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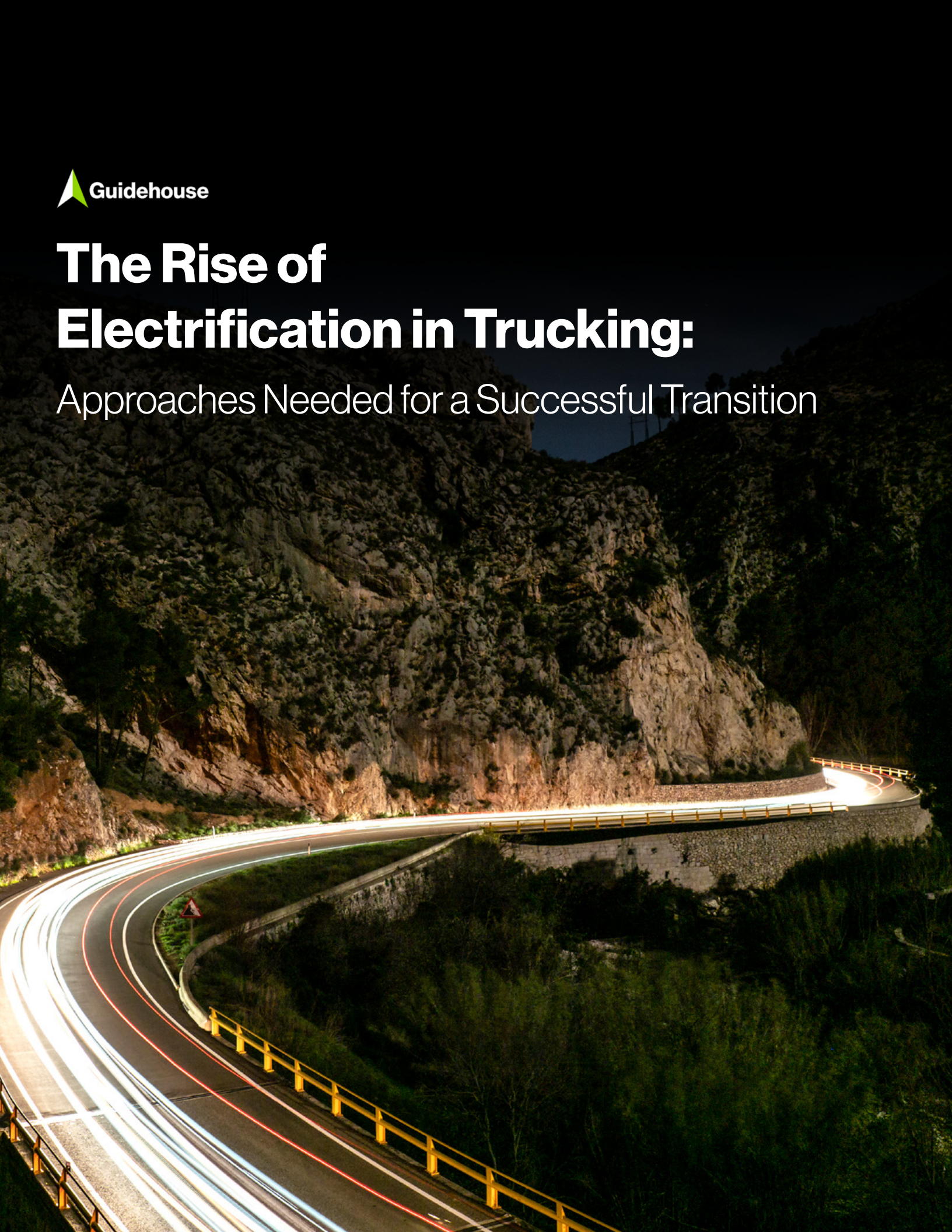
The Rise of Electrification in Trucking:

Approaches Needed for a Successful Transition



INTRODUCTION

Trucking is no stranger to change. The history of the global road freight industry is one characterized by change, and industry is well accustomed to confronting, assimilating, and adapting to it. But the era of decarbonization and the post-Paris Accords world represents less of a change than a revolution—diesel is no longer fit for purpose, so a new energy solution must arise.

Vehicle emission concerns are nothing new, having been of regulatory interest since the 1970s. Initially based on various Clean Air Acts, regulations focused on reducing Nitrogen Oxide (NOx) and particulate matter (PM), not greenhouse gas (GHG) emissions. NOx and PM regulations grew popular and today these regulations cover much of the global heavy commercial vehicle (HCV) market. Emissions reductions regulation over the past 30 years has been remarkably successful. Today's trucks are very clean; as a European example — it would take around 40 heavy duty trucks manufactured to today's regulatory standards to emit the same amount of NOx and PM as just one truck manufactured to the 1990 standard. The focus on NOx and PM is, however, fading, and upcoming iterations of these emissions will likely be the last as industry moves beyond the internal combustion engine (ICE), driven by increased focus on GHG.

The 2015 Paris Accords is a cornerstone of the regulatory trend. It established broad government support for reducing GHG emissions, as well as the mechanisms by which key private sector stakeholders could demonstrate support. Emissions reporting would now demand organizations to measure not only the impact of their operations (classified as Scope 1 emissions) but also the emissions of their suppliers (classified as Scope 3 emissions). With the emergence of environmental, social, and corporate governance investing, suddenly decarbonization is all the rage.

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Decarbonization Options

While the goal of decarbonization in trucking is straightforward -the replacement of a GHG-fuel with one not contributing to GHG emissions- the path to achieve it is anything but simple. Numerous approaches are in service, or being tried, and still more are in development. There are, however, three leading solutions: electricity, hydrogen, and renewable diesel.

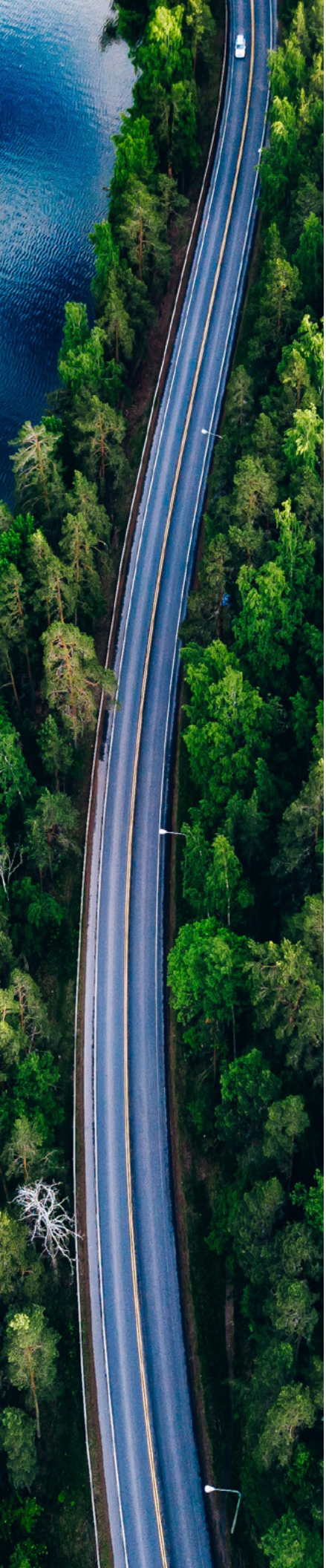
At present, **electric vehicles (EVs)** are the most developed. Legacy original equipment manufacturers (OEMs) have products in serial production, while non-legacy OEMs are near market-ready. EVs are improving rapidly, driven by strong momentum from private sector investment. However, demerits — battery weight cutting into the payload carried by each truck and the paucity of public charging solutions — present challenges.

Hydrogen

Hydrogen**,** either through fuel cell trucks or ICEs, have operational advantages over EVs, such as improved range (~750 miles as opposed to ~275 miles) and less refueling downtime (~15 minutes as opposed to ~60 minutes), and lower weight penalty (1%-2%) compared to (10%-30%). However, hydrogen infrastructure and vehicles are still not fully commercialized, with only a few legacy OEMs yet adopting the technology beyond R&D and experimental phases. Beyond a commercially available vehicle product, the lack of fueling infrastructure from generation to distribution, is a significant challenge. The Department of Energy (DOE) Hydrogen Hub program aims to tackle this problem by allocating $8 billion to develop regional hydrogen hubs. These hubs are partly intended to help establish the first hydrogen refueling networks and facilitate the nationwide expansion of hydrogen vehicle deployment. Additionally, the Inflation Reduction Act (IRA) offers incentives for hydrogen production, making hydrogen fuel more cost competitive for transport applications.

Renewable Diesel

Renewable diesel is a diesel-like fuel extracted from renewable feedstocks such as used cooking oils. Its key advantage is that it can be consumed within existing vehicle and infrastructure technologies. One challenge is that while the fuel may avoid GHG, it will still produce tailpipe NOx and PM emissions. An additional challenge is that the theoretical capacity of the feedstock resource base has significant limitations, plus challenging economic issues that are likely exacerbated by upcoming demands from the decarbonization of commercial aviation and shipping sectors. These sectors have far fewer feasible decarbonization options and are therefore likely to focus on renewable diesel feedstocks siphoning away supply from the trucking market and therein presenting upward pressure on prices.



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A Pathway to Net Zero is Emerging

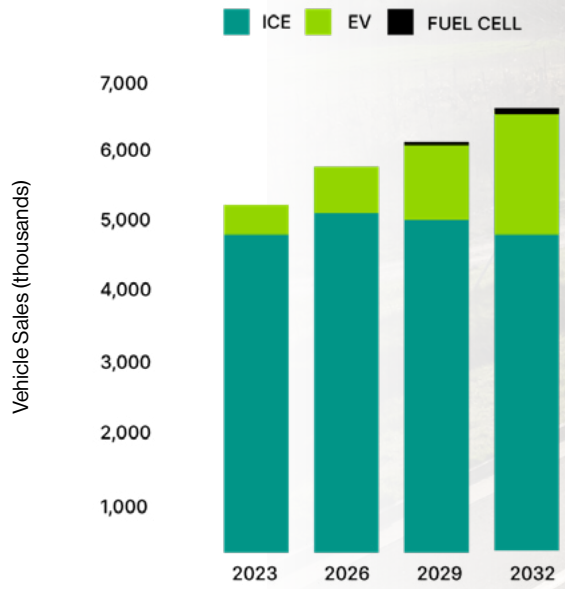
Of the alternatives, EV technology currently has a lead and the rationale is simple. Diesel's replacement must meet three factors:

- **Compliance with relevant regulations**
- **Operational viability**
- **Availability. EVs are, at present, the only alternative satisfying these.**

While any transition of this magnitude is not going to be without its hurdles, the acceptance of battery electric heavy trucks is growing. This likely provides very valuable first mover advantage within the context of the transition away from ICE. Trucking is a pragmatic business and one that views the efficiency of the outcome as more valuable than the elegance of the pathway to that solution. As such, the basic zero-sum economics likely come into play as procurement patterns increasingly coalesce around a battery solution. At some point the economics of volume – from both ends of the value chain will start to hit, rendering the challenge yet more arduous. There is ample historical evidence to support this view. Euro V and EPA 2010 regulations both required significant tailpipe emissions reductions and, during the lead-up to their respective implementations, many alternative technologies emerged to meet the regulatory requirements. The market, however, focused on selective catalytic reduction (SCR) on the basis not just of its availability, but also of its adoption by most of the legacy OEMs. A decade later, SCR technology is the global standard for heavy vehicle NOx and PM emissions reduction. A similar pattern is at play with GHG and EVs having the first-mover advantage.

While EVs have promise, their efficacy across all applications remains in question, and thus hydrogen or renewable diesel may play a role in satisfying duty cycles where EVs are not ready to support. Hydrogen-based drives can be the better solution especially for flexible and demanding applications like long-haul. Exogenous forces, such as the emergence of automated trucking, could disrupt EV momentum or accelerate it, depending on the nature of future energy infrastructure attributes and how truck operators value these attributes. Grid infrastructure may also struggle to support an all-EV fleet of trucks as EVs in light and heavy-duty markets become more numerous. This may highlight a need for a diverse technology mix. Regardless of whether EVs prove themselves to be broadly applicable, it will take decades before the in-service fleet can transition to electricity or hydrogen. In the meantime, renewable diesel will play a significant role in reducing emissions from the legacy ICE-based fleet.

New Heavy-Commercial Vehicle Sales by Powertrain, World Markets



Source: Guidehouse Insights

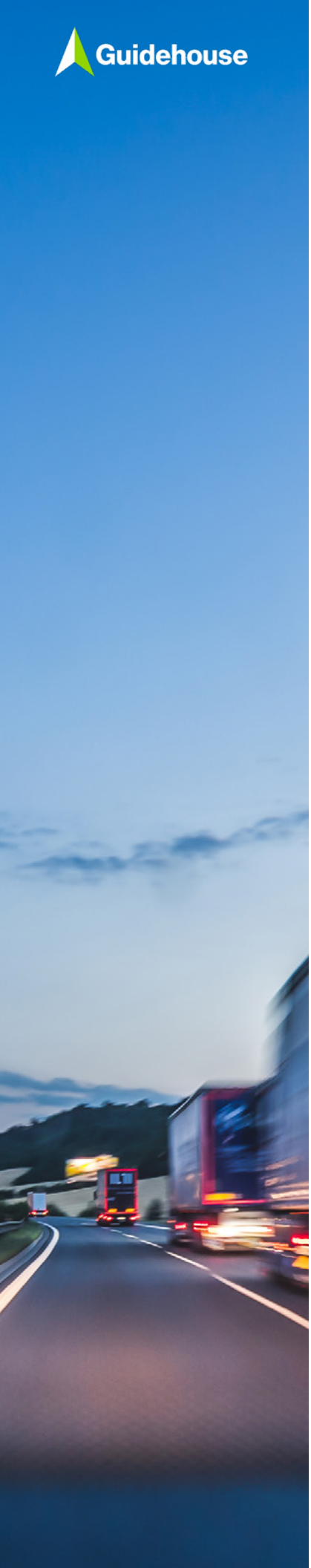
Business Model Rewrite

While the end result remains the same — trucks will still deliver freight and demand significant reliability for uninterrupted deliveries — the impact of electrification on the value chain is seismic. Suppliers, OEMs, dealers, and truck operators are going to be confronted with an entirely new and, for some, an entirely unwelcome landscape. Viability of stakeholders is likely predicated on the ability to adapt and make hard choices.

The modern ICE-powered truck is a complex machine with an equally complex value chain. As demand for the ICE wanes, so too will the viability of smaller suppliers within the chain. The impact of potential market exits by such suppliers could be considerably damaging to OEM brands that have not prepared adequately for the technology phase-out. Thus, legacy OEMs face significant challenges in operating the necessary R&D to create the EV market while maintaining services for the legacy fleet.

The transition is not only operationally challenging, but also financially punitive. Abandoning the ICE abandons revenues from aftermarket parts. Most OEMs book around 20% of revenue from aftermarket business, and 70% of this revenue is tied to the ICE. Contribution to margin by this segment is also considerable. Aftermarket revenues for EVs are unclear, but it is possible that lessened recurring maintenance requirements will significantly reduce aftermarket revenue. The pain here falls considerably on dealers as aftermarket services are where the largest proportion of profit is. Should dealers exit, OEMs will lose servicing infrastructure and this may have damaging consequences for brands.

Challenges are, however, not just upstream. Moving to EVs will be disruptive for truck operators requiring many costly decisions of which vehicles to procure, when to procure them, what type of infrastructure to use, what technicians to hire, and so on. There are also additional uncertainties and risks inherent in the adoption of such a new technology, including the reliability of its expected performance, or how quickly existing infrastructure systems will be rendered obsolete, or what the reasonable expectations for residual value are.



Connecting the Supply & Demand Challenges

The challenges for fleets are likely to drive them toward an asset-light model, such as-a-Service (aaS). This concept is not new. Providers of EV and automated vehicle technologies have been pitching aaS in fleet markets for years. At its core, the concept is effectively bundling new technology uncertainties and risks into monthly subscriptions or pay-as-you-go fees. Advantages for suppliers include a recurring revenue stream that can offset some of the expected aftermarket services diminution, and visibility on technology use and performance that can enhance future product planning. Advantages to the fleet are that capital pressures for financing upfront costs of EV technology procurements are relieved. So too are many of the decisions regarding vehicle procurement and infrastructure development — but not all.

The aaS model has its limits. Assets that are not easily repossessed by suppliers are less attractive to finance. Therefore, the underlying electrical infrastructure at fleet depots and parking structures needed to connect charging equipment to grid infrastructure will likely require ownership by the fleet or its property lessor. Thus, fleet and facility managers must still address challenging decisions regarding what their fleet will look like and how it will be charged.

An additional limitation is the expectation that investments in EVs pay themselves back through reduced energy and maintenance costs. Whether this is true or not will vary for each fleet. Achieving payback will, however, be more challenging when the fleet manager's costs include uncertainty and risk. To get around these limitations, aaS providers need to either demonstrate an expertise advantage and/or total cost of ownership (TCO) savings.

Demonstrating expertise is challenging in the early market. Few can confidently claim expertise and early adopters can be expected to have done their research or have sufficient capital to bear risks and uncertainties at low to no financing cost. As the market expands from early adopter to early majority and beyond, the expertise advantage may become more attractive.

More important is getting to TCO savings. To do so, OEMs or fleet service providers could use performance-based contracting, whereby the aaS fees are no more than the historic, relevant displaced costs for energy and maintenance. Doing so profitably, though, is probably a challenge because the fundamental technology costs may not yet be there.

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What Does Guidehouse Suggest?

The momentum for EVs is strong. Despite economic turbulence, private investment in EVs remains robust and the prospects equally so. The impact and permanence of other decarbonization technologies is highly uncertain, EVs less so. As the market coalesces around EVs, it will become more and more competitive. New OEMs, free from the burden of maintaining or reconfiguring legacy manufacturing lines, can push the engineering envelope to achieve highly competitive performance specifications. The fleet market is not, however, the light-duty vehicle market. It is more practical, and in this regard, legacy OEMs have an advantage if they can gracefully translate the trust in their product quality and their services model from the ICE to the EV. As such, Guidehouse recommends:

Temper aaS Expectations

The aaS model appears to hit all the right elements of addressing customer pain-points. It is, however, easy to overestimate the magnitude of the pain-points, as well as to underestimate the resourcefulness of early adopters. The business model inherently requires a new level of trust between OEM, service provider, and fleet operator. Establishing this trust will take time, and it is a challenging argument that no OEM has yet figured out for EVs. Therefore, have an aaS option, but do not lean on it.

Expect Losses

The industry transition to EVs will likely negatively impact legacy OEM market share as well as revenue. It is not so much a question of if, but when. Profitability from Day 1 should be the expectation of the fleet, not the OEM. Adopting this perspective increases costs at market outset in return for market share and experience. This builds trust that can translate to future success.

Focus on Services

While EVs wipe out some servicing value streams, they may also create new ones. For example, an EV fleet could be tapped to provide services to grid markets, or the EV battery could be continuously monitored within a program intended to optimize the battery value for second-life markets. Developing innovative solutions in nuanced areas of EV technologies, like energy management or second-life markets, establishes brand and addresses key unknowns to EV ownership for many fleets, early adopter or otherwise.

About Guidehouse

Guidehouse is a leading global provider of consulting services to the public sector and commercial markets, with broad capabilities in management, technology, and risk consulting. By combining our public and private sector expertise, we help clients address their most complex challenges and navigate significant regulatory pressures, focusing on transformational change, business resiliency, and technology-driven innovation. Across a range of advisory, consulting, outsourcing, and digital services, we create scalable, innovative solutions that help our clients outwit complexity and position them for future growth and success. The company has more than 16,500 professionals in over 55 locations globally. Guidehouse is a Veritas Capital portfolio company, led by seasoned professionals with proven and diverse expertise in traditional and emerging technologies, markets, and agenda-setting issues driving national and global economies. For more information, please visit guidehouse.com.

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