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Leading the charge:

A guide to electric vehicle batteries and battery performance for fleet operators

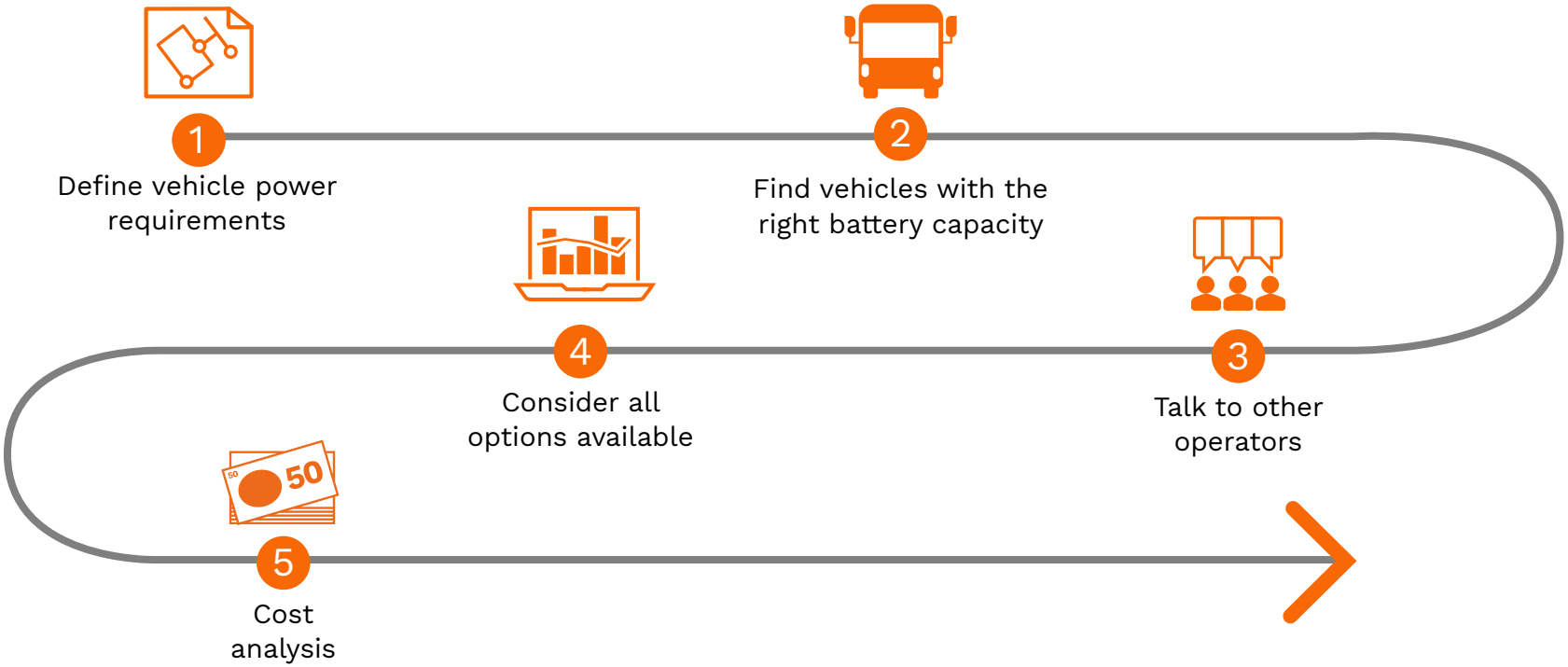
This guide is written to help fleet operators understand two of the key considerations when switching to battery electric vehicles: the batteries themselves, and how to manage their performance.

Breaking down these fundamental elements and drawing on our real-life experience working with operators, Distribution Network Operator (DNOs) and other stakeholders, we hope this guide will help operators to understand, prepare, and lead the charge in their fleet electrification projects.

Contents

How do I know what battery capacity I need?

Battery capacity is measured in kilowatt hours (kWh). Assuming you keep all other conditions constant, the higher the kilowatt hour capacity of a battery, the more miles it will do. But how do you find out what capacity you need and then what do you do? **Consider these principal steps:**



1

Define vehicle power requirements

Begin by defining the distance the vehicles need to travel in between charges.

This, combined with the maximum weight of the vehicle, the topography of the area that it covers and the climate, is what will define the battery capacity.

2

Find vehicles with the right battery capacity

Contact vehicle manufacturers to find out what they recommend and have available that matches your route and vehicle requirements.

If possible, obtain a demonstrator vehicle for a couple of weeks - this may come with a charger, but it may also be possible to charge a single vehicle on a standard 3 phase plug.

3

Talk to other operators

Where possible, talk to other electric fleet operators whose vehicles work in similar conditions to yours.

This will help you to understand how different makes and models operate in real life.

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4

Consider all options available

In some cases you will not be able to find a vehicle that has the battery to deliver the range you need. In this situation, you may need to change schedules and the maximum vehicles available at any one time.

It is also worth checking if a new vehicle is coming out shortly that does meet your requirements – battery technology is developing fast.

5

Cost analysis

As with diesel buses, you can buy vehicles and batteries outright or use a leasing model.

There are also ‘as a service’ models which incorporate the costs of servicing and potentially replacing the batteries in a monthly fee.

It is worth considering all of these as part of your purchase decision.

NMC and LFP - what's the difference?

NMC and LFP are two types of Lithium-ion batteries, which are the most frequently used batteries for electric vehicles due to their high power-to-weight ratio:

- LFP stands for Lithium Iron Phosphate and is the most common battery chemistry for electric vehicle batteries
- NMC stands for Nickel Manganese Cobalt and is most common in consumer electric cars

If you have a view on LFP or NMC, this will help to determine your vehicle selection. We recommend you speak to manufacturers about these options and their views of the pros and cons.

LFP Lithium Iron Phosphate	NMC Nickel Manganese Cobalt
Lithium ion battery with lithium iron phosphate as a cathode material	Lithium ion battery with nickel, manganese and cobalt as the cathode materials
Less energy dense so batteries tend to be heavier	More energy dense so batteries tend to be lighter
Better suited to fast charging	Less well suited to fast charging
Historically more common in buses than cars	Historically more common in cars than buses
Battery warranties subject to fewer restrictions	Battery warranties subject to more restrictions

Complete a power analysis for the whole fleet

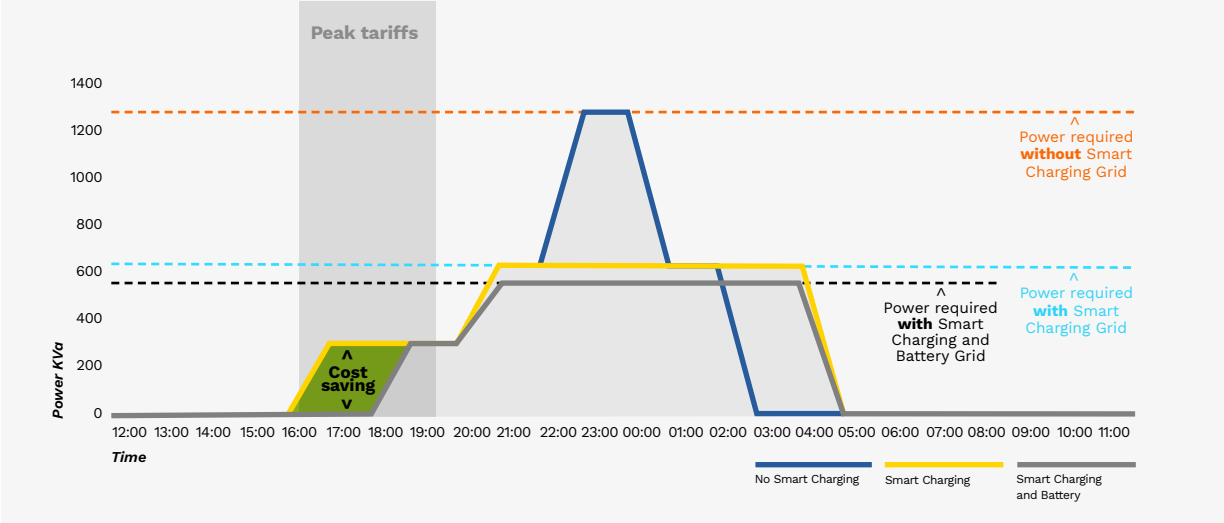
As well as understanding the power required for individual routes, you will need to complete a power analysis to identify how much electricity you will need over your whole site. You'll need to know how much power is needed to charge all your electric vehicles, as well as other demands like depot lighting, heating etc.

Working out the total power requirement of your fleet is rarely a case of multiplying the number of vehicles by the amount of power required to charge a single vehicle: vehicles can be charged slowly or quickly, peaking at certain times of the day.

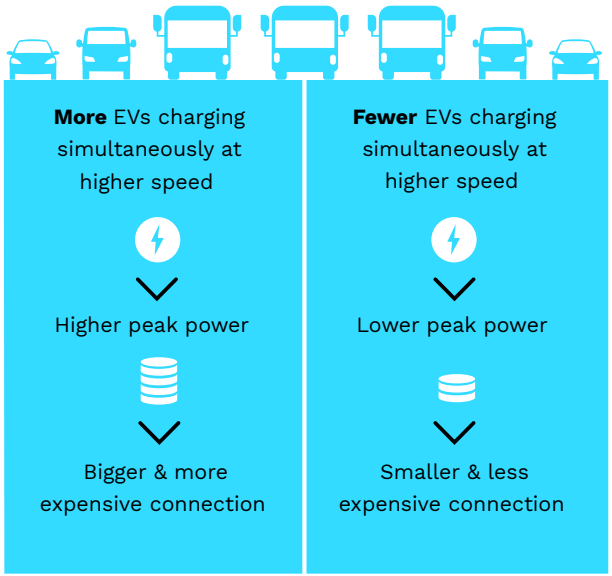
Once you know your total power requirement you can, as described in the resources here, work out whether you will need a new or upgraded connection to the grid.

In some cases, onsite batteries connected to the grid can reduce your power requirements and therefore the cost of works, like at Stagecoach's Park & Ride depot in Guildford here.

Impact of smart charging on power requirements



The link between batteries and your grid connection



Using smart charging strategies and onsite batteries can reduce your peak power requirements and therefore your operational costs. However there are two reasons you might want to apply for greater capacity than you currently need:

- To secure enough power to electrify the rest of your fleet in the future (demand for power will only grow)
- To maximise the power you get for the TCR (Targeted Charging Review) charges: These fixed charges are associated with certain bands of power. It may be sensible to boost your power requirement to the top of the relevant band, as you will be paying the same fee regardless. This provides additional buffer should your peak power requirement increase.

It is always advisable to get in touch with your DNO as early in the process as possible to discuss your requirements prior to submitting a connection application. Partners like Zenobē can carry out a power analysis and provide recommendations on efficient power usage as part of the electrification service, as well as contacting your DNO on your behalf.

Find out more about the connections processes, different connections solutions and key factors to consider to ensure adequate power is available to charge your EV fleet here.

Site planning

As part of the planning exercise, and once you know your peak power requirement, you will need to think about your depot layout. Considerations include:

- The number of vehicles
- The number, make and type of chargers (AC or DC)
- The location of the substation
- Efficient space utilisation
- Future proofing for further electrification

Although chargers and vehicles should be universally compatible, any electric fleet operator will tell you that there are usually teething issues. At Zenobē we have just launched a test centre to overcome this, supporting depot planning and identifying issues before they are a problem.

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How long will my batteries last?

It depends on the intensity of the battery's usage *(see: battery degradation)*. A useful proxy is to look at the average length of an EV battery warranty which is currently between 5 and 10 years.

'Battery as a service' (BaaS), offered by Zenobē and others, means batteries are financed over a contract length between 5-15 years for a fixed monthly rental.

Software to monitor and manage battery performance, as well as replacement batteries, are incorporated into this monthly fee, removing financial and technology risk from the operator.

With batteries representing up to a third of your electric vehicle price, it is worth looking into warranties, replacement costs, BaaS and software to avoid surprises further down the line.

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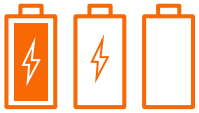
What is battery degradation, and can it be prevented?



Battery degradation is a physical process where the elements of a battery change state and become less effective, meaning the battery is less able to deliver energy.

Once an EV battery has degraded past a certain point, vehicles will be unable to do the mileage required. Degradation is caused by:

1. **Battery aging:** regardless of how it is used a battery will experience degradation over time
2. **Cycling the battery:** the more you charge and discharge a battery, the faster it will degrade, however, the way you do this can have a significant impact *(see next page)*

Degradation cannot be stopped entirely but it can be slowed down by avoiding certain behaviours, such as:

Deep discharging: running the battery charge exceptionally low before recharging

Fast charging: causes faster degradation - as a rule, a lower charging rate is best. However, battery technology is becoming more resilient, so fast chargers can be used to overcome scheduling obstacles

High temperatures: operation and storage of batteries at high temperatures increases degradation

How long does it take to charge up a vehicle?

The two EV ‘fuels’ are Alternating Current (AC) or Direct Current (DC) power. The electricity grid produces AC power, whereas EV batteries only store DC power.

An EV will be configured to accept one of the two (though some accept both), with DC power providing a faster charge.

Charge time depends on several factors:

Battery capacity:
the bigger the capacity, the longer it will take to fully charge

State of charge of the battery:
an emptier battery will take longer to fully charge

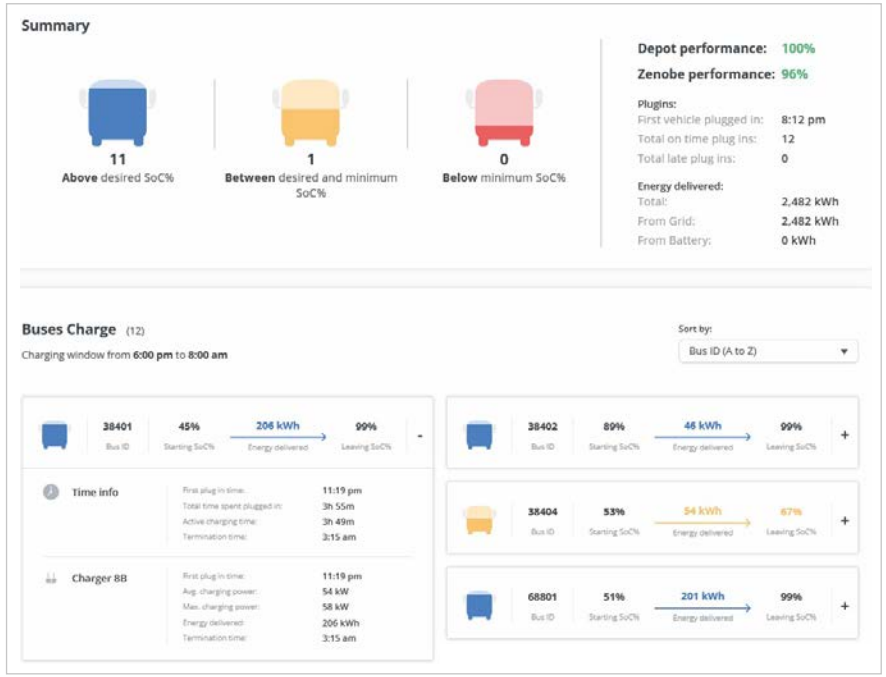
Health of the battery:
An older, degrading battery will take longer to charge than a brand-new one.

Charger type:
the two main types of chargers are plug-in chargers or pantograph chargers, which accept either AC or DC power. Of the two types of power, DC provides a faster charge – *see single decker bus example below*

Charger type	Description	Designed for	Average time to recharge*
Plug-in charger (AC)	A low-medium power AC charger, usually formed of a pedestal and charging cables like a consumer equivalent: **44kW/88kW**	Slower charging	3.5-7 hours
Plug-in Charger (DC)	As above, only using medium to high DC power instead: **60kW/120kW/180kW**	Faster, overnight charging	2-5 hours
Pantograph (DC)	An extremely high-power DC charger, with an automatically connecting **overhead charger:** >600kW	Short-duration, opportunity charging	1 hour

** Based on an e-bus battery of 382 kWh with an average charge curve, charged from a minimum state of charge (SoC) of 20% to full.*

Why do I need software to manage my vehicle charging?



Software should make it easy to ensure efficient and cost-effective fleet operations by monitoring charging infrastructure and batteries. The software should be able to:

Monitor depot efficiency: a short time between buses getting back to the depot and charging indicates efficient charging - slowly, over a long period of time rather than in a short window, requiring rapid charging that is bad for battery life

Optimise charging: software can control the speed of charge to minimise fast charging – maximising battery life and minimising the depot's peak power requirements (thus reducing grid connection and usage costs)

Review driver performance: EV driving style has a significant impact on power usage *(see: regenerative braking)*, battery discharge and therefore on battery life - software can identify inefficient drivers so additional training can be provided

Monitor and manage vehicle issues: where an EV is performing badly regardless of driver, there is likely to be a fault with the vehicle or battery - software can identify trends in performance so that remedial action can be taken

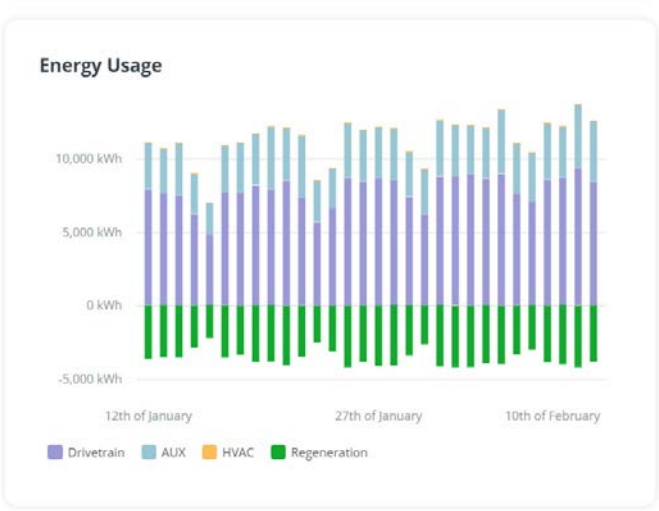
Identify route issues: some routes are, for reasons of topography or traffic levels, harder on the battery than others – software can identify these and influence route planning and scheduling

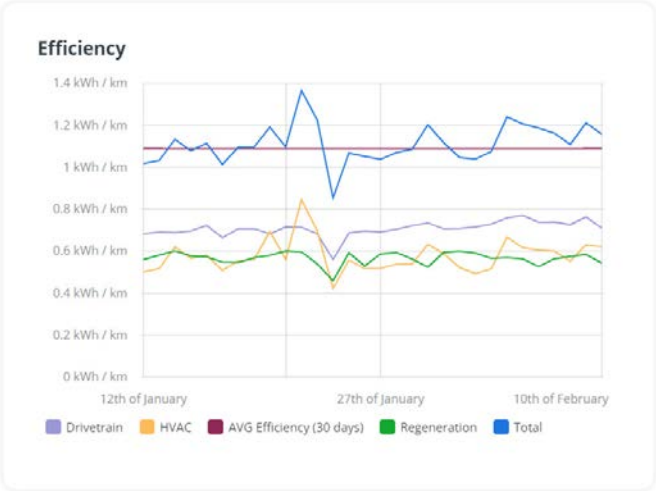
What is regenerative braking?

In electric vehicles, easing the accelerator to slow down (instead of using the brakes) generates energy that is then stored in the battery. This is known as ‘regenerative braking’ and has two functions:

1. It boosts the energy immediately available to power the route
2. It reduces the depth of discharge on the battery, optimising the battery’s life

In terms of driving style, this means that a driver should try to avoid harsh braking and instead slow their vehicle early to maximise the regenerative effect.





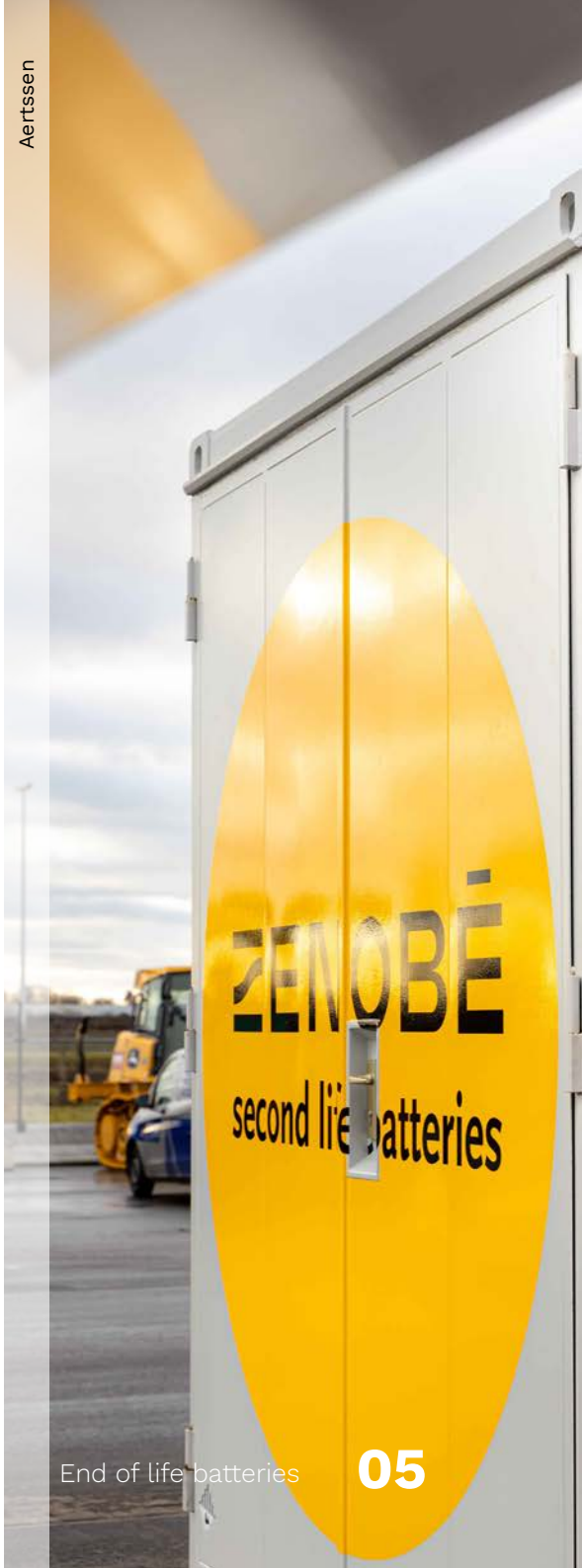
How do I get rid of an old battery?

Whilst battery recycling is an option, it is not yet cost effective. However, it is both **commercially and environmentally** sustainable to repurpose batteries in **second life applications**, keeping their materials and value in circulation.

Commercial
Despite being unusable on an EV, an end-of-life battery retains a certain value which should be considered in your business decisions.

We recommend working with a partner who will repurpose batteries and give them a second life as stationery or portable power. At Zenobē, as part of our 'Battery as a service' we discount the residual value of the battery from the total cost of the contract.

Environmental
The resources used in EV battery manufacture are finite and require energy for extraction, so there is also an environmental benefit to repurposing them. Learn more about the circular economy for batteries here.



Find out more

Please contact us at **fleet@zenobe.com** with your questions on fleet electrification.

You could also visit our market insights page for articles and further guides, or follow us on LinkedIn.

If you would like to do more research around batteries and battery performance you could also:

- Look at the resources on the Zemo partnership website
- Read the publications of The Faraday Institution
- Listen to the Fully Charged podcast
- Attend ITTHub in May

About Zenobē fleet

At Zenobē we're making clean power and fleet transport economically and environmentally sustainable. Our fleet team works closely with operators to find ways to overcome the challenges of switching to electric. To date they have supported the electrification of 22 vehicle fleet depots, with operations in the UK, Benelux, Australia and New Zealand.

We design bespoke solutions that can include financing, planning, designing and project managing the transition of a fleet from diesel to electric. As part of the package, we also provide operational guarantees and proprietary software to enable operators to optimise fleet performance.

Learn more

About Zenobē

Zenobē finances, designs, builds and manages battery systems to help its customers switch to electric vehicle fleets, renewable energy, and efficient power distribution. Zenobē has around 25% market share of the EV bus sector in the UK, its own proprietary charging software and 225MW of contracted battery storage assets providing services to National Grid. By repurposing batteries after their first life, Zenobē gives them second lives in portable power applications.

As well as supporting the transition to zero emission transport, Zenobē uses battery systems to support the switch to renewable energy and efficient power distribution. By repurposing batteries after their first life, Zenobē gives them second lives in portable power applications.

Learn more