eFREIGHT 2030

Business Model Options and Considerations for Depot-Based Charging

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Acronyms & Abbreviations

BMI	Business Model Innovation
CaaS	Charging-as-a-Service
CAPEX	Capital expenditure
EaaS	Energy-as-a-Service
eHGV	(Electric) heavy goods vehicle
EM&O	Energy management and optimisation
EMS	Energy management system
kWp	Kilowatt peak
O&M	Operations and maintenance
OPEX	Operational expenditure
PaYG	Pay-as-you-go
PPA	Power purchasing agreement
ROI	Return on investment
SLA	Service level agreement
ULE	Ultra-low emission
V2G	Vehicle to grid
ZEBRA	Zero Emission Bus Regional Area
ZEHID	Zero Emission Heavy Goods Vehicles and Infrastructure Demonstrator

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1. Executive summary

Executive summary

eFREIGHT 2030: Project overview

- The eFREIGHT 2030 consortium was selected to join the UK government's Zero Emission Heavy Goods Vehicles and Infrastructure Demonstrator (ZEHID) programme.
- Led by Voltempo, the eFREIGHT 2030 project aims to stimulate the deployment of long haul zero emission HGVs.
- The project consortium comprises market leaders from the road freight and low-carbon energy industries.
- The consortium will introduce 100 electric HGV 4×2 and 6×2 tractor units, and 32 new charging locations, all of which will have megawatt-charging capacity from day one.

As a consortium partner, Energy Systems Catapult will help ensure that the eFREIGHT 2030 trials can gather the evidence required to understand the challenges and opportunities, across stakeholders, and operations of electric HGVs in the real world.

The eFREIGHT 2030 project is set to create up to 200 new jobs by 2030 and provide Birmingham with one of the UK's first electric vehicle charging hubs dedicated to HGVs.

Executive summary

Report overview and purpose

- The Catapult's Business Model Innovation (BMI) team is exploring business model options to facilitate the rollout and adoption of electric heavy goods vehicles (eHGVs) and supporting infrastructure beyond the eFREIGHT 2030 trial.
- As summarised to the right and explored further in Section 3, engagement with infrastructure and service providers, fleet operators and vehicle manufacturers highlighted several pain points associated with depot-based eHGV charging.
- In response, this report evaluates a range of business models that could help towards addressing these barriers and support the effective deployment of charging solutions. It addresses the following research questions:
    1. What are the primary benefits, risks and considerations for each depot-based charging model?
    2. How could each model help address the pain points identified by stakeholders during engagement?
- The findings aim to support strategic decision-making and enable fleet operators to identify charging solutions best aligned with their specific operational needs.

Depot-based charging pain points

Depot ownership structures

For leased (or donated) depots, temporary site tenures can discourage investment in charging infrastructure, and landlord approval is also necessary for site modifications.

Site constraints

Limited depot space, local grid constraints, and complex enabling works - especially where access to private land or public roads is required - can all delay or complicate infrastructure deployment.

Infrastructure costs

Significant upfront costs associated with charging infrastructure, renewable energy assets, and potential grid connection upgrades can pose major barriers to deployment.

Executive summary

Overview of depot-based charging business models

Section 4 presents a range of business models to support depot-based eHGV charging, including those that enable the installation of charging infrastructure, reduce costs through energy optimisation or unlock new revenue streams. For each model, the section identifies key benefits, risks, and considerations, and includes a case study demonstrating its practical implementation. It also explores how combining these models can help deliver a comprehensive charging system that maximises overall value. The table below (continued on the next page) summarises each model, its suitability for different fleet operators, and potential compatibility with other models.

Model	Description	Suitability	Compatibility with other models
Owner-Operator	• Allows fleet operators to directly own and manage their depot-based charging infrastructure, providing control over infrastructure and energy procurement and operational scheduling.	• Suitable to fleet operators seeking full asset ownership and control, with the ability to manage upfront investment, operation, and maintenance over the long-term.	• Model aligns with others that permit direct infrastructure ownership and management, while integration with models involving third-party ownership may be limited.
Charging-as-a Service	• Service provider offers a comprehensive eHGV charging solution for fleet operators, covering financing, installation, operation, and maintenance of charging infrastructure, for a regular service payment.	• Suitable for fleet operators with limited access to capital or those preferring an end-to-end solution that reduces operational complexity.	• Model may operate alongside others if asset access, control, and operational responsibilities are clearly defined between different stakeholders.
Energy-as-a-Service	• Service provider offers a comprehensive eHGV charging solution for fleet operators covering financing, installation, operation, and maintenance of charging infrastructure, along with site-wide energy management and optimisation, for a regular service fee.	• Suitable for fleet operators seeking integrated charging and energy services, with the ability to commit to long-term contractual agreements.	• Model is often used as a comprehensive solution, reducing the likelihood of it being combined with other models.
Energy Management and Optimisation	• Third-party provider implements energy management and optimisation solutions at eHGV charging depots, resulting in lower energy costs for fleet operators.	• Suitable for fleet operators looking to optimise energy use and efficiency through smart charging solutions integrated with broader site demands, renewable generation, and storage systems.	• Model can complement a range of others, particularly those that involve direct infrastructure ownership and management.

Executive summary

Overview of depot-based charging business models (continued)

Model	Description	Suitability	Compatibility with other models
Renewable (and Storage) Integration	• Fleet operator installs on-site renewable generation assets, using the energy produced to help meet charging demands.	• Suitable for fleet operators with depot space and investment capacity, seeking to maximise eHGV charging cost savings and enhance energy resilience.	• Model aligns with others that permit direct infrastructure ownership and management but may not to align with third-party solutions that include renewable energy components, due to differing ownership structures.
Power Purchasing Agreement	• Fleet operator enters into a commercial agreement to buy renewable energy from a nearby generator (asset owner) at rates lower than the retail electricity price.	• Suitable for fleet operators looking to reduce emissions and benefit from lower energy costs without owning on-site renewable systems.	• Model may be compatible with others if contractual terms allow for flexibility in how renewable energy is used, particularly when integrated with models that involve energy exports.
Shared Charging Facilities	• Enables a 'lead' fleet operator to maximise charging infrastructure utilisation and generate revenue by allowing other fleet operators to use their depot for eHGV charging when spare capacity is available.	• **Lead fleet operator:** Suitable for fleet operators with spare charging capacity and a willingness to host third-parties on-site. • **Third-party fleets:** Suitable for fleet operators without access to dedicated charging infrastructure either due to site constraints or a preference to avoid significant capital investment.	• Model likely to align best with others that permit direct infrastructure ownership and management but could also align with third-party led solutions if asset access, control, and operational responsibilities are clearly defined between different stakeholders.
Vehicle to Grid	• Enables fleet operators to generate revenue from grid services by using eHGVs as energy assets.	• Suitable for fleet operators willing to invest in bi-directional charging infrastructure and vehicles, with a view to unlocking additional revenue streams.	• Model aligns with others that permit direct infrastructure ownership and management but may not align with third-party solutions that may already offer vehicle to grid services.

Executive summary

Depot-based charging models: Model ability to address pain points and associated risks

Section 5 of this report evaluates the ability of different business models to address key pain points in deploying depot-based eHGV charging solutions, while also highlighting their associated risks. The table below summarises how effectively each model addresses key pain points identified by fleet operators.

Model	Pain Points			
	Landlord Approval	Short-term Leases	Grid Connection Barriers	Space Restrictions
Owner-Operator	2	3	3	3
Charging-as-a Service	2	2	2	2
Energy-as-a-Service	2	3	2	2
Energy Management and Optimisation	2	2	2	2
Renewable (and Storage) Integration	2	3	2	3
Power Purchasing Agreement (Option A)	2	3	2	3
Power Purchasing Agreement (Option B)	2	3	2	2
Shared Charging Facilities (Lead fleet)	2	3	3	3
Shared Charging Facilities (Third-party fleet)	1	1	1	1
Vehicle to Grid	2	2	3	2

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point

Executive summary

Depot-based charging models: Model ability to address pain points and associated risks

The table below outlines the levels of various risk types associated with each model.

Model	Risks				
	Transition Complexity	High CAPEX	High OPEX	Limited Control	Contractual Complexity
Owner-Operator	3	3	1	1	1
Charging-as-a Service	1	1	3	3	3
Energy-as-a-Service	1	1	3	3	3
Energy Management and Optimisation	1	2	2	2	2
Renewable (and Storage) Integration	3	3	1	1	1
Power Purchasing Agreement (Option A)	1	1	2	2	2
Power Purchasing Agreement (Option B)	1	1	2	2	2
Shared Charging Facilities (Lead fleet)	3	2	2	1	3
Shared Charging Facilities (Third-party fleet)	1	1	3	3	2
Vehicle to Grid	1	2	2	2	2

Key:

3	Considerable risk
2	Moderate risk
1	Low risk

Executive summary

Depot-based charging models: Model ability to address pain points and associated risks

Whilst no single model resolves all pain points, each offers distinct benefits, trade-offs, and associated risks. Fleet operators must assess these factors to select the most suitable model - or combination of models - for their operations. Additional insights to emerge from the business model evaluation are summarised below.

Pain points and risks addressed

- Several models explored in this report can minimise upfront infrastructure costs for fleet operators by transferring capital investment responsibilities to third-party providers.
- Grid connection challenges may be partly addressed through energy optimisation, storage and support with the grid application process, though the risk of costly or lengthy upgrade timelines remains.
- Additionally, some models simplify the electrification process by outsourcing key elements such as installation, financing, and maintenance, allowing fleet operators to focus on their core logistics operations.

Persistent challenges

- Short-term depot arrangements make it difficult to justify investment, as most models assume long-term site occupancy.
- Securing landlord approval for installations is a common barrier, though involvement from experienced external parties may help increase confidence in the quality and reliability of proposed solutions.
- Space restrictions are only partially mitigated, and for heavily constrained depots, off-site charging hubs or access to public infrastructure may offer more practical alternatives.

Common trade-offs

- Service-based models often involve complex, long-term contracts that require coordination across multiple stakeholders and may reduce fleet operators' control over charging infrastructure and energy management.
- Additionally, while these models offer reduced financial and operational risks for fleet operators, they typically come at a higher total cost due to service premiums.

Executive summary

The findings of this report have led to the identification of several key observations and corresponding recommendations for future research, which are summarised below.

Observations	Corresponding recommendations for future research
1 Some of the models explored in this report may be compatible and, when combined, could enhance operational efficiency and cost savings for fleet operators. Others may face integration challenges due to differing ownership structures or conflicting asset control requirements.	1 Aim to quantify the benefits of combining different business models to better understand how they can work together to optimise cost savings, improve operational efficiency, and unlock new revenue opportunities for fleet operators.
2 Whilst some models explored in this report offer partial mitigation of space limitations through optimised site design and equipment placement, space restrictions at depots remain a persistent challenge. Few depot-based charging models effectively address this issue.	2 Explore business models for off-site charging hubs or public infrastructure as alternative and practical charging solutions for fleet operators facing limited depot space.
3 Leased or donated depots can pose significant barriers to deploying eHGV charging infrastructure, challenges not fully addressed by the models in this report. Short-term leases can discourage investment in on-site infrastructure, and landlord approval is also necessary for installations or site modifications.	3 Investigate ways to align incentives between landlords and fleet operators for deploying eHGV charging infrastructure. Additionally, research could investigate the potential for developing template contractual terms to streamline the approval process and facilitate negotiations.

2. Introduction

The role of depot-based eHGV charging

- The UK Government has committed to ending the sale of new, non-zero emission HGVs by 2035 for vehicles up to 26 tonnes, and by 2040 for all HGVs[1].
- As outlined in our previous report, eHGV Purchasing Options and Considerations, there are 45 ultra-low emission (ULE) HGV models commercially available in the UK - 43 of which are battery electric models[2].
- Battery electric models currently account for 99.8% of all licensed ULE HGVs in the UK[3].
- The transition to eHGVs depends not only on vehicle adoption but also on the widespread deployment of reliable and accessible charging infrastructure, both at depots and across the public network.
- Depot-based charging is particularly well suited for back-to-base operations with daily ranges of 400 km or less, which are expected to drive the early phase of eHGV deployment[4].
- It is projected that 80–90% of eHGV charging will take place at depots, offering numerous operational and economic advantages, as outlined to the right[5-6].

Advantages of depot charging

Efficient overnight charging during vehicle downtime, with the potential to leverage off-peak energy rates to reduce charging costs.

Smart charging integration enables optimised scheduling that aligns with both operational needs and site power capacity limits.

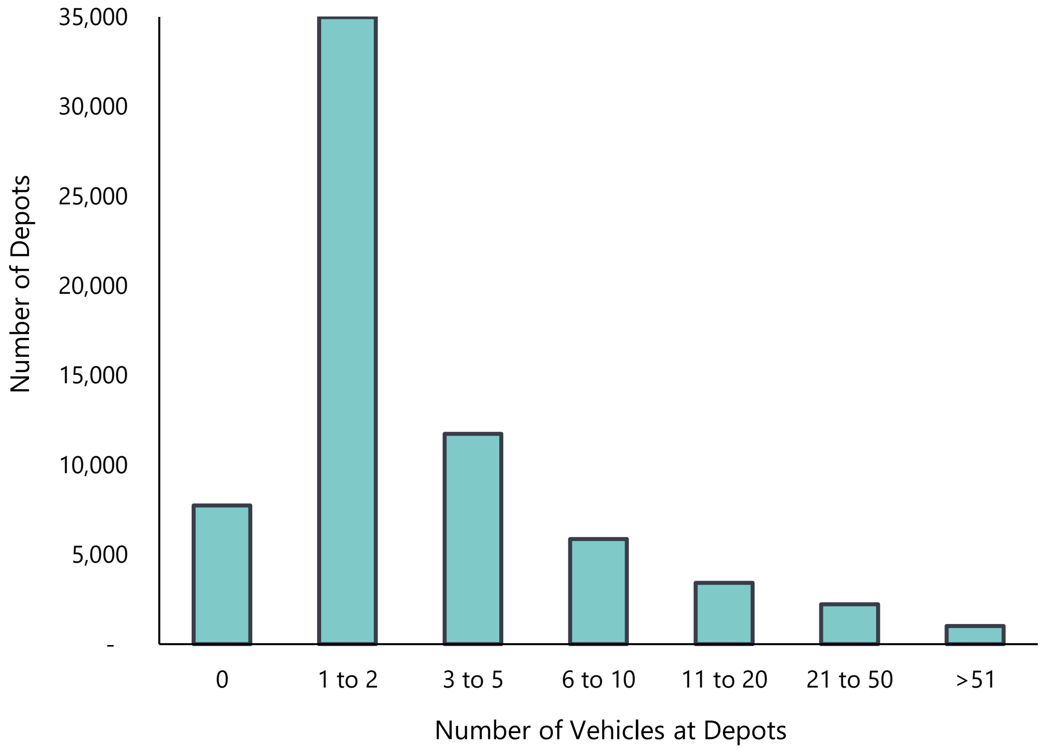
Convenient access to vehicles for routine maintenance and inspection while vehicles are parked.

Enhanced physical security for vehicles and charging infrastructure within a controlled environment.

Understanding the HGV depot landscape

- Across Great Britain, there are approximately 67,000 HGV operating centres (depots), where vehicles are kept when not in use[7].
- As illustrated in the image to the right, most of these depots operate either 1-2 vehicles (52%) or 3-5 vehicles (18%)[7]*.
- Fleet size variation is just one of several factors that can make the design of optimal depot-based eHGV charging solutions highly site-specific.
- Other key considerations include:
  - The tenure status of depots (e.g., freehold, leasehold, or customer-donated)
  - Physical space constraints
  - Site electrical capacity limits
  - Differences in vehicle dwell times and charging requirements.
- Given this diversity, a range of charging solutions and business models will be required to accommodate the distinct needs of each depot and fleet.

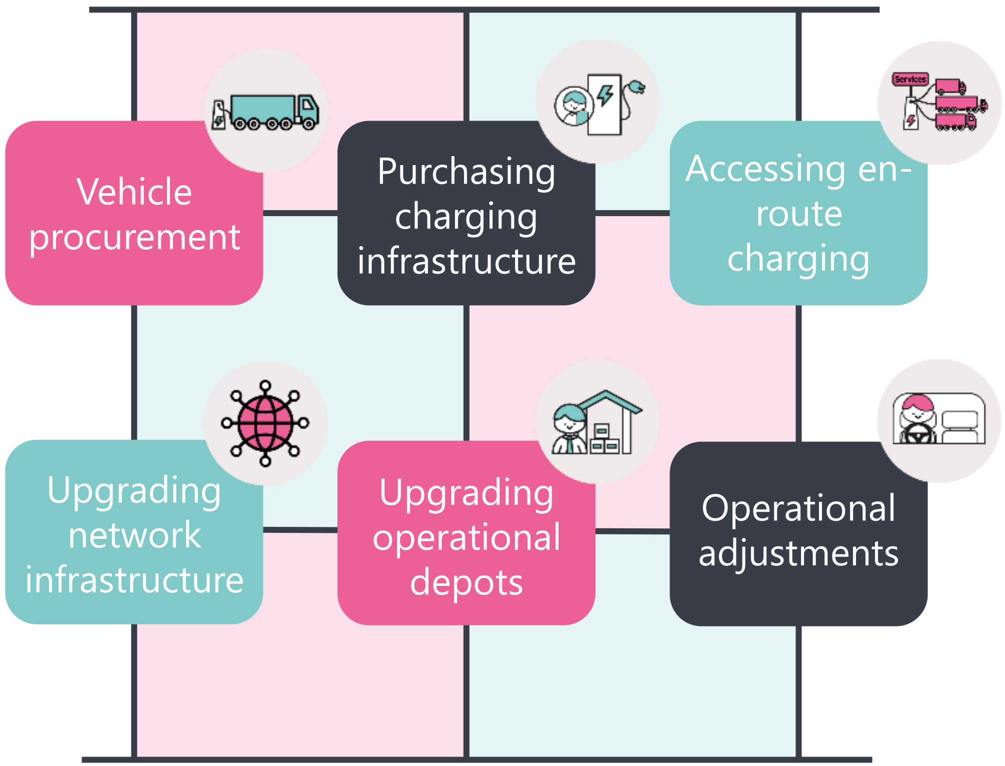
Number of depots vs. number of vehicles at depots



*According to the original data source, 7,733 operational depots did not have any vehicles specified at the time of reporting, represented by '0' segment in the bar chart.

Report purpose and scope

- As part of the eFREIGHT 2030 project, the Catapult's Business Model Innovation team is exploring business models to facilitate the rollout and uptake of eHGVs and supporting infrastructure beyond the trial.
- To inform this work, 13 stakeholder interviews were conducted between June and September 2024, engaging fleet operators, vehicle manufacturers, and charging infrastructure and service providers.
- These discussions explored key aspects of the eHGV transition for fleet operators, including the activities illustrated to the right.
- As explained further in Section 3, a range of challenges related to depot-based charging were identified, including varied depot ownership structures, site constraints, and the significant upfront investment required for infrastructure.
- In response to these findings, this report evaluates a range of business models designed to accelerate the deployment of depot-based eHGV charging. It aims to support fleet operators in identifying the most suitable charging solutions aligned with their specific organisational needs.
- The report addresses two key research questions:
  1. What are the primary benefits, risks, and considerations for each depot-based charging model?
  2. How could each model help address pain points identified by stakeholders during engagement?



3. Depot-based charging pain points

Depot-based charging pain points

Stakeholder engagement unearthed several pain points related to depot-based charging, which can be broadly categorised into three key themes: depot ownership structures, site constraints, and significant infrastructure costs. These challenges are summarised below and revisited in Section 5, which examines how well different business models for depot-based eHGV charging solutions can address them.

Depot ownership structures

1. **Short-term leases –** Fleets on short-term tenancy agreements may struggle to justify investments in charging and renewable energy infrastructure, especially if payback times are long.
2. **Landlord permission –** Landlords may be unwilling to approve permanent infrastructure installations on-site, particularly when lease agreements are short-term and there is uncertainty about liability for the assets once the fleet operator's tenancy ends.
3. **Shared depots –** In shared depot arrangements, challenges can arise around the prioritisation of charging access and the fair allocation of charging costs between fleets.

Site constraints

1. **Depot space limitations –** Sites may have limited space, making it challenging to accommodate charging and renewable energy infrastructure.
2. **Site location –** The lead times for obtaining grid connection upgrades can vary significantly depending on depot location, due to local grid capacity constraints.
3. **Enabling works –** Stakeholders identified difficulties related to infrastructure works, especially when this requires modifications to private land or public roads, leading to complications around permissions, access, and the potential for increased costs.

Significant infrastructure costs

1. **High upfront investment –** Installing charging infrastructure may require significant capital investment, which is further increased if fleets also install on-site renewable energy systems. While these systems can offer operational cost savings, the upfront investment can be prohibitively high.
2. **Grid connection costs and complexity –** Securing a grid connection upgrade can involve high costs, with the application process adding to these expenses due to resource requirements and complexity.

4. Business model options for depot-based charging

Depot-based charging: Key considerations

Alongside installing reliable charging infrastructure, fleet operators may also consider strategies to minimise energy costs and unlock additional revenue streams when developing an optimal depot-based charging solution. By addressing these factors, fleet operators can maximise both operational efficiency and cost-effectiveness.

	Installing charging infrastructure	Reducing energy costs through optimisation	Unlocking new revenue streams
Importance	Having access to well-designed, reliable charging infrastructure helps to minimise operational disruptions, downtime, and under-utilisation.	Optimising energy usage on-site helps to reduce operational expenses associated with vehicle charging.	By leveraging on-site infrastructure in innovative ways, fleet operators can improve their return on investment on assets and offset charging expenses.
What does it entail?	• Site assessments and feasibility works • Electrical infrastructure upgrades • Charger selection and installation • Software integration	• On-site load balancing • Smart charging strategies • Integrating renewable energy and storage assets	• Offering charging to third parties • Participating in grid services • Exporting/ selling surplus renewable energy

Depot-based charging: Business model overview

This section outlines business models to support fleet operators in developing depot-based eHGV charging solutions. A summary of the models is provided in the table below, with further detail and accompanying case studies presented in subsequent pages*. As indicated in the table below, each model aligns with one of the three factors introduced on the previous page. Models aimed at reducing energy costs or unlocking new revenue streams still rely on the installation of charging infrastructure and would therefore need to be combined with models focused on installing charging infrastructure to form a comprehensive solution. The potential for integrating different business model options is explored later in this section.

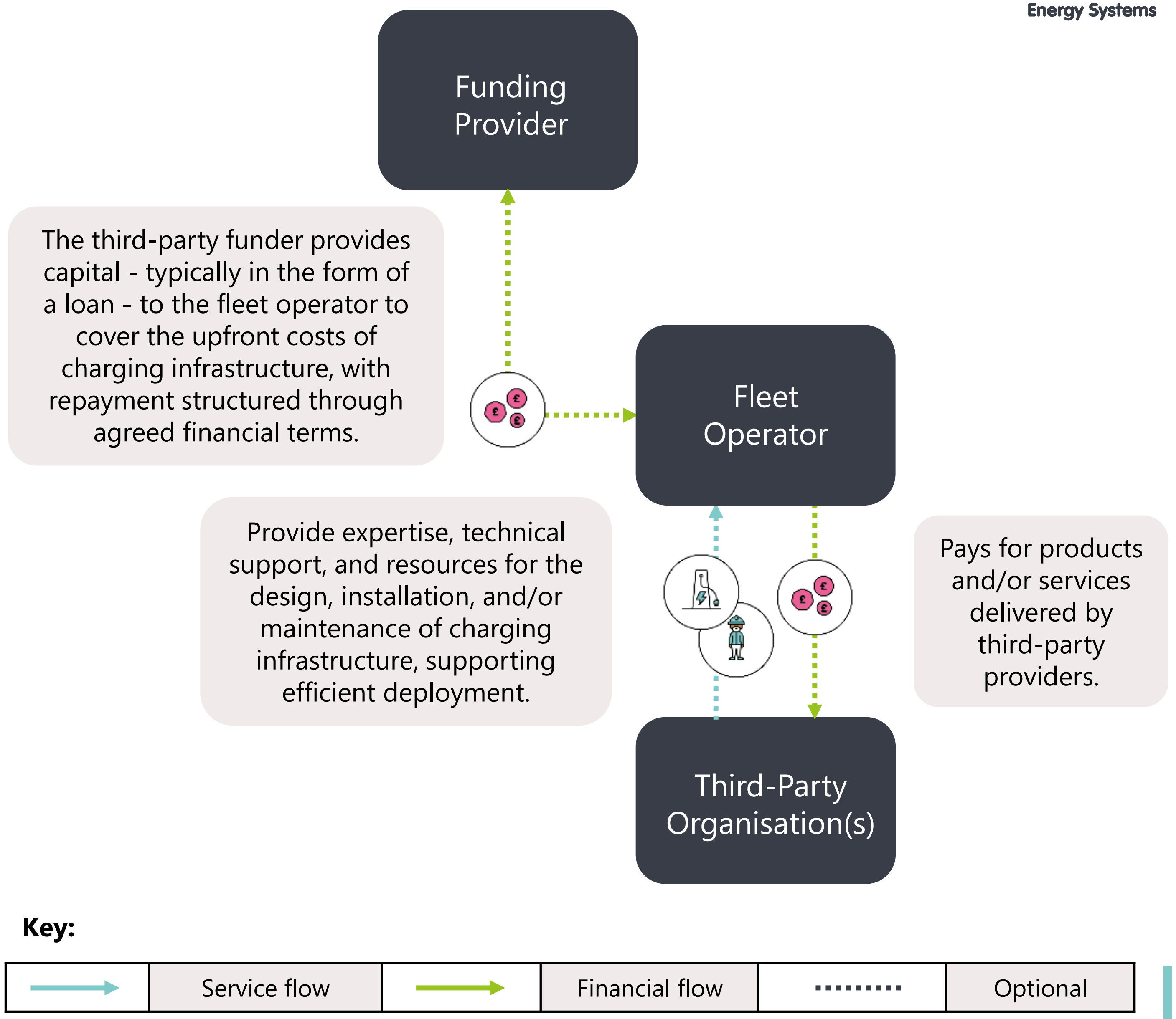
Model	Description	
Owner-Operator	**Enables installation of charging infrastructure**	• Allows fleet operators to directly own and manage their depot-based charging infrastructure, providing control over infrastructure and energy procurement and operational scheduling.
Charging-as-a Service		• Service provider offers a comprehensive eHGV charging solution for fleet operators, covering financing, installation, operation, and maintenance of charging infrastructure, for a regular service fee.
Energy-as-a-Service		• Service provider offers a comprehensive eHGV charging solution for fleet operators covering financing, installation, operation, and maintenance of charging infrastructure, along with site-wide energy management and optimisation, for a regular service fee.
Energy Management and Optimisation	**Reduces energy costs through optimisation**	• Third-party provider implements energy management and optimisation solutions at eHGV charging depots, resulting in lower energy costs for fleet operators.
Renewable (and Storage) Integration		• Fleet operator installs on-site renewable generation assets, using the energy produced to help meet charging demands. The consumption of renewable energy can be maximised by installing energy storage assets on-site.
Power Purchasing Agreement		• Fleet operator enters into a commercial agreement to buy renewable energy from a nearby generator (asset owner).
Shared Charging Facilities	**Unlocks new revenue streams**	• Enables a 'lead' fleet operator to maximise charging infrastructure utilisation and generate revenue by allowing other fleet operators to use their depot for eHGV charging when spare capacity is available.
Vehicle to Grid		• Enables fleet operators to generate revenue from grid services by using eHGVs as energy assets.

**Where eHGV-specific case studies are not available, case studies from the electric bus sector are included to illustrate applications of similar size, scale and vehicle charging requirements. Furthermore, detailed cost data for many case studies are unavailable Fleet operators will require access to this information to enable informed decision-making on the most suitable model.*

Option 1: Owner-operator

Description

- In this model, fleet operators assume responsibility for the design, procurement, installation, and ongoing operations and maintenance (O&M) of eHGV charging infrastructure.
    - Some of these activities may be outsourced to third-party organisations with the required technical expertise.
- Operators can choose various procurement strategies, such as engaging an end-to-end solution provider for a comprehensive service or subcontracting specific elements (e.g., design and maintenance) to different providers.
- The fleet operator is required to fund the upfront cost of the infrastructure, which may be sourced from capital reserves or third-party funding options.
- While this model places both financial and operational risk on the fleet operator, it provides the benefit of full ownership and control of the assets.



Option 1: Owner-operator

Benefits

Financial

- **Long-term cost effectiveness –** While the upfront capital expenditure can be significant, this model has the potential to deliver cost savings over time. For example, by avoiding ongoing leasing or service fees typically associated with third-party-led charging solutions, fleet operators may achieve lower total ownership costs, particularly when infrastructure is efficiently utilised over its full operational life.

Other

- **Operational control –** Full asset ownership allows fleet operators to manage and use the infrastructure according to their operational priorities, without dependency on external providers.
- **Enhanced flexibility –** Ownership of the assets also gives the fleet operator greater flexibility in decision-making, such as choosing when and how to scale infrastructure, upgrade technology, or switch to renewable energy sources.

Risks and considerations

Financial

- **High upfront costs –** The fleet operator is responsible for funding the initial purchase and installation of the charging infrastructure, including any necessary electrical infrastructure upgrades. This can represent a substantial capital outlay and may place pressure on financial resources.
- **Financial and operational risk –** The fleet operator bears full financial and operational risk. This includes exposure to unexpected costs associated with repairs, system upgrades, and potential equipment failures.

Other

- **Complexity of implementation –** Managing the full deployment of charging infrastructure - including design, procurement, installation, and maintenance - can be complex and resource intensive for fleet operators. Although some aspects can be outsourced to experienced third-party providers, doing so requires careful partner selection and coordinated management to ensure effective implementation.

Owner-operator case study: First Bus[8-10]

Overview

- First Bus, a major UK bus operator with over 1,000 zero emission buses currently in operation, has committed to transitioning to a fully zero-emission fleet by 2035.
- A key part of this transition is the electrification of its Caledonia depot in Glasgow, now equipped with 160 rapid charging points.
- The charging stations are managed through smart charging software that optimises energy use and helps minimise the power draw-down from the National Grid at peak times.
- To ensure that the depot is fully prepared to support Net Zero operations, First Bus is also exploring potential opportunities for on-site renewable energy, storage and renewable energy supply.
- The depot will serve as a blueprint for further electrification initiatives as part of First Bus' decarbonisation journey.

Scale of deployment

- In collaboration with Ofgem and Scottish Power Energy Networks, First Bus plans to construct a new substation at the depot.
- Once operational, this will provide enough capacity to support up to 350 charging points and accommodate an additional 200 electric vehicles.
- To support further fleet electrification, First Bus has secured funding through the Zero Emission Bus Regional Area (ZEBRA) scheme and the Scottish Zero Emission Bus (ScotZEB) programme, enabling the deployment of 193 vehicles in England and 74 in Scotland.

Financials

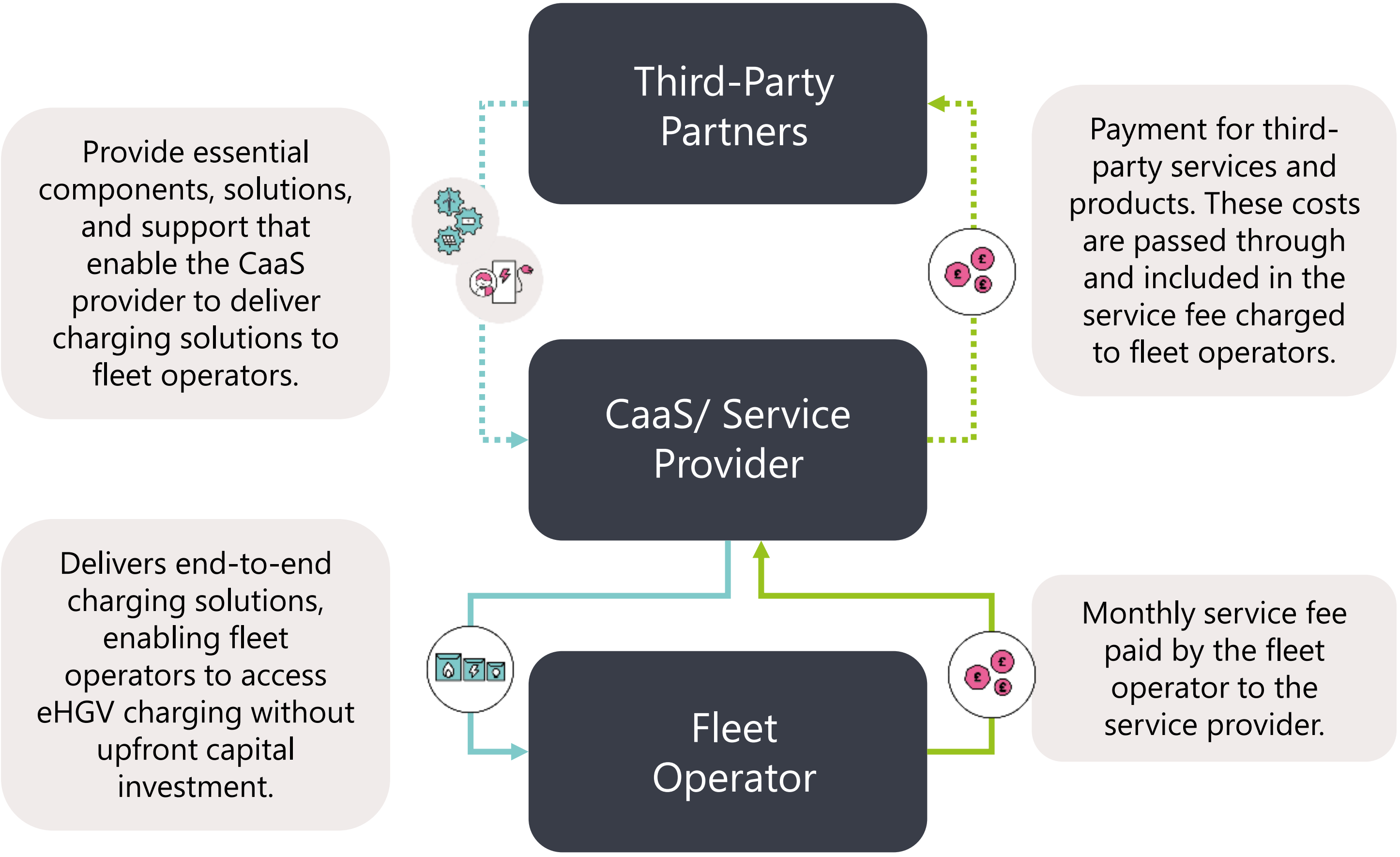
- The Caledonia depot project has been supported through a combination of public and private investment.
- The Scottish Government provided £26.3m to help fund infrastructure development.
- First Bus has also committed £35.6m to accelerate the depot's transition to electric operations.

first bus

Option 2: Charging-as-a-Service (CaaS)

Description

- The CaaS model enables fleet operators to access depot-based eHGV charging infrastructure without the need for upfront capital investment or direct management of the infrastructure.
- A third-party provider assumes responsibility for the financing, design, installation, operation, and maintenance of the charging assets.
- Operators enter into a long-term agreement and pay a regular service fee, which could cover services such as project delivery, grid connection co-ordination, smart charging integration, 24/7 support, and performance monitoring.
- By transferring infrastructure ownership and technical responsibility to the service provider, fleet operators can focus on their core operations while still progressing decarbonisation goals.



Key:

→	Service flow	→	Financial flow	·········	Optional

Option 2: CaaS

Benefits

Financial

- **Minimal upfront investment –** In this model, the fleet operator avoids the upfront costs associated with purchasing and installing charging infrastructure.
- **Cost predictability –** Fleet operators benefit from a single, regular payment that encompasses the costs of infrastructure, ongoing operations, and maintenance, simplifying financial management.

Other

- **Reduced operational complexity –** The service provider takes on the responsibility for planning, designing, and managing the charging infrastructure, allowing fleet operators to focus on their core business operations.
- **Enhanced reliability and uptime –** Service agreements often include performance guarantees that help ensure high system uptime, minimising operational disruptions for fleet operators.
- **Accelerated deployment –** Drawing on their expertise, service providers can often expedite the installation and connection of charging infrastructure, reducing the total time required to implement the eHGV charging solution for fleet operators.

Risks and considerations

Financial

- **Higher overall costs –** While the CaaS model eliminates upfront capital costs, fleet operators may incur higher overall costs compared to outright ownership due to the convenience and expertise offered by the CaaS provider.
- **Long term financial commitment –** To secure lower regular payments, fleet operators are often required to enter into long-term service agreements (typically ranging from 3 to 8 years). Early termination of these contracts may result in financial penalties or buyout fees for fleet operators.

Other

- **Limited asset control –** Fleet operators do not (initially) own charging infrastructure under the CaaS model, which can reduce operational flexibility and limit the ability to modify assets or switch service providers.
- **Data privacy concerns –** Fleet operators may have concerns about the access the service provider has to charging data, including usage patterns, energy consumption, and operational performance, which could raise issues around data privacy and security.
- **Contractual complexity –** CaaS contracts often contain detailed clauses covering pricing, asset control, performance guarantees, and termination terms, which require careful review and negotiation to ensure favourable terms for the fleet operator.

CaaS case study: L-Charge[11-12]

Overview

- L-Charge offers innovative CaaS models to support the electrification of fleet operations.
- The company's ultra-high-power delivery and rapid charging capabilities are particularly suited for eHGVs with larger battery packs.
- As such, L-Charge is currently prioritising the large fleet and HGV market segments, recognising that electric truck adoption is gaining pace.
- L-Charge manufactures, installs, owns, operates and maintains its charging infrastructure, providing a comprehensive end-to-end solution for fleet operators.
- Under the CaaS agreement, customers receive the charging infrastructure with no upfront capital investment. Instead, the cost is repaid through a fixed, monthly subscription.
- At the time of writing, the company primarily focuses on off-grid charging solutions.

Scale of deployment

- L-Charge plans to install ultra-rapid charging infrastructure with power capacities ranging from 250 to 400 kW, tailored to the high energy demands of eHGVs.
- Their goal is to charge trucks from 10-20% to 80% within 45 minutes to 1 hour.

Financials

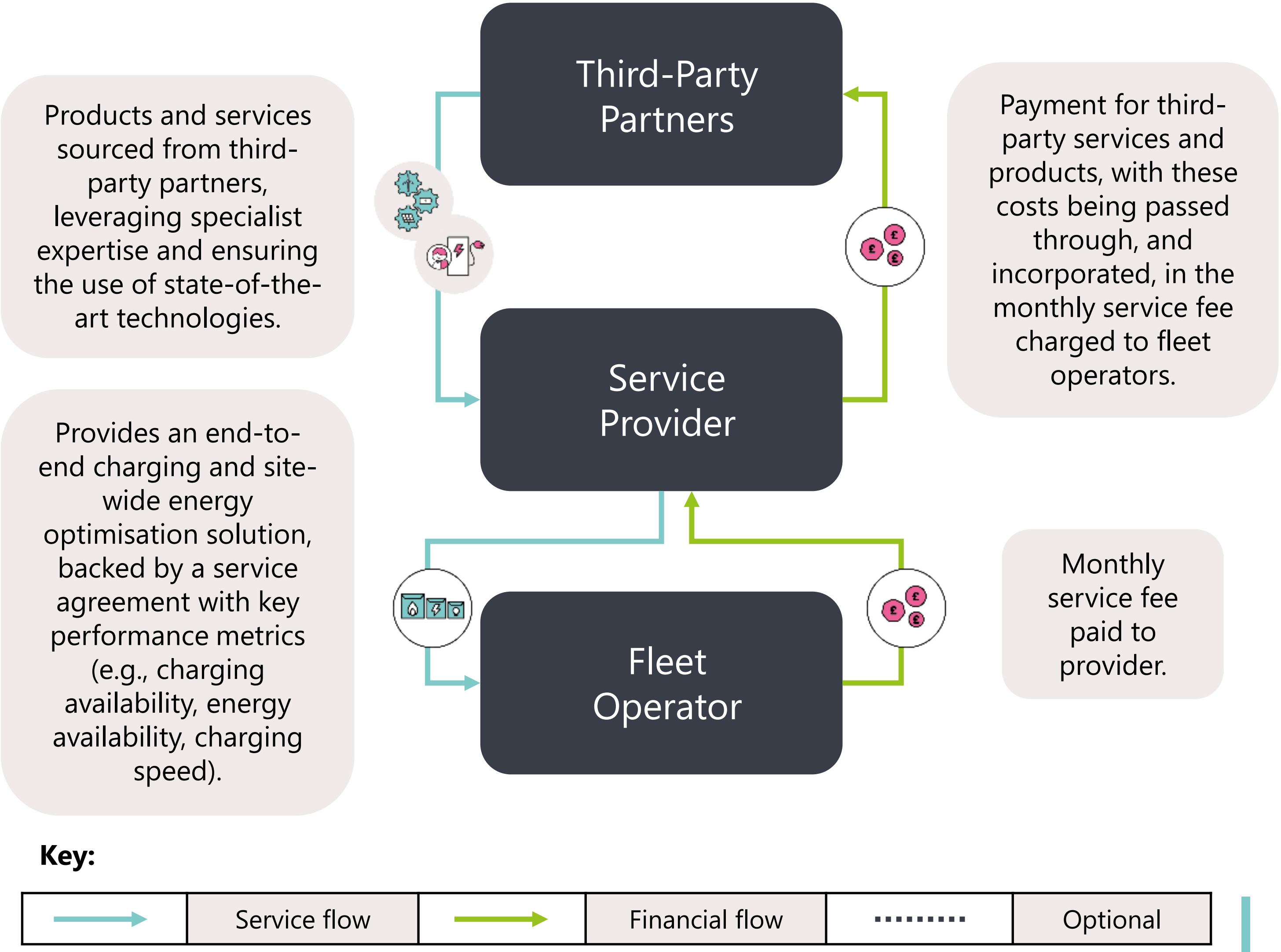
- While the original source does not specify typical monthly subscription fees, it explains that CaaS agreements can range from 3-8 years, depending on the fleet size.
- The monthly subscription fee covers both infrastructure costs and the ongoing service provision.

L-CHARGE

Option 3: Energy-as-a-Service (EaaS)

Description

- The EaaS model is similar to the CaaS model, but in addition to the service provider taking responsibility for financing, installing, operating and maintaining charging infrastructure, they also oversee energy management and/or optimisation as part of their overall offering to fleet operators.
- Energy related services may include installing renewable generation and/or energy storage assets on-site to enhance energy resilience, managing on-site load, optimising charging schedules, and participating in flexibility events.
- To enact this business model, the fleet operator and service provider would enter into a long-term service agreement, typically lasting between 20-25 years[20-21].
- The service fee could be structured in several ways, including a fixed monthly rate based on forecasted energy consumption, a usage-based model charged per kWh of electricity consumed, or performance-based pricing.



Option 3: EaaS

Benefits

Financial

- **Minimal upfront investment –** The EaaS provider finances the charging and renewable energy infrastructure, minimising capital expenditure for fleet operators.
- **Energy cost savings* –** Integrating renewable energy technologies, alongside smart energy management and optimisation, can help fleet operators reduce energy costs.
- **Revenue opportunities –** Fleet operators can earn additional income if the service provider offers to manage participation in flexibility markets on behalf of the fleet.

Other

- **Electrification made simple –** Enables fleet operators to focus on their core operations while the service provider manages the complexities of infrastructure, charging and energy management.
- **Enhanced reliability and uptime –** Performance guarantees within service agreements can help ensure high system uptime, avoiding operational disruptions for fleet operators.
- **Increased emission reductions –** The integration of renewable energy technologies increases emission reduction beyond eHGV adoption.

Risks and considerations

Financial

- **Long-term financial commitment –** EaaS contracts typically span between 20-25 years, requiring a long-term commitment from fleet operators. Early termination may result in financial penalties or buyout fees for fleet operators.
- **Pricing structure –** Fleet operators need to evaluate which pricing model best aligns with their operational and financial priorities. Consumption-based pricing may become expensive with increased demand, while fixed monthly fees offer cost certainty but could lead to overpayment if actual usage is lower.
- **Cost escalation risks –** Contracts may include annual price increases, often linked to inflation. It's important for operators to review escalation clauses and factor them into total cost projections over the contract duration.

Other

- **Limited asset control –** With the EaaS model, fleet operators do not own renewable energy or charging infrastructure. This can limit operational flexibility, including the ability to modify assets or switch providers.
- **Depot tenure alignment –** Fleet operators with short-term depot arrangements – such as leased or donated sites – should carefully assess whether a long-term EaaS contract is appropriate, as early relocation or loss of site access could create contractual and financial complications.
- **Contractual complexity –** EaaS contracts include numerous clauses, covering pricing, asset control, performance guarantees, and termination terms, that require careful review and negotiation.

**Fleet operators should carefully evaluate forecasted savings alongside the fee charged by the service provider.*

EaaS case study: Anaheim Transportation Network[21-23]

Overview

- The Anaheim Transportation Network (ATN) has developed "The Charge", a depot that integrates EV charging infrastructure, solar PV and energy storage technology to supports its goal of transitioning to a fully electric bus fleet.
- ATN commissioned bp pulse to deliver the comprehensive EV charging solution, with their responsibilities covering site design, installation, procurement of equipment, and fleet management.
- Bp pulse also secured battery storage for the depot and designed a microgrid to enhance on-site renewable energy use and charging resilience.
- REC Solar designed and installed the solar canopy and will continue to own, operate, and maintain the asset.
- Under a 20-year fixed-rate agreement with ATN, bp pulse will manage and maintain the charging infrastructure.
    - The fixed monthly fee covers the capital, operational and energy costs of the project.

Scale of deployment

- The depot provides charging for ATN's fleet of 80 battery-electric buses.
- The solar canopy has a generation capacity of 514 kW, which supplies 25% of ATN's total expected energy consumption.
- ATN's clean transportation services replace 2.5 million car trips annually, reducing local air pollution and greenhouse gas emissions by 4.3 tonnes.

Financials

- The project was partially funded by a $5m grant from the California Energy Commission.
- Over the 20-year agreement, ATN is projected to save over $4.8 million in fuel costs compared to liquid natural gas (LNG) or compressed natural gas (CNG).

EaaS case study: Montgomery County and AlphaStruxure Public-Private Partnership[24-25]

Overview

- Montgomery County operates the second-largest transit fleet in the Washington D.C. metro area, making it one of the County's largest sources of greenhouse gas emissions.
- As part of its fleet transition plan, the County committed to replacing all ~400 fossil-fuel-powered buses with battery-electric and hydrogen fuel cell-electric alternatives by 2035, while also expanding the fleet to 600 vehicles.
- Alongside reducing carbon emissions, ensuring energy resilience is a key priority, as the transit network is considered critical infrastructure, making extended power outages unacceptable.
- To meet these goals, the County leveraged its energy purchasing regulations to establish a public-private partnership with AlphaStruxure.
- Under this agreement, AlphaStruxure will design, build, finance, own and operate a renewable energy-powered microgrid at the Equipment Maintenance & Transit Operation Center (EMTOC), which is expected to be operational by late 2025.

Scale of deployment

- Initially, the microgrid will comprise 5.5 MW of solar capacity, 2 MW/6.8 MWh of battery energy storage, up to 2.25 MW of charging capacity, and a 1 MW hydrogen electrolyser.
- Over time, the depot will power 200 zero-emission buses, with the microgrid designed to accommodate additional solar, battery and hydrogen infrastructure in future.

Financials*

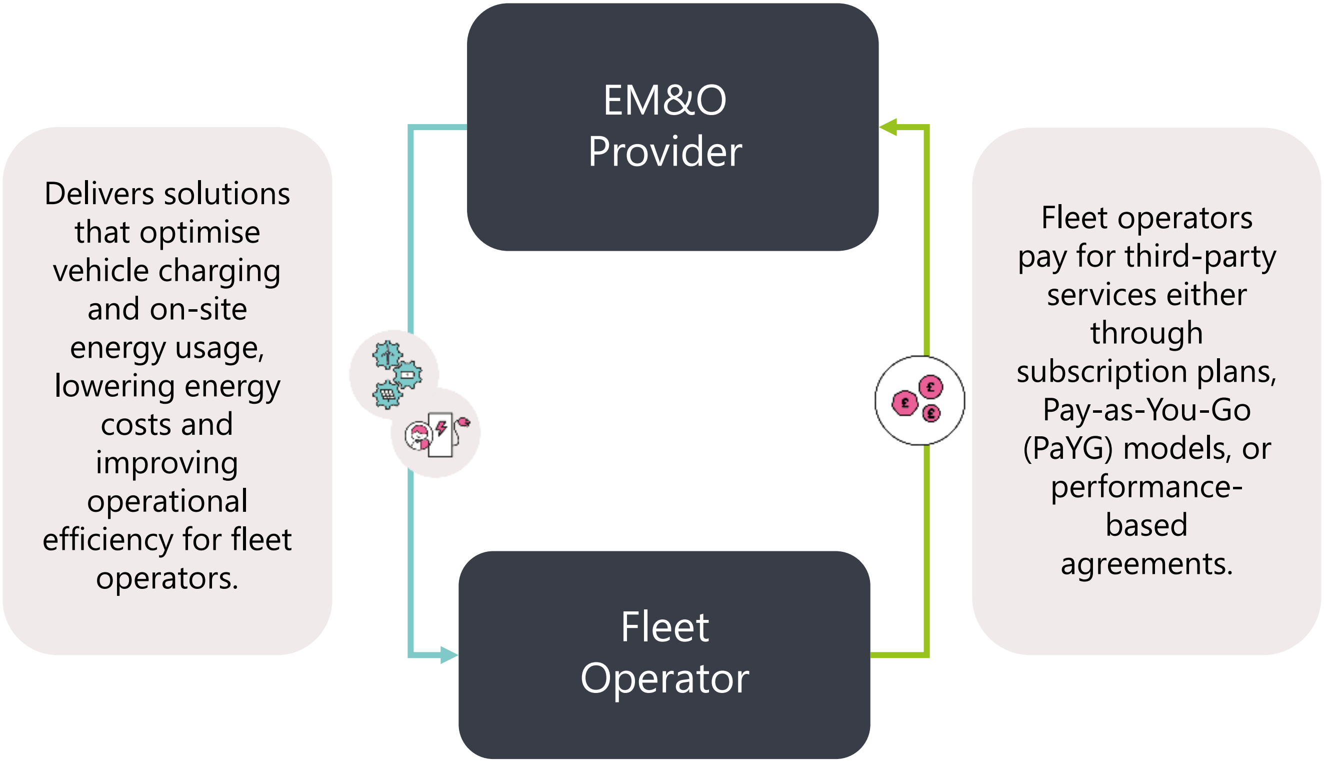
- The solution will be delivered through an EaaS agreement, eliminating upfront capital costs for the County while ensuring predictable operating expenses and guaranteed performance in terms of sustainability, resilience and reliability.

The original sources do not disclose financial specifics such as project capital costs, energy savings, or monthly service fees.

Option 4: Energy management and optimisation (EM&O)*

Description

- This model enables fleet operators to reduce energy costs and improve operational efficiencies by integrating third-party energy management and optimisation solutions, including:
  - **Smart charging** – Optimises eHGV charging schedules to lower peak demand and reduce energy costs.
  - **Energy Management Systems (EMSs)** – Manages site-wide energy use, co-ordinating vehicle charging, renewable assets, and energy storage assets within grid capacity limits.
  - **Fleet analytics** – Generates insights into charging patterns and energy usage, enhancing operational efficiency and supporting predictive maintenance.
- These products and services can be implemented as part of an end-to-end charging solution for depots without existing charging infrastructure or integrated into sites with existing systems at a later stage, if they are compatible with third-party hardware and software.



Key:

→	Service flow	→	Financial flow	·········	Optional

This model would need to be combined with others focused on installing charging infrastructure to form a comprehensive eHGV charging solution (see Page 49).

Option 4: EM&O

Benefits

Financial

- **Cost certainty –** Subscription-based or PaYG pricing models provide predictable operational expenses, improving financial planning and budgeting activities.
- **Energy cost savings* –** EMSs coupled with smart charging schedules can help reduce peak demand charges and enable fleet operators to benefit from lower, off-peak electricity rates.
- **Revenue opportunities –** Some optimisation providers may include flexibility market participation as part of their overall offering, giving fleet operators access to additional revenue streams.

Other

- **Improved efficiency –** Smart charging schedules ensure that high-priority vehicles are available when needed, supporting operational priorities.
- **Predictive fleet maintenance –** Real-time data analytics from charging hardware can detect potential vehicle battery health issues, such as unusual vehicle charge times, helping reduce unexpected downtime and extend vehicle lifespans.
- **Simplified energy management –** Shifts the complexity of energy management to the third-party provider, allowing fleet operators to focus on core operations.

Risks and considerations

Financial

- **Upfront costs –** Depending on pricing model offered by the EM&O provider, fleet operators may incur capital expenses for energy management hardware.
- **Avoiding unexpected costs –** Implementing this model as part of a comprehensive eHGV charging solution ensures compatibility with charging infrastructure from the outset, minimising the risk of costly retrofits.

Other

- **Limited control and flexibility –** Charging schedules are managed by the optimisation provider to maximise energy performance and cost savings, which may conflict with fleet operators' preferred charging times. This could present challenges if fleet usage patterns change frequently or unexpectedly.
- **Integration with operations –** EMSs will need to be integrated with existing logistics and scheduling systems, requiring time and resource for staff training.
- **Contractual considerations –** Fleet operators should carefully review the suitability of any service level agreements (SLAs) in contracts, as poor performance can lead to increased fleet downtime.

**Fleet operators should carefully evaluate forecasted savings alongside the fee charged by the EM&O provider.*

EM&O case study: Go-Ahead Croydon depot[13-15]

Overview

- EO Charging, a fleet electrification solution provider, has developed the 'EO Hub', an EMS that automates load management for all charging stations within a single depot. This enables fleet operators to manage their energy usage and spend.
- The EO Hub can be integrated with an on-site meter or existing building management system to calculate available power and automatically allocate energy to priority vehicles.
- The first installation of the EO Hub took place at Go-Ahead's Croydon depot, with the aim to support their goal of transitioning to a zero-emission bus fleet by 2035.
- EO Charging was appointed to provide a full end-to-end charging solution to address on-site power capacity limitations.
- By implementing the EO Hub, Go-Ahead Croydon was able to nearly double its electric bus fleet, operating 42 buses despite having a limited power supply.

Scale of deployment

- EO Charging's solution included the installation of charging infrastructure (12x 180 kW chargers and 8x satellite chargers), two 600 kW power cabinets, a chargepoint management system and the EO Hub.
- EO charging also provided on-site training and 24/7/365 operations and maintenance support.
- Through load management, despite only having a site power supply of 1.5 MW, the EO Hub consistently manages the delivery of >8MW of power each night.

Financials

- While specific financial figures are not disclosed in the case study, it is noted that costs were reduced because of the implementation of the EO Hub solution.

EM&O case study: Stagecoach and VEV partnership[16-19]

Overview

- Stagecoach, one of the largest bus operators in the UK, is targeting a fully zero-emission UK bus fleet by 2035, with the broader ambition of reaching carbon neutrality by 2050.
- In partnership with Stagecoach, VEV – a company specialising in large-scale fleet electrification – has been appointed to supply charging infrastructure to four of Stagecoach's UK depots as well as installing solar panels at three depots.
- VEV will also supply a digital management platform to optimise power use, charging infrastructure and charging scheduling.

Scale of deployment

- Across the four depots, high-powered DC charging infrastructure will power 150 electric buses.
- The first site to go live is Stagecoach's Chesterfield depot, which will host 57 electric buses – replacing over two-thirds of the local diesel fleet serving Chesterfield and North East Derbyshire.
- The depot has been equipped with 27 dual 120 kW DC chargers, providing 54 charging sockets, and a 2.5 MVA power upgrade.
- A 234 kWp rooftop solar installation is also underway, expected to reduce carbon emissions by 48 tonnes annually.

Financials

- The Chesterfield depot project was partially funded through the ZEBRA 2 scheme, with additional support from Derbyshire County Council and Stagecoach.
- The solar installation at the site is expected to generate 2,000 MWh of renewable electricity annually – at half the cost of grid imported electricity.

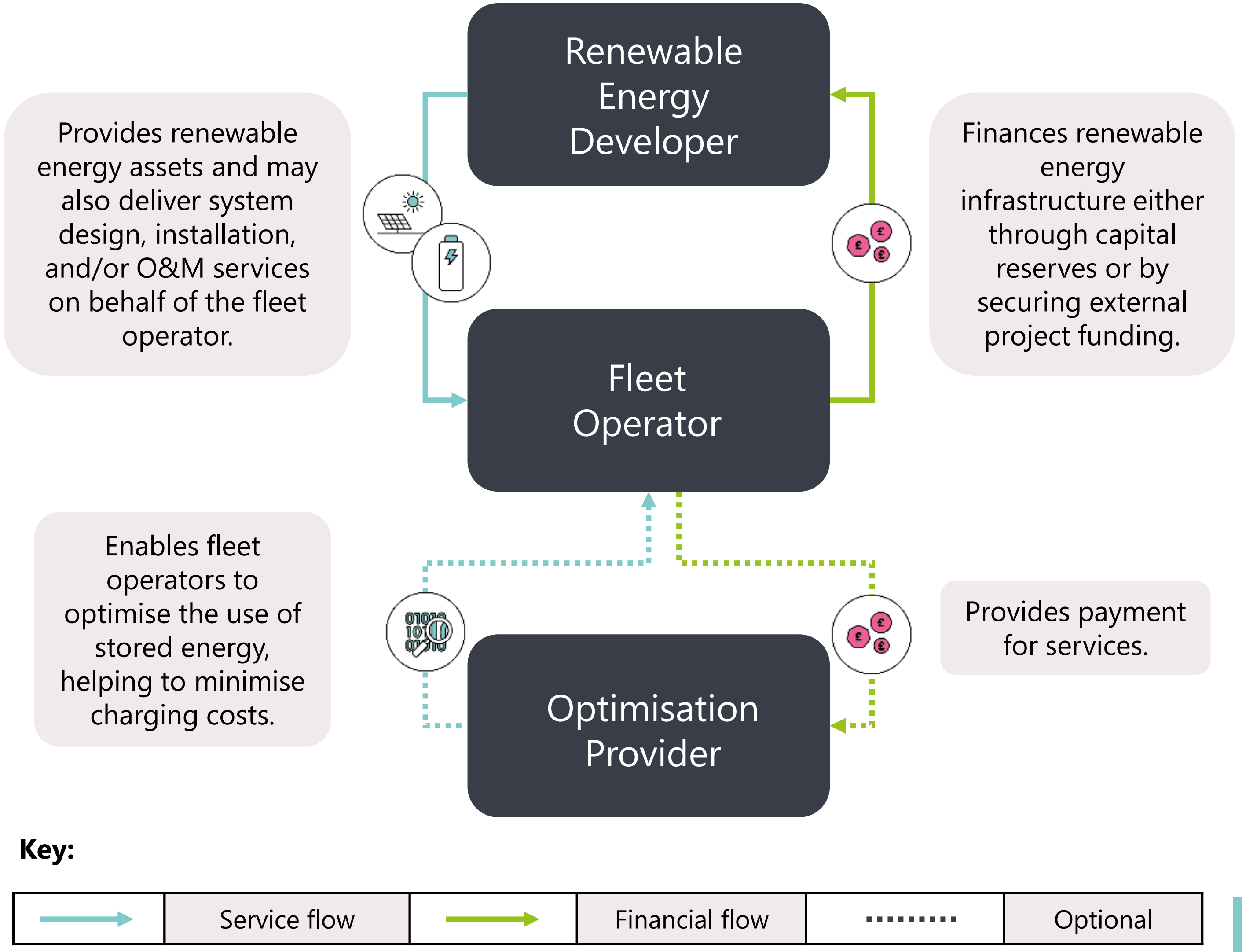
Stagecoach

VEV

Option 5: Renewable (and storage) integration*

Description

- This model involves the installation of on-site renewable generation and, optionally, energy storage systems to support eHGV charging using self-generated, renewable electricity.
- The fleet operator is assumed to own the renewable assets, thereby assuming responsibility for the upfront capital investment, as well as the design, installation, and ongoing operations of the system.
- Using on-site renewable energy reduces reliance on grid-imported electricity, thereby lowering overall eHGV charging costs.
- Incorporating energy storage can enhance these savings by storing excess renewable generation for use during periods of low or no renewable output.
- To maximise the performance of on-site renewable energy systems, fleet operators may choose to partner with a storage optimisation provider to manage the operation of storage assets effectively.



*This model would need to be combined with others focused on installing charging infrastructure to form a comprehensive eHGV charging solution (see Page 49).

Option 5: Renewable (and storage) integration

Benefits

Financial

- **Energy cost savings** – By consuming self-generated renewable electricity on-site, fleet operators can reduce their reliance on grid-imported electricity, thereby lowering overall electricity and eHGV charging costs.
- **Maximising cost savings*** – The integration of energy storage could enable fleet operators to store surplus renewable energy for later use, particularly during periods of low or no generation, further enhancing cost savings.

Other

- **Energy resilience –** This model provides fleet operators with access to a renewable energy source that reduces reliance on grid imported electricity, enhancing energy resilience.
- **Increased emission reductions –** Consuming renewable electricity enables fleet operators to further increase emission reductions beyond the savings achieved by transitioning to eHGVs.

Risks and considerations

Financial

- **High upfront costs** – In this model, the fleet operator owns the renewable (and optional storage) assets and is responsible for the initial capital outlay. These infrastructure investments can be significant, potentially limiting adoption for operators with constrained budgets or low appetite for long-term infrastructure investments.
- **Ongoing O&M costs** – Asset ownership also includes responsibility for ongoing O&M, which may result in unplanned costs as well as the need for component replacement over time. These factors can impact the payback of the initial investment.
- **Variability in renewable generation** –The intermittent nature of renewable energy sources could result in actual renewable generation deviating from that forecasted. This could result in greater reliance on grid-imported electricity than anticipated, potentially reducing projected cost savings.

Other

- **Optimal asset sizing** – Accurate sizing of renewable and storage systems is essential to maximise cost efficiency and system utilisation. Achieving optimal sizing requires a detailed understanding of depot energy consumption profiles, including charging and operational schedules and seasonal demand fluctuations.
- **Space constraints** – Space limitations at depots may restrict the installation of renewable assets, particularly when competing for space with eHGV charging infrastructure. This can constrain the scale of deployment, limiting the financial and operational benefits of on-site generation.

** Fleet operators should carefully weigh the capital costs of storage against the potential additional energy cost savings it provides.*

Renewable (and storage) integration case study: Tootbus' Wandsworth depot[26-28]

Overview

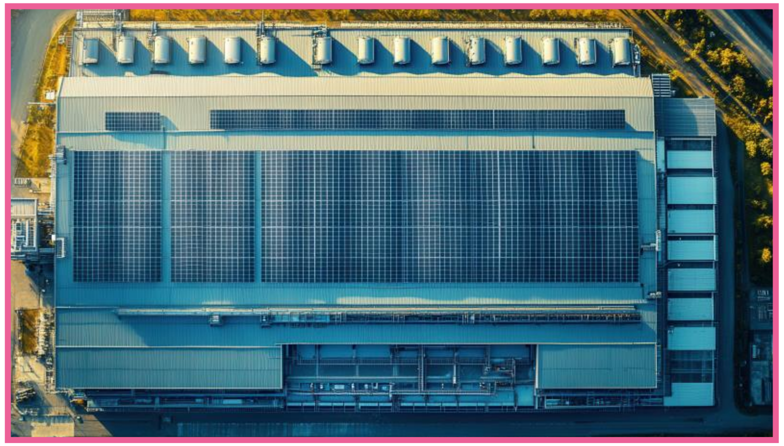
- Tootbus, a hop-on-hop-off sightseeing bus operator, aims to transition to London's first fully electric sightseeing bus fleet by 2029.
- In partnership with end-to-end electrification provider VEV, the company has secured approval to install roof-mounted solar panels at its Wandsworth depot.
- VEV led the planning permission process and is also supplying Tootbus with 100% renewable electricity (via a partner), 10 EV chargers, and ongoing infrastructure support.
- Its software management system will optimise energy use across the depot, balancing charging operations and solar generation within the site's existing power constraints.

Scale of deployment

- The 90kWp rooftop solar system will generate approximately 65,000 kWh annually – enough to support up to 60,000 km of bus travel.
- The project is expected to exhibit carbon emission savings of 15,567 kg per year*.

Financials

- Analysis of the current power consumption at the depot forecasted that the solar system would exhibit a four-year payback period.
- While battery storage was considered, VEV's analysis determined that solar alone was more cost-effective.

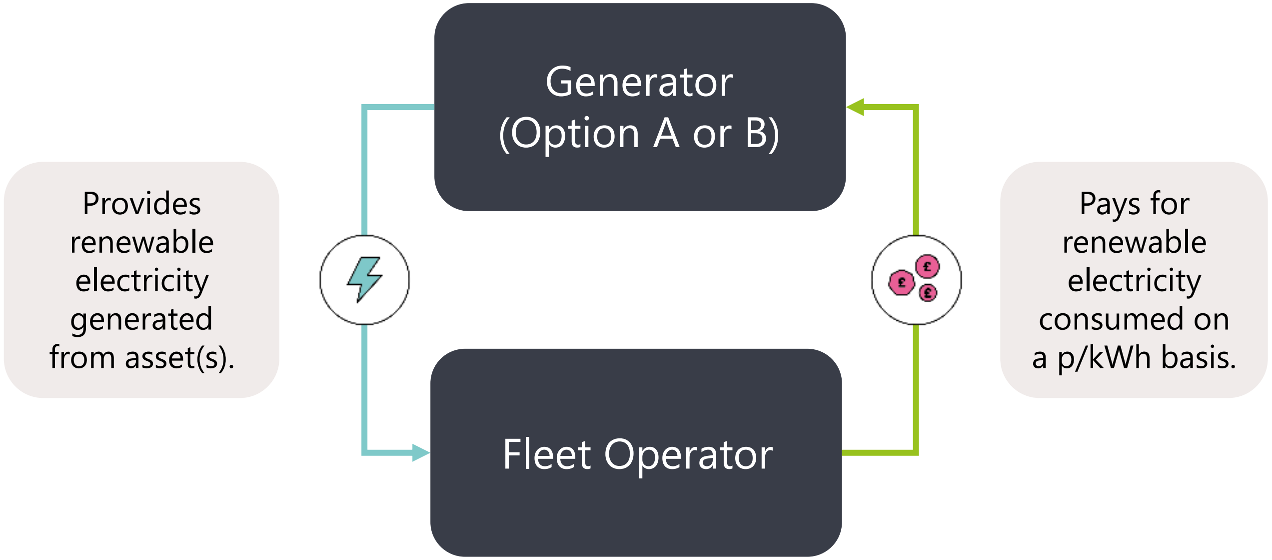


It is not clear whether the reported carbon savings are attributable solely to the rooftop solar system or if they also include emissions reductions from the renewable electricity supply agreement.

Option 6: Power Purchasing Agreement (PPA)*

Description

- A PPA is a commercial agreement between a generator and an off-taker for the sale of (renewable) energy.
- As the off-taker in a PPA, fleet operators can reduce energy costs for eHGV charging, since electricity prices under a PPA are typically lower than retail rates.
- This model could be realised in two ways:
  - **Option A – PPA with Landlord:** The fleet operator enters into a PPA with the landlord of their depot, who assumes the role of generator and is thereby responsible for installing renewable generation assets on-site.
  - **Option B – Private Wire PPA with Nearby Site:** Renewable generation assets are installed at a nearby location by a third-party generator. The energy is then transmitted via a private wire to the fleet operator's depot.
- In both cases, the renewable energy generated is used to power eHGV charging, reducing overall charging costs.



Key:

→	Service flow	→	Financial flow	·········	Optional

This model would need to be combined with others focused on installing charging infrastructure to form a comprehensive eHGV charging solution (see Page 49).

Option 6: PPA

Benefits

Financial

- **Lower electricity costs –** The price of renewable electricity in a PPA (p/kWh) is typically set to ensure a favourable return on investment (ROI) for the generator, while enabling the off-taker to purchase energy at rates below standard retail electricity prices, thereby reducing overall charging costs for fleet operators.
- **Minimal upfront investment –** This model can be attractive for fleet operators seeking the benefits of renewable energy infrastructure without the upfront capital investment or the time and resources required to manage the procurement, installation, and operation of assets, as the generator assumes responsibility for these aspects.
- **Cost certainty –** With a fixed pricing model, a PPA ensures predictable energy costs, improving financial planning and budgeting activities for fleet operators.

Other

- **Increased emission reductions –** By sourcing renewable energy through a PPA, fleet operators can further increase emission reductions beyond the savings achieved by transitioning to eHGVs.
- **Energy resilience –** This model provides fleet operators with access to a renewable energy source that reduces reliance on grid imported electricity, enhancing energy resilience.

Risks and considerations

Financial

- **Maximising cost savings –** The cost savings achieved through this model will not be as significant as those observed in the Renewable (and Storage) Integration model. In this model, fleet operators benefit from a reduced rate for renewable energy consumed rather than directly off-setting grid-imported electricity costs. Operators should assess which model aligns best with their needs, balancing their desire for cost savings against their willingness/ability to invest in and manage the installation of renewable infrastructure.
- **Long-term financial commitment –** Generators will likely seek long-term PPA contracts to ensure they recover their investment. Early termination could result in penalties or buyout fees for fleet operators.

Other

- **Seasonal generation variation –** Renewable energy sources are subject to seasonal fluctuations, which may lead to periods of insufficient energy to meet charging demands, resulting in increased reliance on grid electricity at higher rates. Energy storage can mitigate this risk, but operators should weigh the capital costs of storage against the potential energy savings it provides.
- **Competition for space –** In Option A, renewable generation assets could compete for space with eHGV charging infrastructure, potentially limiting available space for operations. This issue does not apply to Option B, although space for eHGV charging infrastructure can still be a challenge for fleet operators in general.

PPA case study: Cardiff Bus and Zenobe[29-31]

Overview

- Cardiff Bus, which provides bus services across Cardiff and covers 27,000 miles per day, received funding from the Department for Transport's Ultra-Low Emissions Bus scheme to support the addition of 36 new electric buses to its fleet.
- Zenobe, a company specialising in battery solutions and fleet electrification, was appointed as the principal design and build contractor for the project.
- Zenobe developed an end-to-end charging solution for Cardiff Bus, managing the financing and installation of grid connection upgrades and charging infrastructure. They also provided a 15-year 'as-a-service' support agreement, which includes ongoing smart software upgrades and power load management.
- In addition, Zenobe set up a bespoke PPA with Cardiff Bus, enabling them to optimise charging by using cheaper night-time tariffs, which helped reduce monthly energy costs.

Scale of deployment

- The following assets were deployed as part of the project:
  - 36 battery electric buses;
  - A 2 MVA transformer and an accompanying low voltage panel;
  - 18 dual-gun 120kW electric vehicle chargers.

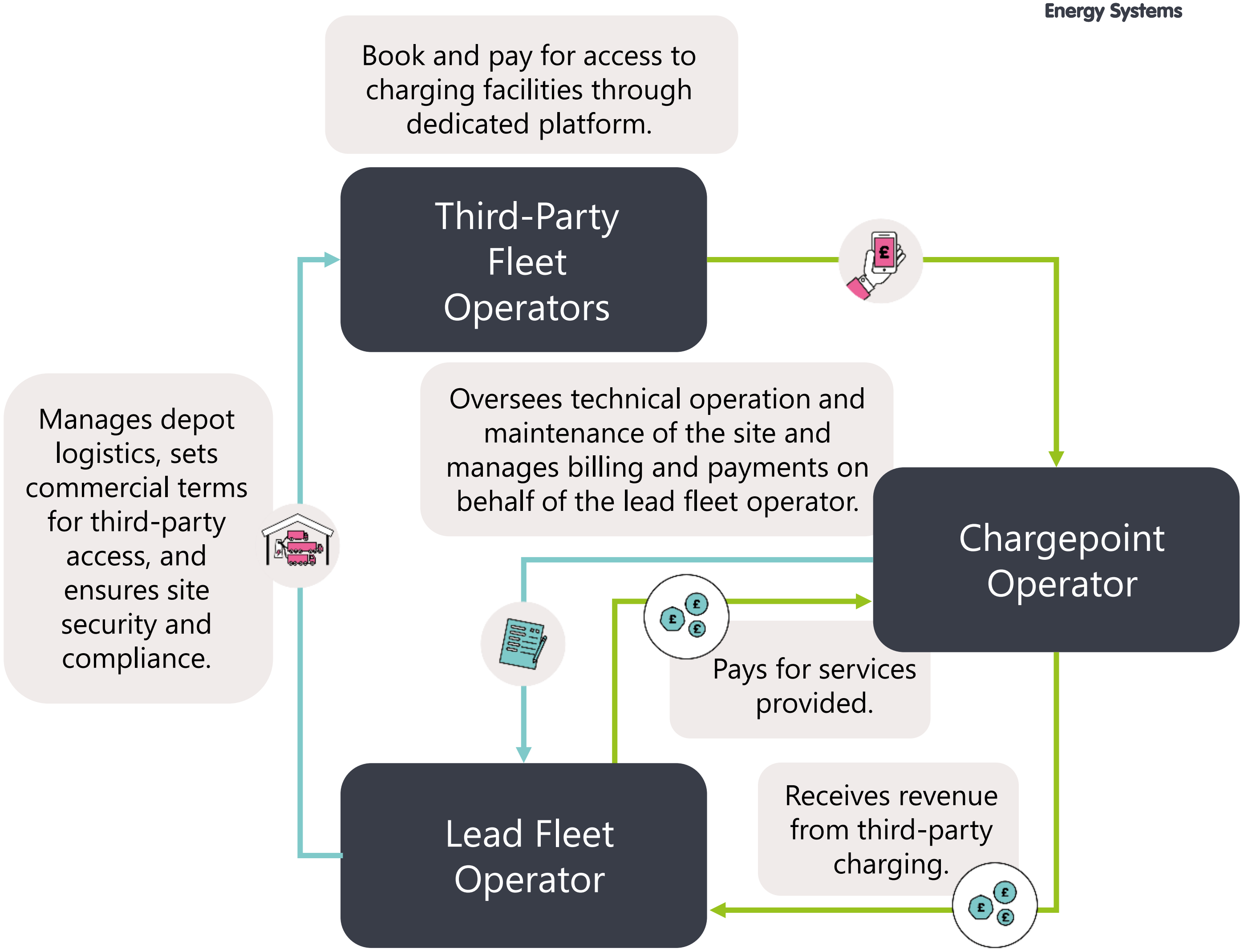
Financials

- The project secured approximately £5.7m in grant funding, with around £5.4m allocated for the purchase of buses, and roughly £350,000 dedicated toward infrastructure costs.
- While the specific amount Cardiff Bus pays for energy through the PPA is not disclosed, the original source highlights that monthly energy bill savings were observed.

Option 7: Shared charging facilities*

Description

- This model maximises infrastructure utilisation by enabling shared access to charging facilities across operational depots.
- A lead fleet operator would act as the host, allowing other fleet operators to use their depot for vehicle charging when spare capacity is available.
- In return, third-party operators would pay for access, with potential pricing structures including:
  - **PaYG** – Operators are charged per kWh or per session.
  - **Subscription model** – Fleets pay a fixed monthly fee for guaranteed depot access.
  - **Volume commitment discounts –** Fleets commit to a minimum energy usage to receive lower kWh rates.
- The shared charging service can be delivered in partnership with a chargepoint operator (CPO), who would oversee the technical operation of the charging infrastructure, manage billing and payments through a dedicated booking platform, and ensure ongoing site maintenance.



Key:

→	Service flow	→	Financial flow	·········	Optional

This model would need to be combined with others focused on installing charging infrastructure to form a comprehensive eHGV charging solution (see Page 49).

Option 7: Shared charging facilities

Benefits

Financial

- **Unlocking new revenue streams –** Fleet operators can unlock new revenue streams by offering excess charging capacity to third parties.
- **Lower electricity costs –** Volume commitments from third-party fleets may enable the lead fleet operator to negotiate reduced energy rates with suppliers. These savings may be passed on to third-party fleets through lower charging tariffs.
- **Reduced infrastructure and maintenance costs –** This model supports third-party fleets in transitioning to eHGVs by reducing the need for significant investment in charging infrastructure and reducing ongoing maintenance expenses, thereby supporting wider fleet electrification.

Other

- **Addressing tenure challenges –** For fleet operators in leased depots or customer donated sites, this model provides access to charging infrastructure without requiring landlord approval for installation*.
- **Addressing constrained sites –** This model offers fleets operating in depots with limited grid capacity or space the ability to access charging infrastructure*.

Risks and considerations

Financial

- **Stranded asset risk –** If demand from third-party fleets is lower than anticipated, the initial investment in charging infrastructure may take longer to generate a return, potentially impacting the viability of this model.
- **Energy cost volatility –** Fluctuations in energy prices could impact the profitability of this model for the lead fleet operator, especially if fixed-price tariffs are offered to third-party fleets. Regular tariff reviews can help mitigate this risk.
- **Pricing competitiveness –** The lead fleet operator must carefully balance pricing to remain competitive while ensuring profitability, especially if competing with public charging infrastructure in the longer term.

Other

- **Operational complexity –** Managing third-party access, scheduling, and site security increases the operational burden for the lead fleet operator.
- **Charging availability –** If the shared charging site becomes increasingly utilised, third-party fleet operators - especially those who have become reliant on that site - may struggle to secure access during peak times, potentially disrupting their operations. To help mitigate this risk, they could negotiate a premium with the lead fleet operator for priority or guaranteed access.

**Shared charging facilities may be limited to specific locations, especially in the near term, meaning not all fleet operators will be able to benefit from this model.*

Shared charging facilities case study: First Bus 'Electric Vehicle Charging Partnerships'[32-34]

Overview

- First Bus provides fast, high-volume charging for fleet operators through its 'Electric Vehicle Charging Partnerships', enabling partners to charge their vehicles at First Bus depots.
- The partnership also offers access to large parking pays and long charging cables, accommodating a variety of vehicle types.
- Secure, restricted access facilities are available to approved users, ensuring vehicle safety.
- First Bus has already established partnerships with several commercial organisations, including Welch Group and Samworth Brothers, both of which operate eHGV fleets.

Scale of deployment

- First Bus has deployed rapid charging infrastructure across more than ten operational depots nationwide, offering charging capabilities from 75 kW to 350 kW (see image to right).
- As of March 2025, seven of these live depots can support eHGV charging.

Financials

- As of March 2025, all existing customers are on a legacy tariff of 63p/kWh, which will soon drop to 55p/kWh.
- First Bus is currently developing 'advanced commitment' tariffs, which will require an upfront payment/membership fee, to help lower charging costs further.
- The target rate for this model is 33p/kWh, contingent on a firm volume commitment of approximately 400,000 kWh per year.
- First Bus is also exploring a consortium model, which would allow multiple operators to aggregate their energy demands to secure the lowest possible rate*.

EV charging locations

*Please refer to the Catapult's report on eHGV purchasing models for more detail on consortium-led aggregated purchasing.

Shared charging facilities case study: Shared charging online platform[35]

Overview

- The Association of Fleet Professionals (AFP) plans to commission an online platform that will enable fleets to share their charging facilities with other organisations.
- This initiative builds on previous research which found that 58% of van fleets would consider sharing their depot charging infrastructure to make electrification more practical.
- The platform will act as a matchmarking service, connecting fleets with spare charging capacity to those in need of charging solutions in specific locations.
- Initially, the platform will connect fleets, leaving them responsible for establishing their own commercial agreements for charging.

Scale of deployment

- Future developments to the platform will introduce a more structured system, detailing pricing and payment terms, while enabling users to search for and book charging sessions.

Financials

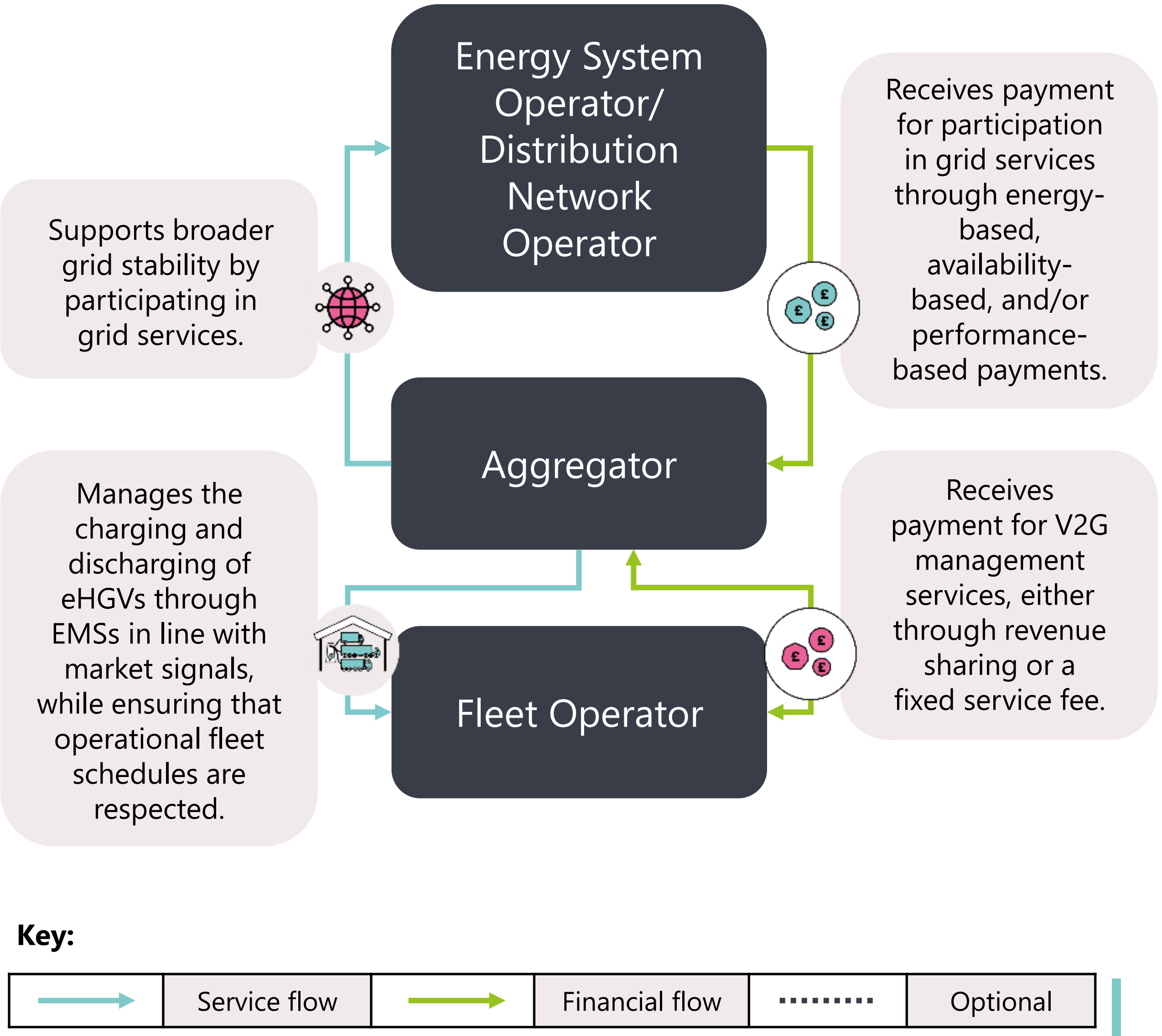
- While charging rates will be set by individual fleet operators, the AFT has indicated there is a general acceptance that 40 p/kWh should be the upper limit for shared charging to remain viable.
- This price shows similarity to the target rate proposed under First Bus' Advanced Commitment tariff.

AFP Association of Fleet Professionals

Option 8: Vehicle to Grid (V2G)*

Description

- This model offers fleet operators the opportunity to generate revenue by utilising eHGVs as energy assets.
- By installing bidirectional charging infrastructure, which enables energy flow both into and out of eHGVs, along with smart EMSs, vehicles can supply stored energy to the power grid to support system stability.
- This could be achieved by fleet operators collaborating with an aggregator who can facilitate participation in grid balancing services and energy markets.
- The aggregator brings the necessary expertise to aggregate energy from multiple eHGVs (and other assets) into a virtual power plant, allowing participation in energy trading and flexibility services.
- There are several pricing models that aggregators may offer for their services:
  - **Revenue sharing** – The fleet operator and aggregator split earnings, with the percentage allocation agreed during contract negotiations.
  - **Fixed service fee** – The fleet operator pays a monthly fee for V2G management but retains all earnings.



*This model would need to be combined with others focused on installing charging infrastructure to form a comprehensive eHGV charging solution (see Page 49).

Option 8: V2G

Benefits

Financial

- **Unlocking new revenue streams –** Fleet operators can unlock new revenue streams by leveraging their eHGVs as energy assets to participate in grid services and energy markets.
- **Improved ROI on eHGV investment –** This model improves overall asset utilisation, enabling fleet operators to generate revenue when vehicles are otherwise not in use, thereby improving the ROI on eHGVs*.
- **Energy cost savings –** If operating on a time-of-use tariff, aggregators can help fleet operators reduce charging costs by charging eHGVs during off-peak periods when electricity prices are lower and avoiding consumption during more expensive peak times.

Other

- **Simplified access to energy markets –** Aggregators simplify V2G participation by managing market access, responding to price signals, and controlling technical operations – activities that would otherwise be complex, resource-intensive, and costly for individual fleet operators to undertake alone.
- **Wider system benefits –** By participating in grid services, fleet operators contribute to balancing the grid and thereby support grid stability.

Risks and considerations

Financial

- **High upfront costs –** Depending on the business model chosen to deploy charging infrastructure, fleet operators may face upfront costs for bidirectional charging infrastructure and energy management hardware.
- **Uncertain payback period –** With the V2G market in the UK still in its early stages and most eHGV applications in the demonstration phase, limited participation in grid events can lead to unpredictable revenue.
- **Pricing structure –** Fleet operators need to evaluate which pricing model best aligns with their operational and financial priorities. Revenue share agreements align incentives, with aggregators earning only when the fleet does, making them suitable for early-stage deployments. Whereas, fixed service fees provide cost predictability and 100% revenue retention, but place performance risk on the operator.

Other

- **Battery state of health** –** Frequent cycling (charging/discharging) could accelerate battery degradation, potentially reducing its lifespan.
- **Fleet availability and scheduling** –** If not carefully managed, V2G participation could conflict with fleet operations, as vehicles may be unavailable when required for core operations.

The financial benefit of V2G participation should be balanced against the potential impact on battery health and longevity.
*** Both risks can be mitigated through careful contractual negotiations.*

V2G case study: Kaasai Services' demonstration of V2G for eHGVs[36-37]

Overview

- While there have been several V2G demonstrations in the passenger vehicle sector, eHGV participation in UK-based V2G trials remains limited.
- The V2X (Vehicle-to-Everything) Innovation Programme was launched to help overcome barriers to enabling energy flexibility through bi-directional EV charging.
- Phase 2 of the programme allocated up to £9.4 million in funding to support small-scale V2X demonstration projects.
- Among the successful projects is 'eHGVs – First Roll-out and Demonstration of V2X and Grid Decarbonisation', led by Kaasai Services Ltd.
- The project aims to show how V2X can significantly lower the total cost of ownership for eHGVs, potentially making them more cost-effective than diesel alternatives.

Scale of deployment

- The project will explore the potential of eHGVs to deliver V2G services such as load balancing and frequency stabilisation.
- Kaasai's digital platform will integrate data from Project Better Energy's bi-directional chargers and ZevHub's fleet charging infrastructure to enable V2G functionality.
- The trial will also deploy user-facing apps to help fleet operators balance energy trading opportunities with operational demands and battery health considerations.
- The original source does not disclose how many fleet organisations will participate in the trial.

Financials

- The project received £1,404,414 in grant funding.
- At the time of writing, no public timeline has been provided for the release of trial results.

Business model integration potential

- The business models in this section that focus on reducing energy costs or unlocking new revenue streams still depend on the installation of charging infrastructure. As such, they would need to be combined with models focused on installing charging infrastructure to create a comprehensive solution.
- Fleet operators may also benefit from combining other models to maximise the overall value of their eHGV charging systems.
- The table opposite presents a compatibility assessment using a Pink-Amber-Green (PAG) rating system:
    - **Pink** – Models are likely to be incompatible.
    - **Amber** – Models may be compatible, but integration could be complex due to contractual, ownership, or technical factors.
    - **Green** – Models are compatible and may enhance one another's value if combined*.
- This analysis aims to support fleet operators in designing integrated eHGV charging solutions.

Business model compatibility

	Owner-Operator	CaaS	EaaS	EM&O	Renewable Integration	PPA	Shared Charging Facilities	V2G
Owner-Operator	NA							
CaaS		NA						
EaaS			NA					
EM&O				NA				
Renewable Integration					NA			
PPA						NA		
Shared Charging Facilities							NA	
V2G								NA

*<u>Appendix 1</u> provides the justification behind each compatibility rating.

Section summary: Business model suitability

This section has outlined the benefits, risks, and key considerations associated with numerous depot-based eHGV charging business models. These factors inform the suitability of each model for different fleet operators. The most appropriate model - or combination of models - will depend on a fleet's specific requirements, including investment capacity, risk appetite, and depot constraints. The table below provides a summary to support fleet operators in identifying which models could be most aligned with their operational needs and strategic objectives.

Model	Potential suitability
Owner-Operator	• Suitable to fleet operators seeking full asset ownership and control, with the ability to manage upfront investment, operation, and maintenance over the long-term.
CaaS	• Suitable for fleet operators with limited access to capital or those preferring an end-to-end solution that reduces operational complexity.
EM&O	• Suitable for fleet operators looking to optimise energy use and efficiency through smart charging solutions integrated with broader site demands, renewable generation, and storage systems.
EaaS	• Suitable for fleet operators seeking integrated charging and energy services, with the ability to commit to long-term contractual agreements.
Renewable (and Storage) Integration	• Suitable for fleet operators with depot space and investment capacity, seeking to maximise eHGV charging cost savings and enhance energy resilience.
PPA	• Suitable for fleet operators, within proximity to renewable generation assets, looking to reduce emissions and benefit from lower energy costs without owning and investing in renewable systems.
Shared Charging Facilities	• **Lead fleet operator:** Suitable for fleet operators with spare charging capacity and a willingness to host third-parties on-site. • **Third-party fleets:** Suitable for fleet operators without access to dedicated charging infrastructure either due to site constraints or a preference to avoid significant capital investment.
V2G	• Suitable for fleet operators willing to invest in bi-directional charging infrastructure, with a view to unlocking additional revenue streams.

5. Business model evaluation: Ability to address pain points and key risks

NB: This section evaluates each business model individually. However, models aimed at reducing energy costs through optimisation or unlocking new revenue streams still rely on the installation of charging infrastructure. Fleet operators may therefore consider combining models from Section 4 to enhance the overall value of their depot-based eHGV charging solution. Where models are combined, it is important to consider their benefits and risks as a whole to support informed decision-making.

Business model evaluation: Ability to address pain points and key risks

Building on the eHGV depot-based charging business model overview in Section 4 and the fleet operator pain points outlined in Section 3, this section evaluates each model's ability to address those challenges and highlights the associated risks. This assessment is designed to help fleet operators make informed decision-making about eHGV charging solutions, aligned with their specific priorities and risk tolerance. The pain points and risks considered in this ranking are summarised below.

Pain points

1. **Landlord approval –** Limited willingness from landlords to support the implementation of charging (and renewable energy) infrastructure on leased (or donated) depots.
2. **Short-term leases –** Limited appetite to invest in charging (and renewable energy) infrastructure when operating under a short-term depot lease.
3. **Grid connection barriers –** High upfront costs and significant administrative burden associated with securing grid connection upgrades, including a complex application process.
4. **Depot space restrictions –** Limited space on-site to install charging (and renewable energy) infrastructure.

Risks

1. **Transition complexity –** Risk of operational burden from managing the design, installation, and operation of infrastructure outside of core fleet activities.
2. **High capital expenditure (CAPEX) –** Risk of high upfront costs for deploying charging and renewable energy infrastructure.
3. **High operational expenditure (OPEX) –** Risk of high ongoing costs related to the use and management of charging and renewable energy infrastructure.
4. **Limited control –** Risk of limited operational control and reduced autonomy in choosing installation and operational partners.
5. **Contractual complexity –** Risk of administrative and legal burden due to complex contractual clauses, potentially delaying implementation.

Option 1: Owner-operator model

Pain Point	Rating	Rationale
Landlord approval	2	• Model does not directly address this pain point as landlord approval is still required for infrastructure installation. However, landlords may support this if it increases site value and makes it more attractive to future tenants.
Short-term leases	3	• Short-term leases can make upfront investment in charging infrastructure hard to justify due to the risk of stranded assets if the fleet leaves the depot.
Grid connection barriers	3	• The fleet operator bears the full cost and complexity of grid upgrades. Although the application process can be outsourced to experienced third-party providers, doing so still requires careful partner selection and coordinated management from fleet operators.
Space restrictions	3	• Model doesn't address depot space constraints for charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	3	• Fleet operators assume responsibility for funding and managing the delivery of charging solutions, even if some key activities are outsourced to third-party organisations.
High CAPEX	3	• Fleet operators are responsible for funding the installation of eHGV charging infrastructure.
High OPEX	1	• This model can offer lower total ownership costs compared to third-party solutions due to avoidance of markups, financing charges, and profit margins.
Limited control	1	• Fleet operator maintains full control over partner selection and infrastructure use through direct procurement and asset ownership.
Contractual complexity	1	• Model likely to be less contractually complex than service-based approaches due to fewer Parties being involved and simpler contract scopes.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 2: CaaS

Pain Point	Rating	Rationale
Landlord approval	2	• Landlord approval for site modifications is still required. However, the CaaS model, where a specialised organisation handles installation and operations, may appeal to landlords as it could provide confidence in the quality of installation and operations.
Short-term leases	2	• Literature suggests that CaaS agreement terms typically range from 3-8 years, making this model a potentially suitable solution for shorter-term leases[12].
Grid connection barriers	2	• The CaaS provider can optimise fleet charging to potentially reduce grid capacity upgrade requirements and manage the complex grid connection process, including applications.
Space restrictions	2	• While the service provider can optimise chargepoint placement, this model still requires space for the installation of charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	1	• Model reduces transition complexity by outsourcing the financing, installation and maintenance of charging infrastructure to the service provider.
High CAPEX	1	• CaaS provider finances the installation of charging infrastructure on behalf of the fleet operator.
High OPEX	3	• Model will likely result in higher OPEX costs as the service provider assumes the risk and complexity of managing assets, which is reflected in the overall service fee.
Limited control	3	• The agreement with the service provider will likely involve predetermined delivery partners and restrict the fleet's ability to choose their own partners or control over the charging assets.
Contractual complexity	3	• Model is likely to be contractually complex due to the need for detailed agreements between the fleet operator, service provider, and other stakeholders, covering aspects like asset ownership, liability, and long-term service terms.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 3: EaaS

Pain Point	Rating	Rationale
Landlord approval	2	• Landlord approval for site modifications is still required. However, the EaaS model, where a specialised organisation handles installation and operations, may appeal to landlords as it could provide confidence in the quality of installation and operations.
Short-term leases	3	• Literature suggests that EaaS agreement terms typically range from 20-25 years, making this model highly unlikely to align with short-term leases[20-21].
Grid connection barriers	2	• The service provider can optimise fleet charging and deploy renewable energy assets to reduce overall grid capacity requirements, potentially lowering costs for fleet operators.
Space restrictions	2	• The service provider brings expertise in optimising site layout, but the inclusion of renewable energy assets may require additional space beyond what is needed for charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	1	• Model reduces transition complexity by outsourcing the financing, installation and maintenance of charging and renewable energy infrastructure to the service provider.
High CAPEX	1	• Capital costs are covered by the service provider, minimising upfront investment for fleet operators.
High OPEX	3	• Model will likely result in higher OPEX costs as the service provider assumes the risk and complexity of managing assets, which is reflected in the overall service fee.
Limited control	3	• Agreement with the service provider may involve predetermined delivery partners and restrict the fleet's ability to choose their own partners or control the infrastructure on-site.
Contractual complexity	3	• Model is likely to be contractually complex due to the need for detailed agreements between the fleet operator, service provider, and other stakeholders, covering aspects like asset ownership, liability, and long-term service terms.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 4: EM&O*

Pain Point	Rating	Rationale
Landlord approval	2	• Landlord approval is still required for energy management equipment. However, similar to the CaaS and EaaS models, the EM&O model may appeal more to landlords because a third-party handles installation and operations.
Short-term leases	2	• Depending on the pricing model adopted, this model may still require upfront investment for energy management equipment, which may be hard to justify with short-term leases.
Grid connection barriers	2	• The EM&O provider can optimise fleet charging to minimise grid capacity upgrade requirements, potentially reducing total costs. Some providers may also manage the grid connection application process on behalf of fleet operators.
Space restrictions	2	• The EM&O provider may optimise asset placement, but this model still requires space for the installation of energy management equipment.
Risk	**Rating**	**Rationale**
Transition complexity	1	• The EM&O provider handles energy optimisation and management, easing operational complexity for the fleet operator.
High CAPEX	2	• Fleet operators may be required to invest in energy management equipment, depending on the pricing model offered by the EM&O provider.
High OPEX	2	• The EM&O provider can help lower energy costs through optimisation. However, operators will need to evaluate if the forecasted savings are enough to outweigh the fee charged by the EM&O provider.
Limited control	2	• Fleet operators are likely to have limited flexibility in day-to-day charging operations, as schedules are managed by the EM&O provider. However, fleet operators retain control over which provider they choose to select.
Contractual complexity	2	• Contracts may involve some complexity due to performance guarantees and integration with site operations.

**This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.*

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 5: Renewable (and Storage) Integration*

Pain Point	Rating	Rationale
Landlord approval	2	• Model still requires landlord approval for the installation of renewable energy assets. However, landlords may support this if they see potential for increased site value for future tenants due to decarbonisation benefits.
Short-term leases	3	• Short-term leases can make upfront investment in renewable energy infrastructure hard to justify due to the risk of stranded assets if the fleet leaves the depot.
Grid connection barriers	2	• Deploying renewable energy assets could reduce overall grid capacity requirements, potentially lowering the cost of grid connection upgrades. However, the fleet operator would likely still assume responsibility for managing the grid connection application process.
Space restrictions	3	• The installation of renewable energy assets may require additional space beyond what is already required for charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	3	• Fleet operators assume responsibility for funding and managing renewable energy assets, even if some key activities are outsourced to third-party organisations.
High CAPEX	3	• Fleet operator invests in renewable energy infrastructure and thereby assumes capital cost burden.
High OPEX	1	• Using on-site renewable energy to offset grid electricity consumption reduces energy expenses, thereby lowering overall OPEX costs.
Limited control	1	• Fleet operators maintain full control over partner selection and asset use through direct procurement and asset ownership.
Contractual complexity	1	• Model likely to be less contractually complex than service-based approaches due to fewer Parties being involved and simpler contract scopes.

This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 6A: PPA – Landlord*

Pain Point	Rating	Rationale
Landlord approval	2	• As the landlord is assumed to be the generator in this model, approval for installing renewable energy infrastructure on-site is already built in.
Short-term leases	3	• BtM PPAs are are usually structured as longer-term contracts to allow the energy generator to recover the upfront capital invested in the renewable energy assets.
Grid connection barriers	2	• On-site renewables may not eliminate the need for grid upgrades if peak demand from eHGV charging still exceeds available capacity.
Space restrictions	3	• The installation of renewable energy assets may require additional space beyond what is already required for charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	1	• The landlord is responsible for the financing, installation, and maintenance of renewable infrastructure.
High CAPEX	1	• The landlord covers capital costs for renewable energy assets, minimising upfront investment for fleet operators.
High OPEX	2	• A PPA can offer electricity at rates lower than retail prices, resulting in reduced charging costs for fleet operators. However, the savings are typically less substantial than those achieved by directly offsetting grid electricity - as observed in the Renewable Integration model.
Limited control	2	• Fleet operators have limited control over renewable energy assets and may be contractually required to purchase energy when it's generated, even if it doesn't align with charging needs, reducing operational flexibility.
Contractual complexity	2	• PPA models pose moderate contractual complexity due to long-term agreements on pricing, duration, and asset ownership, though standardisation in the energy sector helps mitigate this.

This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 6B: PPA – Nearby site*

Pain Point	Rating	Rationale
Landlord approval	2	• Although landlord approval is not required for installing off-site renewable assets, it may still be necessary for any on-site modifications—such as installing private wire infrastructure.
Short-term leases	3	• BtM PPAs are are usually structured as longer-term contracts to allow the energy generator to recover the upfront capital invested in the renewable energy assets.
Grid connection barriers	2	• This model may not eliminate the need for grid upgrades if peak demand from eHGV charging still exceeds available capacity at the depot.
Space restrictions	2	• This model avoids the use of on-site space for renewable energy infrastructure but does not impact the space requirements associated with eHGV charging infrastructure at the depot.
Risk	**Rating**	**Rationale**
Transition complexity	1	• The third-party generator is responsible for the financing, installation, and maintenance of renewable infrastructure.
High CAPEX	1	• The third-party generator covers capital costs for renewable energy assets.
High OPEX	2	• A PPA can offer electricity at rates lower than retail prices, resulting in reduced charging costs for fleet operators. However, the savings are typically less substantial than those achieved by directly offsetting grid electricity - as observed in the Renewable Integration model.
Limited control	2	• Fleet operators have limited control over renewable energy assets and may be contractually required to purchase energy when it's generated, even if it doesn't align with charging needs, reducing operational flexibility.
Contractual complexity	2	• PPA models pose moderate contractual complexity due to long-term agreements on pricing, duration, and asset ownership, though standardisation in the energy sector helps mitigate this.

**This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.*

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 7A: Shared charging facilities (lead fleet)*

Pain Point	Rating	Rationale
Landlord approval	2	• There may be reluctance from landlords to accommodate shared charging facilities due to concerns around shared access, site safety, and liability. However, the model could also enhance the strategic value of the depot, potentially attracting external charging users and boosting the site's utility.
Short-term leases	3	• Fleet operators on short-term leases are unlikely to assume the role of lead fleet operator, given the long-term commitment that such a role would require.
Grid connection barriers	3	• This model does not directly address grid connection barriers.
Space restrictions	3	• Allowing third-party fleets on-site could exacerbate existing space constraints, making it more challenging to accommodate charging infrastructure.
Risk	**Rating**	**Rationale**
Transition complexity	3	• Managing a shared charging model introduces considerable transition complexity for the lead fleet operator, who must coordinate multiple stakeholders, set and manage tariffs, oversee site logistics, and handle access and operational governance.
High CAPEX	2	• The lead fleet operator may incur moderate capital costs for access control, legal setup, and administration to implement the shared charging model.
High OPEX	2	• The lead fleet operator may also face moderate ongoing costs for managing access, administering shared use, and coordination, partly offset by revenue from third-party charging.
Limited control	1	• Fleet operators have the flexibility to decide when to offer spare charging capacity, ensuring it aligns with their own operational requirements and priorities.
Contractual complexity	3	• Complexity likely to be high due to the need for multiple commercial agreements, covering aspects such as billing, priority access, and other operational considerations.

This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 7B: Shared charging facilities (third-party fleet)

Pain Point	Rating	Rationale
Landlord approval	1	• By utilising charging infrastructure at other fleets' sites, the need for landlord approval is removed, as the responsibility for securing permissions shifts to the lead fleet operator.
Short-term leases	1	• This model is agnostic to depot tenure as the third-party fleet gains access to charging infrastructure at other fleets' sites.
Grid connection barriers	1	• Model eliminates grid connection upgrade costs and the application process for third-party fleets, as they are not required to install infrastructure at their own site.
Space restrictions	1	• Model alleviates space restrictions for the third-party fleets by removing the need for infrastructure on their own sites, as they access charging facilities at other fleets' depots.
Risk	**Rating**	**Rationale**
Transition complexity	1	• Transition complexity is minimised for third-party fleet operators, as they rely on charging infrastructure that has been designed, installed, and managed by another organisation.
High CAPEX	1	• Third-party fleet operators using shared charging facilities are unlikely to incur capital expenditure.
High OPEX	3	• Third-party fleet operators will most likely incur higher charging costs than if using electricity at their own depots and may also face additional premiums for priority access.
Limited control	3	• As the shared site becomes more utilised, third-party fleets may struggle to secure access during peak times. While this risk could be partially mitigated through negotiated agreements - such as paying a premium for priority access - these arrangements still leave third-party operators subject to the lead fleet's overarching control and operational decisions.
Contractual complexity	2	• Depending on the pricing structure adopted, there could be a need to negotiate agreements with the lead fleet operator, including terms for access, billing, priority at chargepoints, and potential fluctuations in availability.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Option 8: V2G*

Pain Point	Rating	Rationale
Landlord approval	**2**	• Regardless of the model chosen to deploy eHGV charging infrastructure, landlord approval will still be needed for site modifications and infrastructure. However, landlords may be more open to V2G if they perceive it as having the potential to boost the depot's value.
Short-term leases	**2**	• While the V2G model could technically be deployed during a short-term lease, aggregators *may* be less inclined to partner with a fleet operator on V2G projects if the location is under a short-term lease.
Grid connection barriers	**3**	• The cost of grid connection upgrades is unlikely to be reduced under the V2G model, meaning it does not directly address this pain point.
Space restrictions	**2**	• V2G does not directly address space limitations. However, it may enable eHGVs to function as mobile storage units, reducing the need for other on-site storage systems in situations where they were previously considered.
Risk	**Rating**	**Rationale**
Transition complexity	**1**	• In this model, V2G participation is assumed to be managed by an aggregator, thereby reducing complexity for fleet operators to participate in grid services.
High CAPEX	**2**	• Fleet operators may be required to invest in energy management equipment, but the aggregator's pricing model is OPEX-based (revenue sharing or fixed service fee).
High OPEX	**2**	• As eHGV participation in V2G services is still in the demonstration phase, revenue potential is uncertain, but some revenue is expected. Fleet operators should assess whether the forecasted revenue outweighs the aggregator's service fee, especially with a fixed pricing model.
Limited control	**2**	• V2G participation may interfere with core fleet operations by limiting vehicle availability when needed, posing a moderate risk to operational control.
Contractual complexity	**2**	• Careful contract negotiation is required to address key terms such as battery degradation liability, fleet availability constraints, and prioritisation clauses.

This assessment does not consider charging infrastructure deployment, as its implications vary depending on the chosen delivery model (e.g., Owner-Operator, CaaS, and EaaS). For more details, see Page 51.

Key:

3	Does not address pain point
2	Could (partially) address pain point
1	Addresses pain point
3	Considerable risk
2	Moderate risk
1	Low risk

Section summary: Model ability to address pain points

The table below summarises how effectively each model addresses the different pain points considered throughout this section. Key observations related to this summary are outlined on Pages 65 and 66.

Model	Pain Points			
	Landlord Approval	Short-term Leases	Grid Connection Barriers	Space Restrictions
Owner-Operator	2	3	3	3
CaaS	2	2	2	2
EaaS	2	3	2	2
EM&O	2	2	2	2
Renewable (and Storage) Integration	2	3	2	3
PPA (A)	2	3	2	3
PPA (B)	2	3	2	2
Shared Charging Facilities (A)	2	3	3	3
Shared Charging Facilities (B)	1	1	1	1
V2G	2	2	3	2

Section summary: Risks for fleet operators

The table below outlines the levels of various risk types associated with each model. Key observations related to this summary are outlined on Pages 65 and 66.

Model	Risks				
	Transition Complexity	High CAPEX	High OPEX	Limited Control	Contractual Complexity
Owner-Operator	3	3	1	1	1
CaaS	1	1	3	3	3
EaaS	1	1	3	3	3
EM&O	1	2	2	2	2
Renewable (and Storage) Integration	3	3	1	1	1
PPA (A)	1	1	2	2	2
PPA (B)	1	1	2	2	2
Shared Charging Facilities (A)	3	2	2	1	3
Shared Charging Facilities (B)	1	1	3	3	2
V2G	1	2	2	2	2

Evaluation summary: Key themes

- The evaluation of business models for depot-based eHGV charging highlights that no single approach fully resolves all the pain points faced by fleet operators.
- Each model addresses specific pain points to varying extents but also introduces its own set of risks, trade-offs, and limitations.
- As a result, fleet operators must carefully weigh these factors when selecting the most appropriate model – or combination of models – for the delivery of eHGV charging solutions.
- A number of key themes emerge across the models, including pain points and risks that are effectively mitigated, those that remain unaddressed, and broader, cross-cutting trade-offs.
- These are summarised in this slide and the one that follows.

Pain points and risks addressed across models

1. **Charging and energy infrastructure costs –** Several models, including CaaS, EaaS, PPA, and Shared Charging Facilities (third-party fleets), address the high upfront costs of charging and/or energy infrastructure by shifting capital investment to other stakeholders, minimising upfront investment for fleet operators.
2. **Grid connection barriers –** Models such as EM&O, EaaS, and CaaS can reduce the scale of required grid upgrades through smart energy management and optimisation, lowering peak demand. They may also streamline the process by managing applications on behalf of fleet operators. However, they do not eliminate potential upgrade costs or long lead times, which vary by depot location.
3. **Transition complexity –** Models like CaaS and EaaS can help simplify the electrification process for fleet operators, by outsourcing the financing, installation, and maintenance of charging (and renewable infrastructure) to the service provider. Similarly, the PPA model allows fleet operators to benefit from lower-cost renewable electricity without needing to invest in their own generation assets. These approaches reduce operational complexity and allow operators to remain focused on core fleet activities.

Evaluation summary: Key themes (continued)

CATAPULT Energy Systems

Pain points and risks remaining unaddressed

1. **Short-term leases –** The challenge of investing in charging or renewable infrastructure under short-term depot leases remains unresolved across most models, as they typically assume long-term occupancy to justify capital investment or commitment to long-term service agreements. The Shared Charging Facilities (third-party fleets) model is the only approach that directly addresses this issue by being agnostic to depot tenancy agreements.
2. **Landlord approval –** Securing landlord consent for infrastructure installation remains a common challenge across most models. However, models involving third-party specialists may provide landlords with greater confidence in the quality and professionalism of installation and operations, which may help increase the likelihood of securing approval.
3. **Space restrictions –** Some models offer partial mitigation of physical space limitations through optimised site design and equipment placement. However, they do not fully resolve the underlying issue. For depots with severe space restrictions, alternative solutions such as off-site charging hubs or public infrastructure may present more practical options.

Model trade-offs

1. **Contractual Complexity and Long-Term Commitments –** While service-based models reduce upfront capital requirements and streamline the deployment of charging (and renewable energy) infrastructure, they typically involve multi-year contracts that may include performance guarantees and coordination with multiple stakeholders, increasing legal and administrative complexity.
2. **Reduced Operational Control –** Models that outsource infrastructure ownership or energy management, such as EM&O or service-based approaches, can limit fleet operators' direct control over operational aspects, potentially resulting in conflicts with fleet operations, stressing the importance of careful contract review and negotiation.
3. **Higher Total Cost of Service-Based Models –** Although these models simplify the electrification process and reduce financial and operational risk for fleet operators, they are likely to involve higher overall costs, due to the premiums charged by service providers for assuming these responsibilities.

6. Summary and recommendations for future research

Report summary

- In response to numerous stakeholder-identified pain points related to depot-based eHGV charging, this report explored a range of business models to aid strategic decision-making and help fleet operators select the most suitable charging solution.
- The report:
  - Provided an overview of the primary benefits, risks, and considerations for each business model, with supporting case studies demonstrating their practical implementation.
  - Assessed the potential for combining models to improve operational efficiency and maximise energy cost savings.
  - Evaluated the effectiveness of each model in addressing pain points, while identifying associated risks and trade-offs.
- This has resulted in the development of key considerations for fleet operators, along with emerging observations and corresponding recommendations for future research, which are summarised on this slide and the next.

Considerations for fleet operators

Model suitability – Each business model explored has distinct benefits, risks and limitations, making some more suitable for specific fleets or depot sites. The optimal choice of model - or combination of models - depends on factors such as investment capacity, risk appetite, and depot constraints.

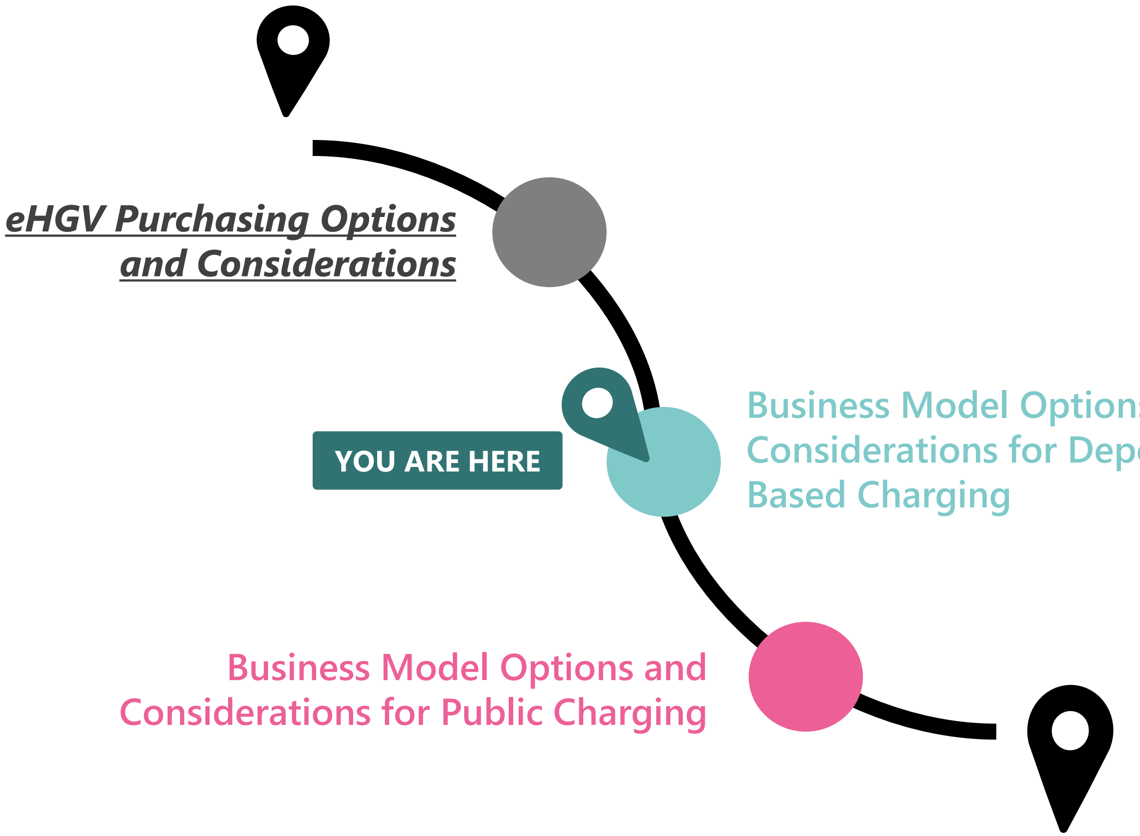
Balancing trade-offs – Selecting the right solution involves balancing trade-offs. Third-party led solutions reduce initial costs and simplify deployment but often come with long-term contracts, higher total costs, and limited operational control. Owner-operator models provide more control and potential long-term savings but require higher capital investment.

Key observations and recommendations

Observations	Corresponding recommendations for future research
1. Some of the models explored in this report may be compatible and, when combined, could enhance operational efficiency and cost savings for fleet operators. Others may face integration challenges due to differing ownership structures or conflicting asset control requirements.	1. Quantify the benefits of combining different business models to better understand how they can work together to optimise cost savings, improve operational efficiency, and unlock new revenue opportunities for fleet operators.
2. While some models explored in this report offer partial mitigation of space limitations through optimised site design and equipment placement, space restrictions at depots remain a persistent challenge. Few depot-based charging models effectively address this issue.	2. Explore business models for off-site charging hubs or public infrastructure as alternative and practical charging solutions for fleet operators facing limited depot space.
3. Leased or donated depots can pose significant barriers to deploying eHGV charging infrastructure, challenges not fully addressed by the models in this report. Short-term leases can discourage investment in on-site infrastructure, and landlord approval is also necessary for installations or site modifications.	3. Investigate ways to align incentives between landlords and fleet operators for deploying eHGV charging infrastructure. Additionally, research could investigate the potential for developing template contractual terms to streamline the approval process and facilitate negotiations.

Future deliverables

- As illustrated in the image to the right, this report is one of three business model exploration reports centered around activities intrinsic to the transition to eHGVs for fleet operators.
- The final report in the series - *Business Model Options and Considerations for Public Charging* - will explore various public charging business models, detailing their key benefits, risks, and considerations.



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Appendix 1. Justifications for business model compatibility ratings

Justifications for business model compatibility rankings

Business models	Ranking	Rationale
Owner-Operator vs. CaaS	Likely not compatible	• Not compatible due to different ownership structures.
Owner-Operator vs. EM&O	Compatible	• Fleet operators can procure services of EM&O provider as part of the owner-operator model.
Owner-Operator vs. EaaS	Likely not compatible	• Not compatible due to different ownership structures.
Owner-Operator vs. Renewable (and Storage) Integration	Compatible	• Fleet operators can install renewable energy (and storage) assets as part of the owner-operator model.
Owner-Operator vs. PPA	Compatible	• Fleet operators can still benefit from purchasing discounted renewable electricity while choosing to invest in their own eHGV charging infrastructure.
Owner-Operator vs. Shared Charging Facilities	Compatible	• Fleet operators could enlist owner operator model to deploy shared charging infrastructure*.
Owner-Operator vs. V2G	Compatible	• Bi-directional charging, enabling V2G benefits, can be implemented under the owner-operator model if planned from the outset.
CaaS vs. EM&O	May be compatible	• EM&O services may be included within a CaaS offering or procured separately if not. However, integrating them independently requires careful stakeholder co-ordination due to differing ownership structures.
CaaS vs. EaaS	Likely not compatible	• Fleet operators seeking a service-based solution would typically opt for either CaaS or EaaS, not both.
CaaS vs. Renewable (and Storage) Integration	May be compatible	• Fleet operators could pursue both models, but coordination between the charging assets and renewable energy assets is essential, especially with different ownership arrangements.

** This applies only to fleet operators acting as the lead operator. For third-party users of shared charging facilities, the rating would instead be pink.*

Justifications for business model compatibility rankings (continued)

Business models	Ranking	Rationale
CaaS vs. PPA	Compatible	• Fleet operators can benefit from both models as long as they are responsible for handling their own energy procurement.
CaaS vs. Shared Charging Facilities	May be compatible	• The lead fleet operator could use the CaaS model to install charging infrastructure as long as the CaaS provider is willing to offer a CaaS agreement for shared infrastructure and has a clear understanding of utilisation patterns to ensure a confident ROI.
CaaS vs. V2G	May be compatible	• Fleet operators could pursue both models, but challenges may arise with asset control, as the aggregator would require it, but the CaaS provider owns the assets, not the fleet operator.
EaaS vs. EM&O	Likely not compatible	• EM&O would already be an integral component of the overall EaaS offering.
EaaS vs. Renewable (and Storage) Integration	Likely not compatible	• Not compatible due to different ownership structures for renewable energy assets.
EaaS vs. PPA	Likely not compatible	• EaaS providers typically include financing for renewable energy assets in their offering and incorporate the cost of renewable energy into their monthly service fee to recover the initial investment, eliminating the need for a separate PPA.
EaaS vs. Shared Charging Facilities	May be compatible	• The lead fleet operator could benefit from both models, although conflicts around operational control may arise.
EaaS vs. V2G	May be compatible	• The EaaS provider may already include V2G participation as part of their offering to fleet operators, eliminating the need for a separate partnership with an aggregator. However, some may not.
EM&O vs. Renewable (and Storage) Integration	Compatible	• Fleet operators can still install renewable energy (and storage) while benefiting from the value offered by the EM&O provider.

Justifications for business model compatibility rankings (continued)

Business models	Ranking	Rationale
EM&O vs. PPA	May be compatible	• Fleet operators could still benefit from EM&O while acting as an off-taker in a PPA agreement as long as the PPA allows flexibility in how energy is used. For example, if the EM&O provider includes flexibility market participation as part of their offering, the potential for renewable energy to be exported to the grid will need to be covered in the PPA terms.
EM&O vs. Shared Charging Facilities	May be compatible	• Unless utilisation patterns are well understood, optimising charging schedules could be challenging for the EM&O provider, particularly if third parties are on-site.
EM&O vs. V2G	May be compatible	• Some EM&O providers may already offer V2G management, eliminating the need for a partnership with an aggregator, while others may not.
Renewable (and Storage) Integration vs. PPA	Likely not compatible	• These models are unlikely to be combined, as both aim to reduce energy costs using locally generated renewable energy but differ in ownership structure.
Renewable (and Storage) Integration vs. Shared Charging Facilities	Compatible	• The lead fleet operator could deploy renewable energy assets on-site while still allowing third-party access to any unused charging capacity.
Renewable (and Storage) Integration vs. V2G	Compatible	• On-site renewable energy assets could boost revenue generation opportunities from V2G participation, particularly if battery storage is installed.
PPA vs. Shared Charging Facilities	May be compatible	• The two models are technically compatible and could be commercially viable if the PPA is structured for shared access (e.g., allowing third-party consumption outside of the named off-taker) and any resale complies with regulatory requirements. Legal advice may be necessary to ensure compliance.
PPA vs. V2G	May be compatible	• These models could co-exist technically however this may result in competing commercial priorities. For example, the PPA may focus on using the energy on-site, while the V2G partner may want to export energy to the grid to maximise revenue generation.
Shared Charging Facilities vs. V2G	May be compatible	• Technical integration between the two models is feasible, but commercial and contractual complexities may arise, particularly around the participation of third-party vehicles in grid services.

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