BERYLLS STRATEGY ADVISORS

TRUCK CHARGING: THE CHALLENGES IN ITS QUEST FOR DECARBONIZATION

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INSIGHT

AGENDA

INTRO

The trucking industry is faced with a formidable challenge in its quest for decarbonization, given its substantial climate footprint. The International Energy Agency reports that a staggering 40% of global road transport emissions originate from this sector. Within the European Union, road transport is responsible for a significant one fifth of total greenhouse gas emissions, with an alarming upward trajectory. Recognizing the urgency, the European Commission has charted a course for change, announcing a planned revision of carbon emission standards for heavy-duty vehicles in 2023. This proposal has set a very ambitious target, i.e. a 90% reduction in carbon emissions per kilometer driven for new heavy-duty vehicles, using the reference period spanning from July 1, 2019, to June 30, 2020.

The European Commission has set interim goals for most new trucks to reduce emissions by 45% by 2030, 65% by 2035, and 90% by 2040, and has also called for a higher share of zero-emission vehicles. According to recent estimates by the International Council on Clean Trans-portation (ICCT), if all manufacturer pledges are met, the EU will be able to achieve its climate goals. However, the conversion of these pledges into regulations will require a 60% target by 2030 (as compared to the proposed target of 45%), 90% by 2035 (as compared to 65%), and 100% by 2040 (as compared to 90%). Against this backdrop of environmental commitment and regulatory transformation, the trucking industry is at a pivotal juncture that calls for strategic reevaluation and innovation.

When it comes to long-distance transport, it is imperative to prioritize effective ways of cutting carbon emissions and sustainable drivetrain technologies play a vital role in this respect. While an internal combustion engine (ICE) has an emission reduction potential of only 15%, a battery electric vehicle (BEV) can reduce emissions far more substantially. There is a major push to-wards reducing carbon emissions and electrically powered trucks are a big part of that.

For the popularity of battery electric trucks to truly take off, however, three factors need to be addressed, i.e. economic viability, range, and charging speed compared to their conventional counterparts.

The undeniable economic viability of electric trucks is clearly demonstrated by their total cost of ownership (TCO). The industry's focus on TCO ensures a smoother transition to decarbonization, while drivers benefit from perks such as faster acceleration and reduced driving noise.

Original Equipment Manufacturers (OEMs) have already launched electric trucks with a range of more than 400 kilometers, a considerable development, particularly for long-haul routes. This increase in range is a game changer for the long-haul market, implying that widespread decar-bonization can be achieved once we overcome the current technical and charging infrastructure challenges.

However, despite the advances in electric truck technology, building the necessary infrastructure remains a hurdle. European Union regulations mandate truck driver break times, necessitating infrastructure that enables recharging within 45 minutes for the available 300–400 km range. Addressing this rapid charging requirement is a critical factor. While OEMs play a fundamental role in achieving technological advancements, the collaboration of all stakeholders is essential to ensure the long-term viability of electric trucks.

1

EMBRACING AFIR FOR A SUSTAINABLE FUTURE

Amid the pressing environmental challenges, regulatory steps are emerging as a pivotal lever for guiding industries along a true pathway towards sustainability. The recent adoption of the Alternative Fuel Infrastructure Regulation (AFIR) by the European Council marks a decisive step forward in steering the transport sector towards net-zero emissions, harmonizing with the overarching aims of the EU's "New Green Deal."

AFIR's objectives for the trucking industry are twofold and strategically aligned to combat the carbon emissions challenge. Firstly, it aims to establish a comprehensive infrastructure network that facilitates the refueling or recharging of commercial vehicles with alternative fuels, thereby reducing carbon emissions. Secondly, it strives to achieve full interoperability across the EU to ensure widespread infrastructure usability.

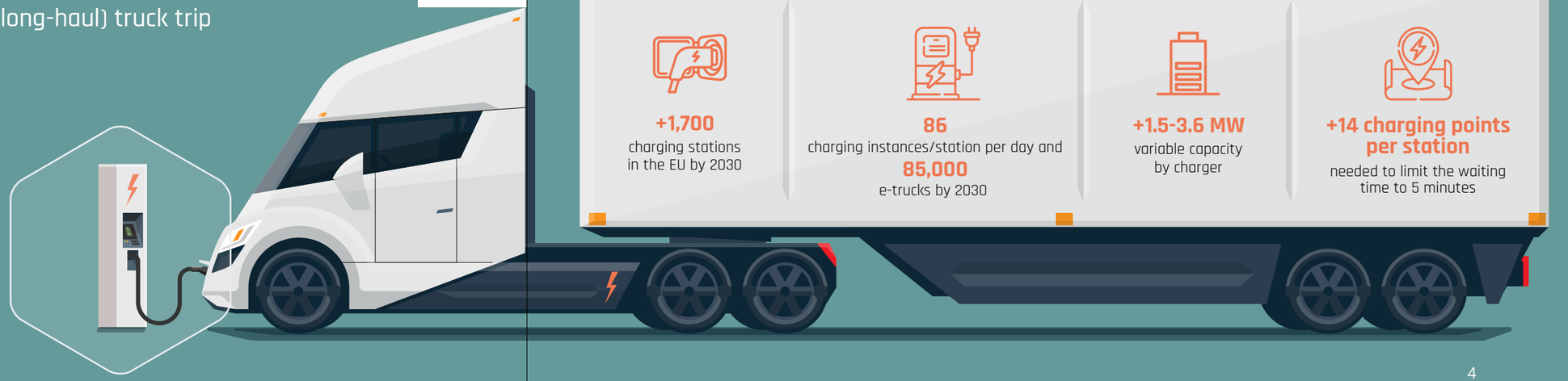
As the graphic shows, the core network of the "Trans-European Network – Transport" (TEN-T) is regarded by the European Union as the principal route system. This network encompasses both existing and future connections for road, rail, air, and marine refueling stations within the EU.

THE ELECTRIFICATION OF THE TRUCK INDUSTRY CHANGES THE OVERALL BUSINESS

The impact of electrification extends across the entire trucking environment, encompassing the charging infrastructure along highways to the daily routines of long-haul trucking.

MAIN CHALLENGES OF TRUCK ELECTRIFICATION

1. Electrify the highway
2. Electrify the fleet
3. Electrify the (long-haul) truck trip



1 TEN-T Core network displayed
Source: Berylls Strategy Advisors, European Commission

1

DEEP DIVE: ELECTRIFY THE HIGHWAY ON MAIN EUROPEAN ROUTES[1]

According to the stipulations, charging facilities are mandated to be installed at intervals of 100 kilometers throughout the vital TEN-T network and at 60-kilometer intervals along the "core routes" threading through the EU, a benchmark scheduled for achievement by 2030. This deployment strategy will culminate in a total of some 1,700 charging stations spanning the entire EU.

+1,700
charging stations in the EU by 2030

86
charging instances/station per day and
85,000
e-trucks by 2030

+1.5-3.6 MW
variable capacity by charger

+14 charging points per station
needed to limit the waiting time to 5 minutes

The primary aim of the initiative entails installing these charging stations along 50% of the EU's main transport routes by 2028, providing a variable capacity ranging from 1.5 megawatts to 3.6 megawatts, depending on the charging location.

While this blueprint embodies a substantial step towards a more sustainable transport model, a fundamental question presents itself: Is it sufficient to merely introduce quantifiable steps towards achieving an ecologically balanced future for the transportation of goods?

The charging locations outlined and mandated by the AFIR pose various questions regarding the sum total of energy and charging points required for each location. To minimize charging time on the road, electric trucks are most likely to start their trips fully charged, optimizing recharging during loading and unloading at destinations, and resorting to "opportunity charging" en route at nearly 50% of public charging locations – a measure chiefly calibrated to coincide with the mandatory 45-minute steering break every trucker is required to observe after a 4.5-hour driving stint.

Within the legally stipulated driving times, trucks cover distances of 300–360 kilometers, with a corresponding energy consumption of approximately 360–430 kilowatt-hours, necessitating a recharging time of approximately 30 minutes, taking waiting and plug-in intervals at charging stations into account. This equation results in an average charging power of 720 kilowatts, accentuating the imperative for high-capacity charging exceeding the 1-megawatt threshold.

In line with the sustainability goals of the "New Green Deal," a fleet of nearly 85,000 electric commercial vehicles will be on Europe's roads and, by extension, almost 150,000 charging procedures at public and semi-public charging stations will take place daily in the EU by 2030. Aligning this figure with the prescribed number of AFIR stations, each station is set to accommodate 86 charging procedures per day.

The key question therefore arises: How many charging points will be required at each station? Since routes with higher volumes of traffic tend to align with the TEN-T core network, characteristically interspersed with shorter intervals between stations, uniform utilization across stations within the EU's sphere of influence is a plausible assumption. Although the per-hour average utilization per charging point stands at 4.17% (evenly distributed across the day), actual observations on German highways show that up to 8.5% of daily trucks arrive within one hour, translating to an average of 3.5 charging procedures and a peak of 7.3 procedures per hour. Consequently, each location requires a minimum of 3 charging points to cover average charging needs, while the surge in demand during peak hours warrants an upper limit of 14 charging points, if waiting time is to be limited to 5 minutes. Underpinned by this analysis, fueling the skepticism regarding the technology's readiness for full commercial usage by 2025.

All in all, the prescribed intervals between charging stations set out in the AFIR can be considered adequate, with 6 chargers per station emerging as a judicious number in line with average truck stop proportions. However, a closer look at the prescribed charging capacities of 1.5 megawatts or even 3.5 megawatts per station reveals a significant underestimation of the urgent requirements of the logistics sector by 2030.

2

NAVIGATING THE AFIR FRAMEWORK

The issue of electric transportation is as much about infrastructure as it is about widespread vehicle adoption. The widely discussed AFIR initiative underpins a supply-driven strategy for network expansion. Yet, as the demand for battery electric vehicles (BEVs) grows, the pivotal question emerges: Will the AFIR's supply-side approach be able to adequately cater to this burgeoning demand?

A deep dive into the OEMs' "Clean Room Talks" ramp-up curves, juxtaposed with our models, suggests a potential misalignment. The OEM model underscores a surging trend, i.e. a marked rise in newly registered battery electric trucks. Forecasts indicate that these BEVs could constitute 57% of the fleet by 2030. Comparing this rapid adoption with the AFIR's current charging infrastructure blueprint paints a concerning picture - the available infrastructure could fall short of the growing demand.

However, these forecasts should be approached with caution. Our analysis suggests potential overestimations, with OEMs possibly projecting overly positive sales figures. The reality, according to the ACEA report, is sobering: BEVs currently represent a mere 0.6% of market share, a far cry from the Clean Room Talks' 5% projection in 2024. The previously anticipated 9% share of BEVs by 2025 now seems overly optimistic.

Our revised outlook, as illustrated below, suggests a more grounded projection of 5% by 2025. This revised figure suggests a steeper climb to 25% BEV adoption by 2030. The previously envisioned 57% BEV market share now seems more of a lofty dream than a probable reality.

Even armed with these conservative figures, one conclusion remains unaltered: A significantly more substantial investment in charging infrastructure is non-negotiable in order to pave the way for an electrified future in the world of trucking.

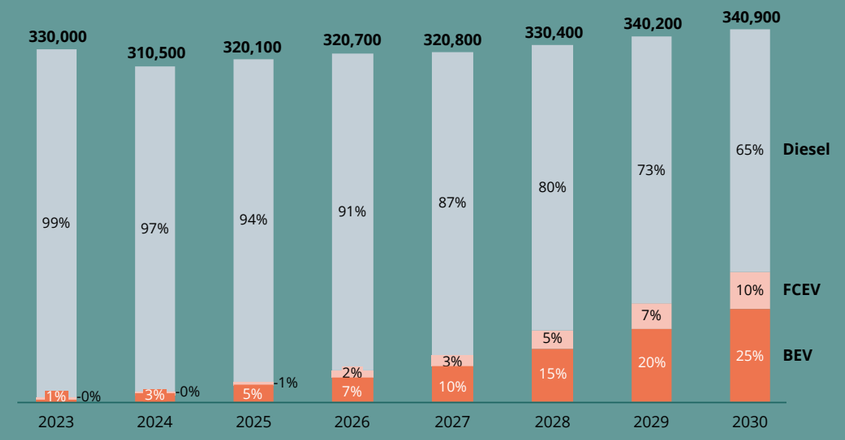
2

DEEP DIVE: ELECTRIFY THE LONG-HAUL FLEET

The electrification of trucking faces conflicting goals, as the push for fleet electrification necessitates the electrification of routes – due to the associated costs, we anticipate a gradual but steady increase in the share of electrified trucks

STEADY MARKET DEVELOPMENT WITH STRONG ELECTRIFICATION

Heavy-duty commercial vehicle sales forecast, class N3 (> 12 t GVW) in Europe



COMMENTS

- The current market share for battery electric vehicles (BEVs) is just 0.6%, far from projected figures
- Berylls model suggests a 5% projection in 2025 and 25% BEV adoption by 2030
- Significant investment in charging infrastructure is essential for an electric future in trucking
- While Alternative Fuel Infrastructure Regulation (AFIR) sites offer sufficient charging station coverage, much like battery-electric passenger cars, the key to cost-effective and seamless use lies in having the right number of charging points at each station
- Truck drivers' user journeys must consider daily routines such as rest breaks, charging times, and servicing

In conclusion, the presence of AFIR sites ensures that the area will have adequate network coverage. Nonetheless, it should be emphasized that more than merely having access to charging capacity is needed to meet all the requirements. There may be additional factors to consider, such as the specific driving patterns of long-haul truck drivers, contributing to a seamless user experience.

Source: Berylls Strategy Advisors

3

MEGAWATT CHARGING AND THE FUTURE OF LONG-HAUL TRUCKING

Charging capacity remains the most significant barrier to electric long-haul trucking – not only due to the infrastructural challenges, but also because it is changing conventional long-haul operations. While diesel trucks typically need refueling only once every few days, electric trucks must be charged on a daily basis, effectively making charging an integral part of daily trucking operations.

Two key parameters that would increase the acceptance of battery electric commercial vehicles are longer ranges and shorter charging times. Charging time, which can be quantified as distance per time unit set, should be considered across the entire fleet and also take into account lost charging time due to delayed charging or even charging equipment issues. Megawatt Charging Systems (MCS) offer the charging rate necessary to realize the widespread adoption of battery-powered electrification in the commercial vehicle market by increasing the driving range gained per minute spent charging. MCS also offers improved communication robustness, reducing downtime related to failed setting events. MCS chargers must be accessible by large commercial vehicles requiring drive-through capabilities.

THE A TO B ROADTRIP MAP

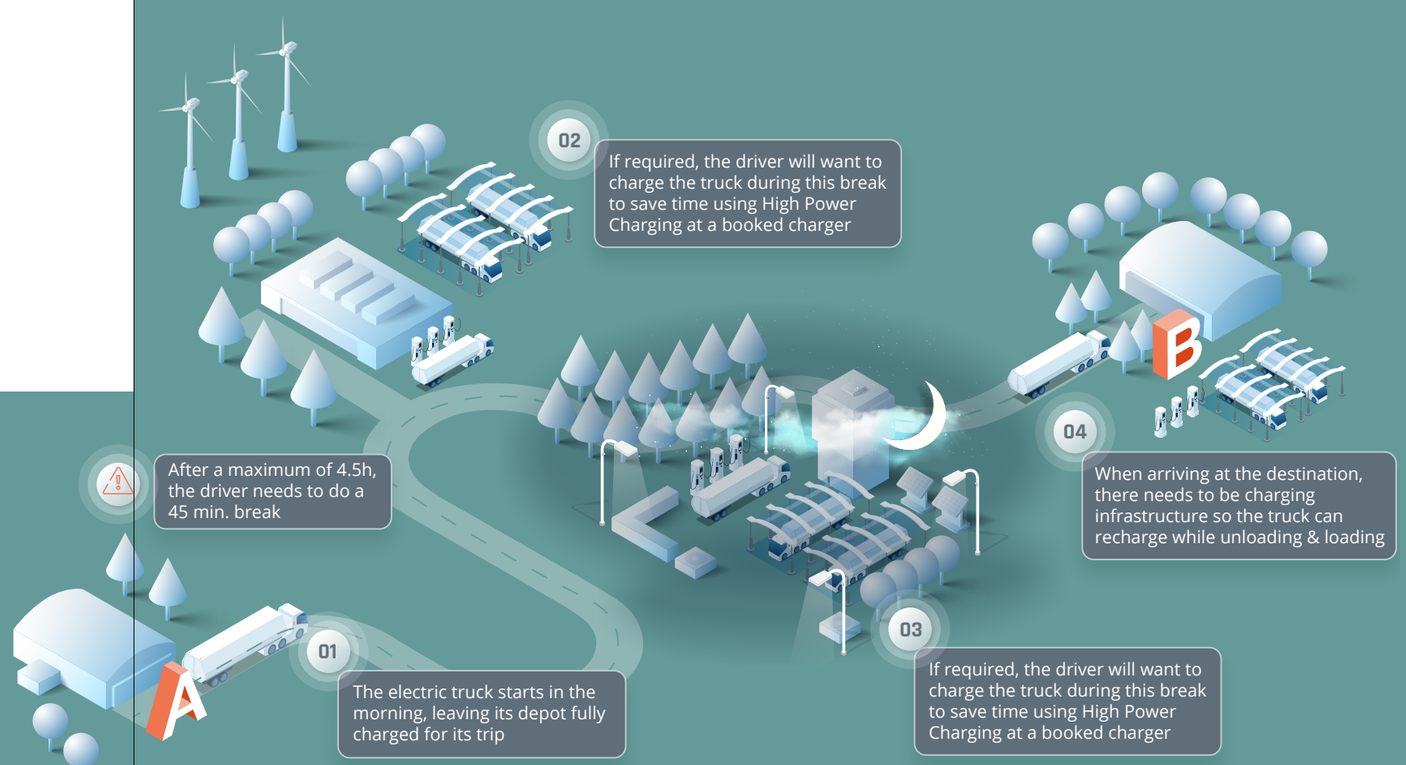
The standard for MCS is set to be developed by the end of 2024, with the current focus on the plug and the communication protocol between the charger and the truck. From Q2 2025, MCS chargers will be available for purchase and installation. The first product generation will have level 2, which translates to 1.2 MW. Level 3 with 1,250 V and 3,000 A will also be technically feasible going forward, as charger development follows the vehicle in terms of specification, not vice versa. Charging stations will have complex charging management and battery buffer storage systems to determine grid load and charging management will selectively limit power if the required battery capacity can be charged in less than 45 minutes. Gradual scaling is assumed, with the ratio of MCS to CCS being about 1:4. The adequate peak power per site will be about 50% of the nominal capacity.

In the world of electric truck charging, several players have distinct roles. The Charging Point Operator (CPO) ensures that the physical charging infrastructure is operational, secure, and well-maintained. eMobility Service Providers (eMSPs) offer seamless services to EV owners, including access to charging networks and payment processing.

3

DEEP DIVE: ELECTRIFY THE (LONG-HAUL) TRUCK TRIP

Electrification transforms daily routines in long-distance trucking, requiring charger reservations and offering charging opportunities at loading and unloading destinations



Original Equipment Manufacturers (OEMs) contribute to integrating charging solutions, offering tailored setting options for their vehicle models.

Freight forwarders need to consider charging infrastructure when optimizing transportation logistics for electric trucks. By working collaboratively, these players can help accelerate the adoption of electric trucks and develop a reliable charging network.

In the following chapter, we will focus on the various market players and provide them with helpful recommendations.

Source: Berylls Strategy Advisors

4

CALL TO ACTION

In the world of e-trucks, the services market players offer play a crucial role in setting them apart from their competitors. However, this also means that the complexity of the systems powering these services is constantly increasing. However, simply investing in vehicle innovation is no longer enough for market players from OEMs to freight forwarders to remain competitive. In response to these evolving dynamics, we offer tailored guidance specific to various stakeholder groups:

1.

OEMs: To increase both customer satisfaction and operational flexibility, OEMs should expand and adapt their fleet management systems. Furthermore, they need to strategically integrate themselves in the charging revenue and return system and engage with eMSPs for more robust data monitoring. The development of a truck-as-a-service model, which includes energy costs, can be a valuable addition. These strategic steps are imperative in order to reduce dependence on intermediaries.

2.

CPOs/eMSPs: Prioritizing site security and regular power grid capacity monitoring is paramount. While there may not be an immediate need to install the final charging station network, it is crucial to prioritize the construction of the primary network and focus on designing an effective expansion plan for the final network. This approach will ensure that the charging station infrastructure is developed both strategically and efficiently. However, it is imperative to proactively address energy and grid capacity availabilities as soon as possible. Combining over-night and opportunity charging options in a convenient one-stop location can save time and streamline the process for truck drivers. Implementing charging management strategies to optimize energy us-age is a critical factor.

3.

eMSP-specific: Improving data monitoring, including locations in OEMs' navigation and routing systems, is highly recommended. Incorporating dynamic pricing in routing systems can provide CPOs with insights into truck charging patterns. For more details on optimizing energy usage, see Berylls "Insights" on second-life batteries.

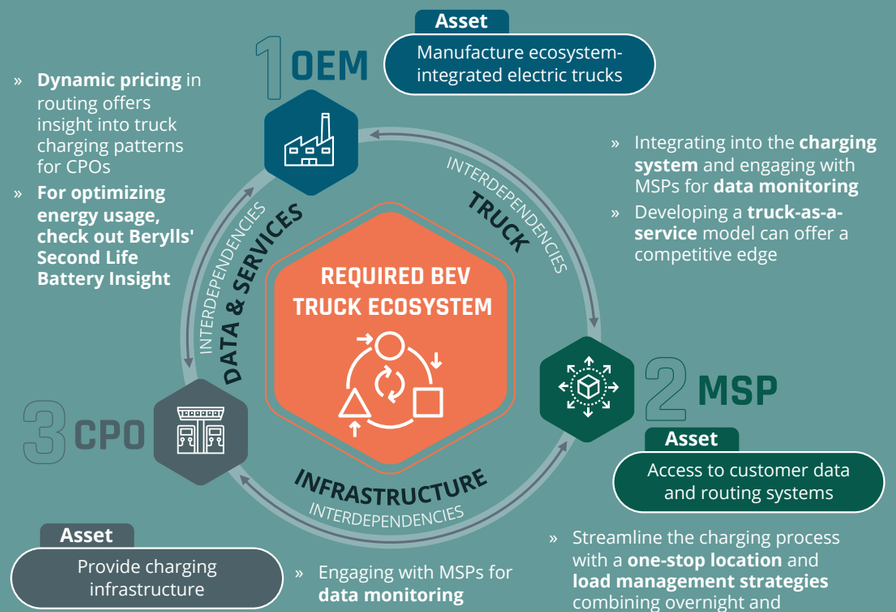
4.

Freight forwarders: Long-term planning is essential, especially when it comes to fleet management. Developing a comprehensive strategy for the coming decade while optimizing electricity costs is crucial. Given the rising energy consumption, exploring cost-saving measures such as photovoltaic (PV) systems, renegotiating contracts, or partnering for public and semi-public charging also need to be considered. These proactive measures will help better position your business to tackle future challenges.

4

DEEP DIVE: WHAT IS IN IT FOR THE MARKET PLAYERS?

Our call to action is for all market players to recognize the pivotal role of distinctive services in e-trucks' competitive landscape, helping customers navigate the escalating complexity of underlying systems



WHAT TO TACKLE FIRST:

OEM: Enhance customer **satisfaction and operational flexibility**

MSP: Improving **data monitoring**, including locations in OEMs' navigation and routing systems

CPO: Next to building the necessary charging stations, prioritizing **site security and regular power grid capacity** monitoring is paramount

Source: Berylls Strategy Advisors

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Berylls Strategy Advisors – The expertise of our top management consultants extends across the complete value chain of automobility – from long-term strategic planning to operational performance improvements. Based on our automobility thought leadership Berylls Strategy Advisors stand out with their broad experience, their profound industry knowledge, their innovative problem-solving competence and, last but not least, their entrepreneurial thinking.

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