie deport using different speed chargers and numbers of vehicles.

A desk top depot survey has been undertaken to understand current power available to the Buckie depot, as well as the cost and timescales to upgrade that connection.

A plan has then been created that provides a roadmap towards a just transition to Zero Emissions including a Return on Investment calculation and considering the potential socialisation of charging infrastructure.

2 - Simulations

In 2022 MacPhails Coaches ran 3,520 vehicle journeys activities that were in the scope for investigation at an average of almost 10 vehicles being used per a day representing 630,475 total KM driven.

If the Salsburgh depot were electrified, 1,563 KM could be performed using the Yutong TCe12 charging at its maximum rate of 150kW as required (assuming charging is always available). That is **44%** of journeys representing 211,093 kms which would save **175 tonnes of CO2 per year**.

10	3.520	630,475
vehicles per day	vehicle journey activities	total km driven

1,563	211,093

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The graph below shows that the work pattern is highly mixed showing no discernable difference between midweek and weekend activity showing that the company has a mixed portfolio of work.

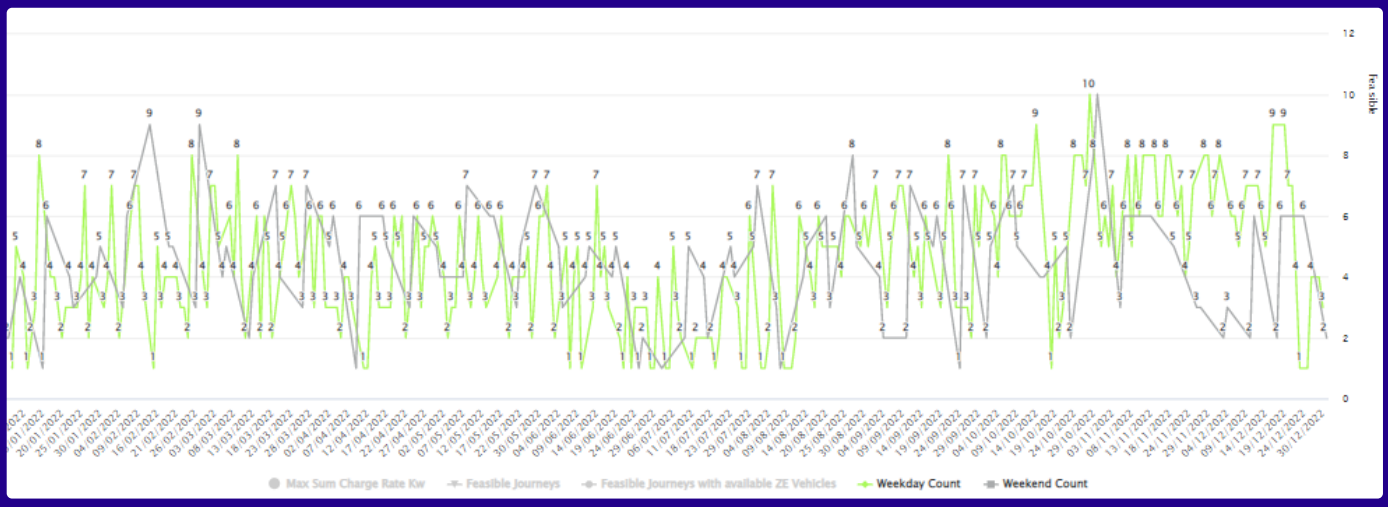


Figure 1: Daily usage by weekday and weekend

This case study focuses on the electrification of the Salsburgh depot. If the maximum number of vehicles were purchased to cover all journeys that could be electrified then a grid connection of **900kW** would be required.

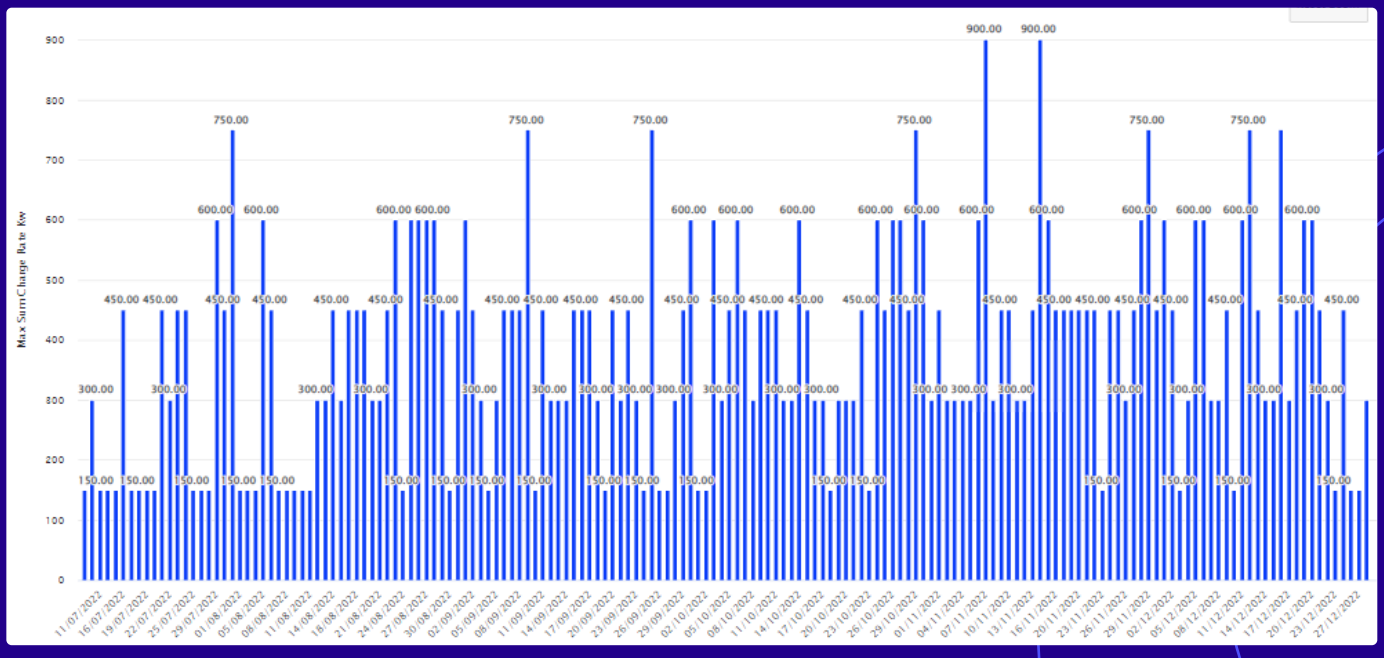


Figure 2: Unlimited power draw

3 - Depot

The current supply at the Main Street depot is registered as 3-phase Non Half Hourly Metered, so no capacity is set but is deemed as handling up to 69kVA. An application was made to the DNO on the 2 February 2023 for a quote to upgrade this connection to 249kVA.

The DNO replied with a quotation on 10 March 2023 that is valid for 3 months that the upgrade will cost £85,777 and can be delivered within a 9 month time-frame.

As the DNO is proposing the installation of a 500kVA substation in the works it may be possible to achieve a higher bandwidth for a similar cost. A further application will be required to the DNO to establish whether this is the case, which was deemed out of scope of this study due to the the extra costs associated with the application.

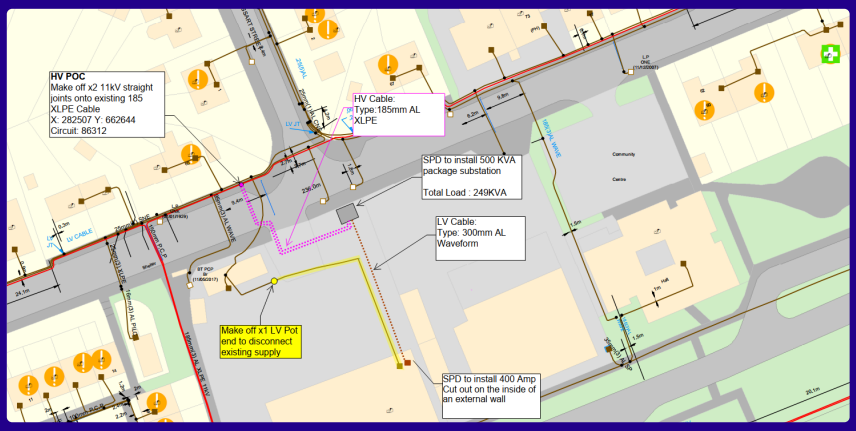


Figure 3: DNO works plan

The diagram below, provided by Zenobe[1], shows the proposed grid layout with a phased approach to installation. The ground site work can be performed at one time to minimise disruption. Ducting can be installed so that cables can be pulled through as required in each phase.

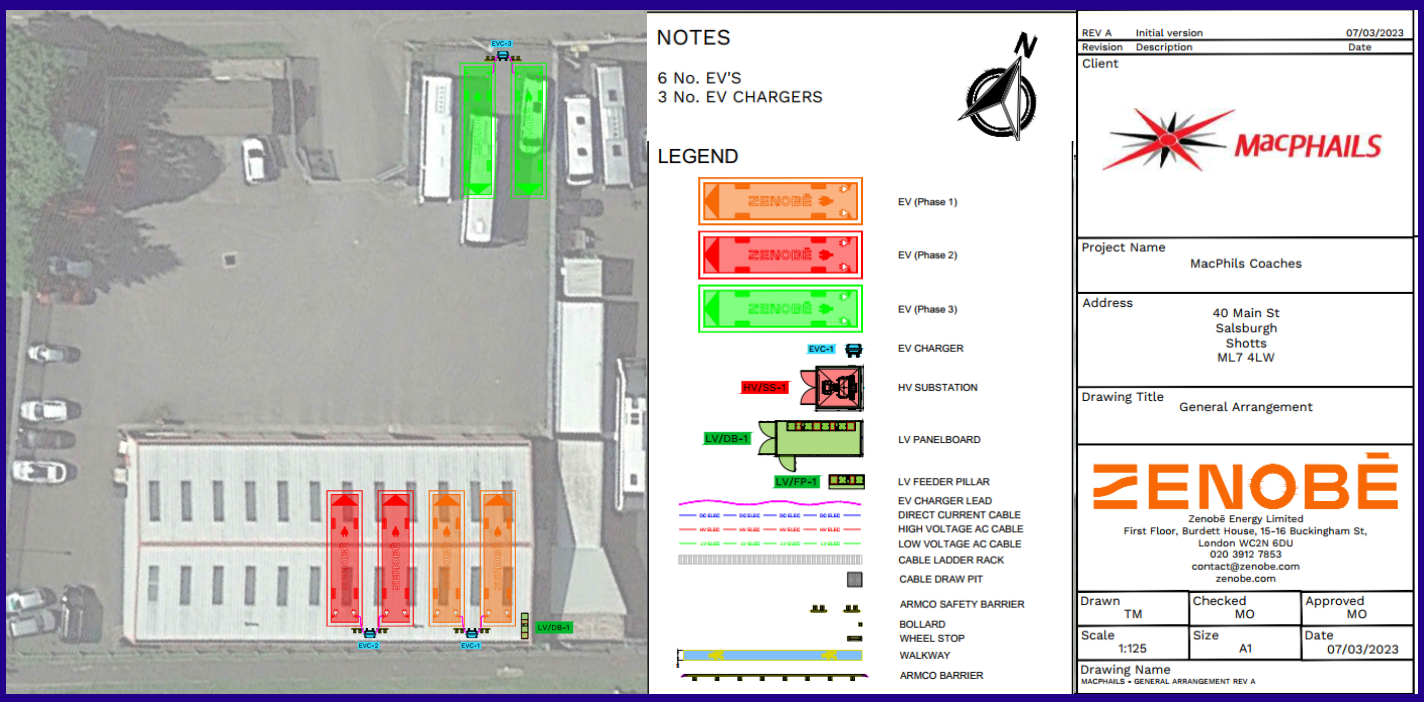


Figure 4: Depot site plan

[1] Zenobe; "We design, finance, build and operate battery solutions. Our batteries capture renewable energy, balance its supply on the grid and transport it to electric vehicles. At the end of their lifecycle we repurpose them. We're building a circular economy for batteries, the output from one process can be the input for the next, saving vital materials, carbon and value.
Today in the UK, we're the leading owner and operator of battery storage. We are supporting the National Grid with the uptake of renewable power and work with c.90% of the major bus companies, powering 25% of the UK e-bus market."

4 - Phased Approach

Chargers configured to charge at 40kW to keep within the existing grid limit of 69kVa.

Existing chargers powered up from 40kW to 120kW.

Phase 1	2 vehicles	1 twin plug charger	69 kVA
Phase 2	4 vehicles	2 twin plug chargers	249kVA
Phase 3	8 vehicles	4 twin plug chargers	249 kVA

Phase 1

This phase does not require an upgrade to the current 69kVa grid connection, therefore removes any dependency on the DNO.

Rather than buy “suitcase” chargers that will become redundant in Phase 2, one 120kW charger will be purchased and configured to run at a maximum of 40kW.

The power draw diagram shows that, due to there only ever being two vehicles available to charge, the power requirement never breaches the 69kVa grid limit.

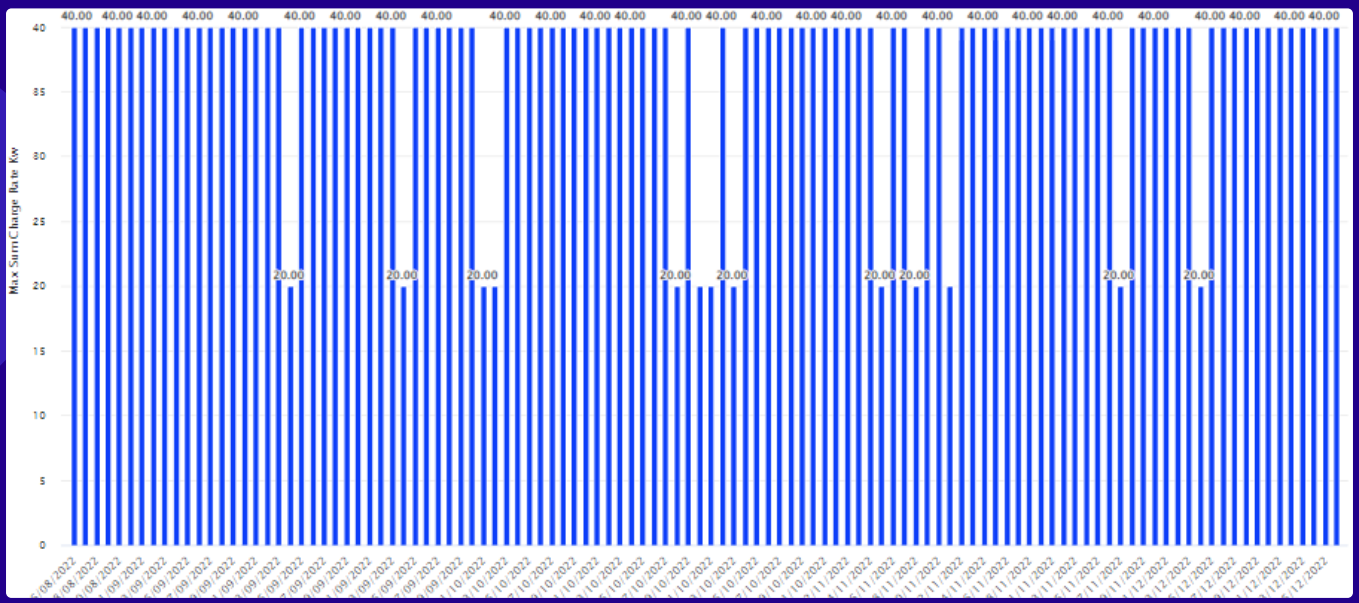


Figure 5: Power draw for 2 vehicles charging

Running 2 vehicles would of allowed MacPhails to drive 100,853 kms at an average of 138km per vehicle based on 2022 usage

Phase 2

This phase involves reconfiguring the existing chargers to charge at their full power rate of 120kW and installing one more 120 kW charger. The grid connection also needs to be upgraded to a minimum of 249kVA to support the extra charging requirements.

The work profile shows that there will be solid utilisation of 4 vehicles if 2022 levels are repeated,

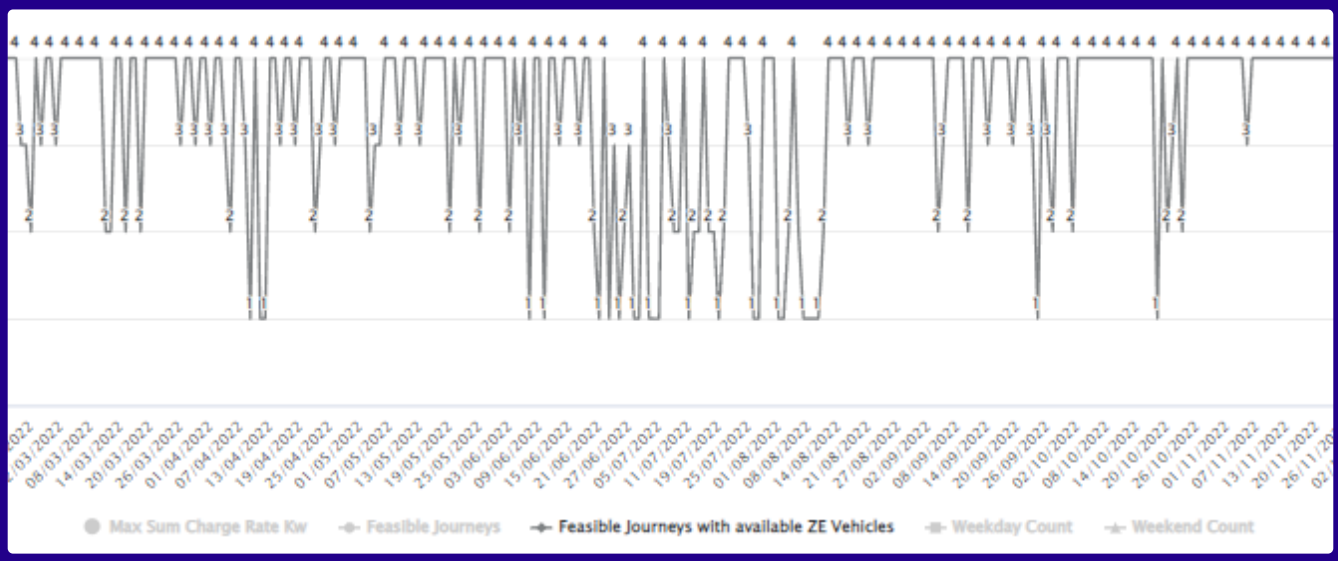


Figure 6: Feasible journeys 4 vehicles

The exceptions where 4 vehicles are not fully utilised tends to occur most in the summer months. This confirms that a large part of MacPhails business is tour based as can easlily be seen when analysing the journeys.

The modelling below shows that as expected with 4 chargers and 4 vehicles the the grid limit will not be exceeded meaning that all vehicles will be able to charge suitably

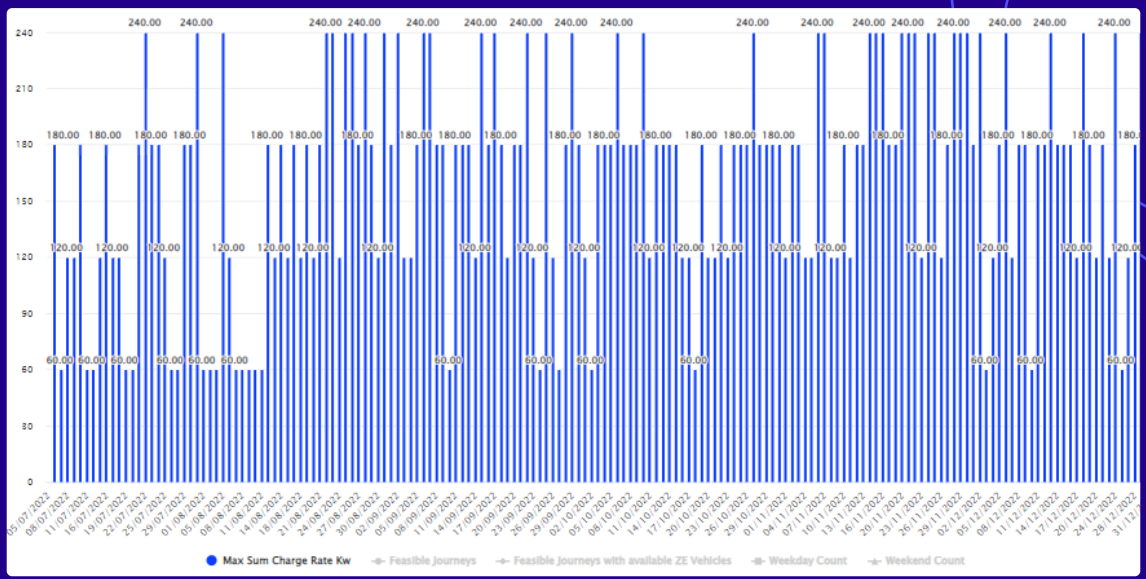


Figure 7: Power draw for 4 vehicles

Phase 3

This phase involves purchasing 2 more chargers to complete the charger rollout and 4 more vehicles bringing the total to 4 120 kWh twin-plug chargers and 8 vehicles.

The demand for 8 vehicles is not as constant as it is for 4. With the 2022 workload 1,550 daily journeys would have been possible for a total of 208,869 KMs. This is 72km per vehicle (based across 365 days), compared to an average of 138km per vehicle per a day when running 2 vehicles.

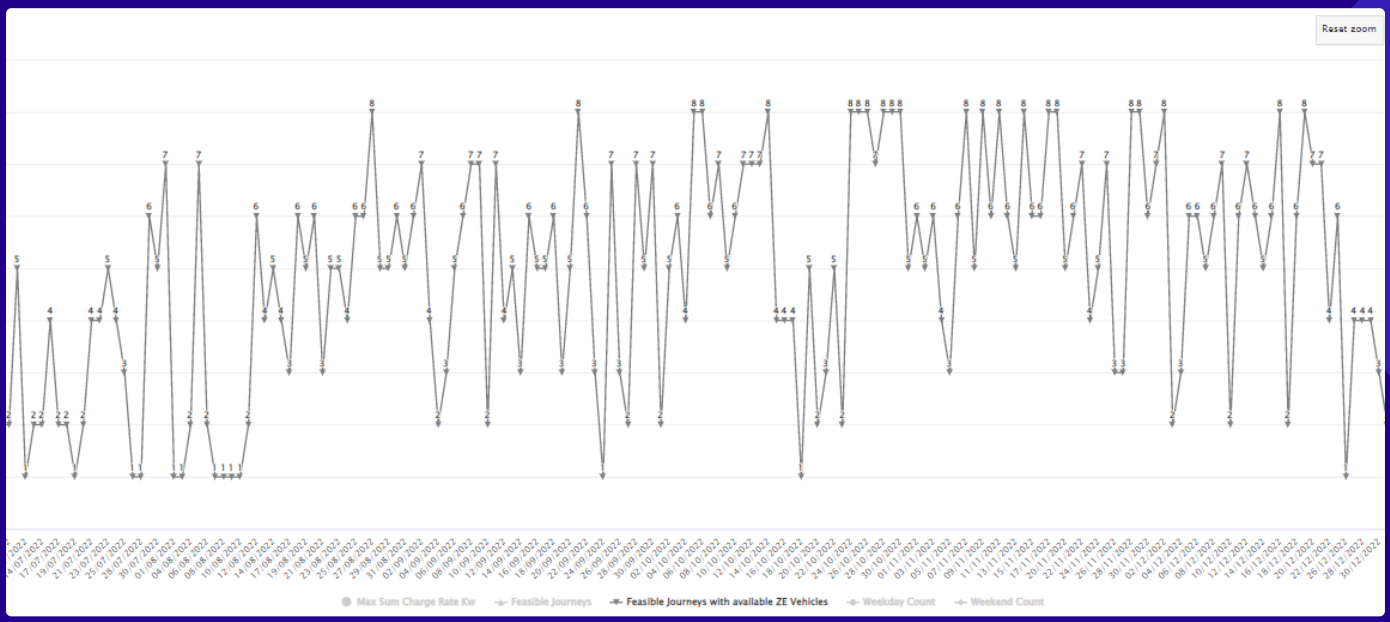


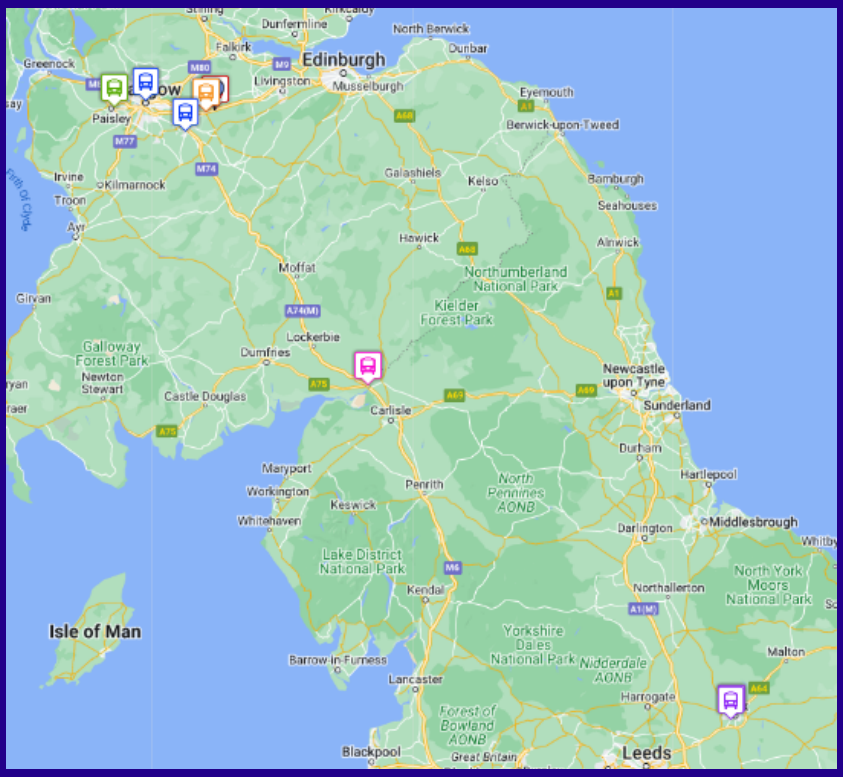
Figure 8: Daily usage for 8 vehicles

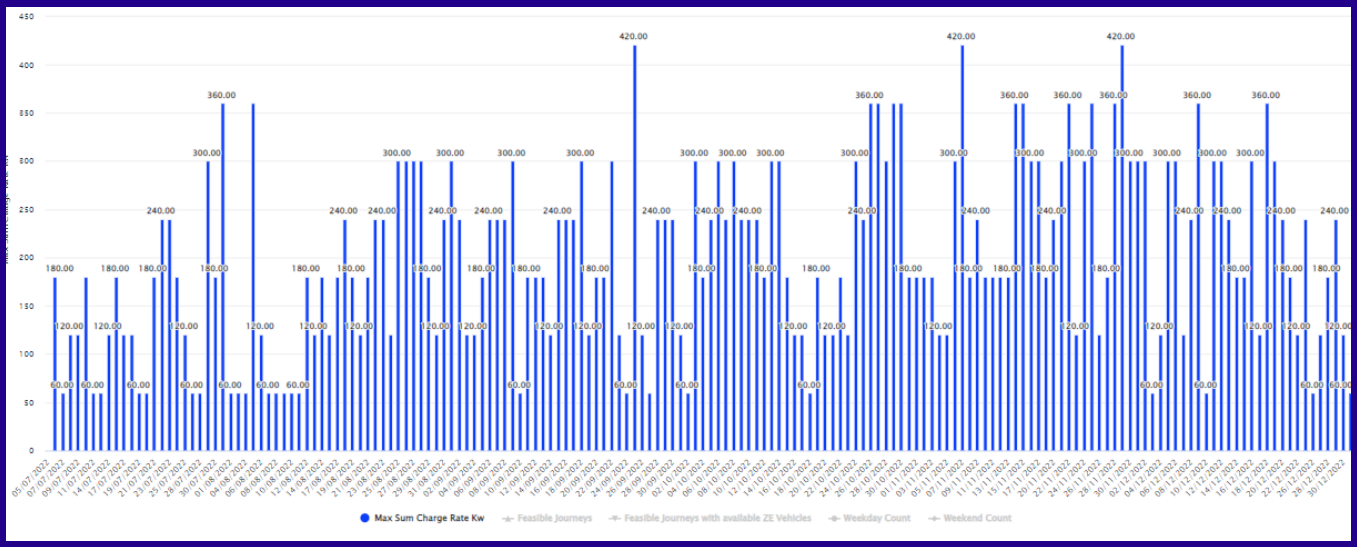
To counter this, MacPhails can plan tactically to ensure vehicles make the most ZE miles as possible though this can be difficult with driver constraints.

Due to the large volume of tour work that McPhails perform they need to make use of off-site opportunity charging to make the best use of their vehicles. They require a network of Charge stations to be made available at service stations and attractions.

The data shows frequent trips to Blackpool, York, Scarborough, Liverpool and other Northerm destinations. The common denominator is that all of these trips stop at either Gretna or Tebay services.

Providing fast charging at these services and at destination resorts such as Blackpool would open up the North of England greatly increasing ZE mileage, reducing more CO2 emissions and providing quicker ROI.





Running 8 vehicles and 4 120kW chargers does mean that sometimes the 249kVA grid limit will be breached.

If it is possible to extend the grid connection to 450kVA for a similar price as increasing 249kVA then this should be pursued. Otherwise Zenobe provide charging software and hardware that analyses power usage to the millisecond and ensure that individual charger power levels are managed to ensure that the established grid limit is respected and that each vehicle is charged in time.

This is called load balancing and is done by spreading the charge load over the time available for each vehicles charge session.

Employing load balancing or increasing the grid limit will also provide opportunities for socialisation of the charging infrastructure

5 - Business Case

The following high level return on investment calculation uses data from 2022 to calculate KMs that could be driven ZE and multiplies to understand the Opex costs for one year. It shows a **return on investment of 10.5 years**.

This calculation does not take into account the future value of money. It should also be noted that the calculation uses MacPhails current contracted electricity rate and not the current available market rate. If the market rate of 35p/kWh is used then the ROI increases to 15 years.

CAPEX

Vehicle cost	£2,800,000
Charger cost	£120,000
Install cost (per charger/vehicle)	£80,000
Grid applications & consultancy	£25,000
Grid upgrade	£85,000
	£3,110,000
Diesel alternative	£1,760,000
CAPEX difference	£1,350,000
Subsidy % for difference	75% £1,012,500
CAPEX total difference	**£337,500**

OPEX

Smart charging software	£8,000
Fuel cost	£79,495
Maintenance cost	£10,443
	£97,939
Diesel alternative fuel cost	£113,311
Diesel alternative maintenance cost	£16,710
	£130,021
OPEX total difference	**£32,082**

ROI 10.5 years

For the calculation the following parameters were used:

Purchase price Yutong TCE12e	£350,000
Purchase price Diesel equivalent	£190,000
Cost per 120kW Charger	£30,000
Cost to install 120kW Charge	£20,000
Consumption rate for Yutong TCE12e	1.07/km
Consumption rate for Diesel equivalent	0.3557
Cost per litre diesel	£1.75

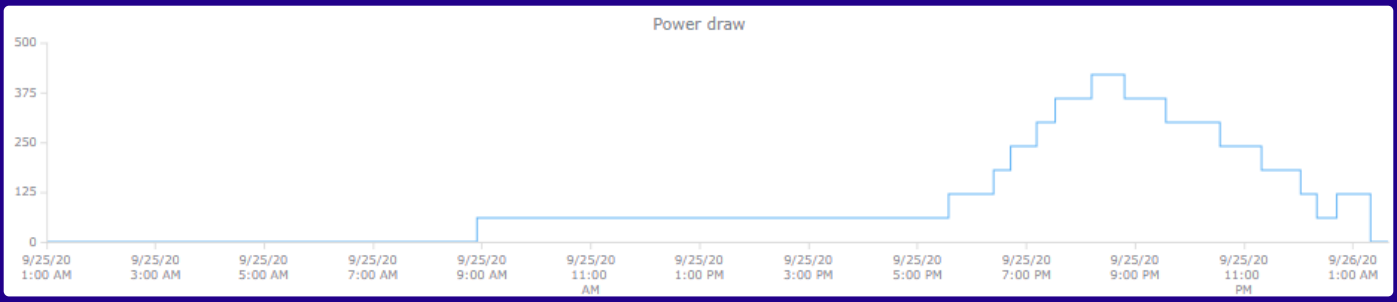
Note the parameters provided are illustrative only and do not represent official quotations from any manufacturer or supplier.

6 - Socialisation of charging cost

MacPhails depot is conveniently located for the potential socialisation of charging.

They share a boundary with Bruces Coaches and are in the same street as Golden Boy Coaches.

The power draw graph below shows that even on the busiest charging days there is plenty of scope to manage the load with smart charging.



It is recommended that Golden Boy and Bruces be approached with a view to analysing their data in combination with MacPhails to see what savings can be made with a joint approach

7 - Conclusion

MacPhails work profile works well for a **transition towards a Zero Emissions** fleet for their contract work. The parts of their portfolio that travel between Edinburgh and Glasgow and the surrounding area are well suited to transition.

For the touring part of their business they require a national charging network before they will be able to deliver services into the highlands and beyond and to open up the North of England.

If fast charging was reliably available at Gretna and Tebay services and at destination towns and cities such as Leeds, Liverpool, York, Blackpool and Scarborough, MacPhails could ramp up their ZE kilometres significantly.

MacPhails is well located in that it can establish a suitable power connection within reasonable time-frames.

The transition can be a fair one if the difference between investment in electric vehicles, infrastructure and associated installation costs and the cost of diesel vehicle replacement were subsidised by 75% AND IF a cap on electricity could be established.

MacPhails would be able to phase the rollout of ZE vehicles with a vehicle refresh program over 3-4 years, though this would mean replacing vehicles that would not normally need replacing.

Including the subsidy this represents a substantial investment of over £2m to with a return on investment (ROI - not discounted for the future value of money (NPV)) of 10.5 years.

Financial assistance for purchasing the vehicles and infrastructure is seen as the most important factor at this time. Without assistance it would not be an interesting investment to make at this initial stage.

To make this financial commitment without assistance the ZE vehicles available would need to be capable of performing greater mileage so that more activities can be linked.

The reason the ROI period is prohibitive is that MacPhails recently had to change energy tariffs and now pay 36.5p per kWh compared to 16p previously.

Factoring in the future value of money (NPV) and the current cost of borrowing and inflation the proposition will not be commercially viable without a government subsidy that either caps the cost of an electrical unit for ZE operators or links it to the price of diesel so that it is always cheaper by a fixed ratio.

Please note that the financial calculations provided in this report are not quotations and provided as a guide and not be used in a financial application without detailing.

Before proceeding with any application further consideration should also be given to the following that were considered outside the scope of this study:

- Integrated planning with Bruces and Golden BOy Coaches to investigate sharing infrastructure
- Analysis of the effects of opportunity charging on route
- Sensitivity analysis of journeys simulating different consumption efficiencies
- Further analysis of charging utilising the charge curve for the Yutong TCe12

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Energy consultancy experts and leaders in energy transition from our work with the largest providers of zero emission public transport vehicles outside of China including Transdev, National Express and the Go-Ahead group. We have a rich history in the Coach Industry providing finance, compliance, operations and scheduling solutions integrating dozens of industry data sources.

With our deep understanding and experience founded through working with partners such as The Mobility House and PwC and from building financial models, energy models, charging strategies, and understanding battery usage, we help unlock value in zero-emission strategies.

We provide the logic and toolsets to take the risk out of the transition to hydrogen or electric whilst maximising business benefits

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