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ROUTE 2030 – THE FAST TRACK TO THE FUTURE OF THE COMMERCIAL VEHICLE INDUSTRY

September 2018

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EXECUTIVE SUMMARY

The truck industry is entering a new era: while revenue and profits are still mainly generated in the diesel world, new technologies are increasingly impacting OEMs' product and investment strategies. Truck OEMs seeking a leading position in new technologies face the challenging balance of keeping the incumbent business profitable and laying the foundation for the fundamental impacts that new opportunities such as alternative powertrains or autonomous driving will bring to the industry.

The report at hand sets out to quantify the risks and opportunities for truck OEMs to inform a discussion on the strategic actions OEMs need to take. We have arrived at this assessment of industry revenue and profit pool by quantifying the industry's development along 11 key trends. From this, three key messages can be derived:

We are positive on the industry's outlook – profit pools expected to grow by more than 40 percent (EUR 4.9 billion) to EUR 16.1 billion by 2030

Overall, the future of the global truck industry looks positive. Although we expect more moderate volume growth (CAGR of less than 1 percent until 2030), revenues and profits are expected to grow at CAGRs of more than 2 percent.

We expect total OEM profits to increase by EUR 4.9 billion to about EUR 16.1 billion by 2030 resulting in a slight industry profitability increase from 6.6 percent in 2017 to 6.7 percent in 2030 (Exhibit 1).

Additional profits from macroeconomic growth are eaten up by other market effects[1]

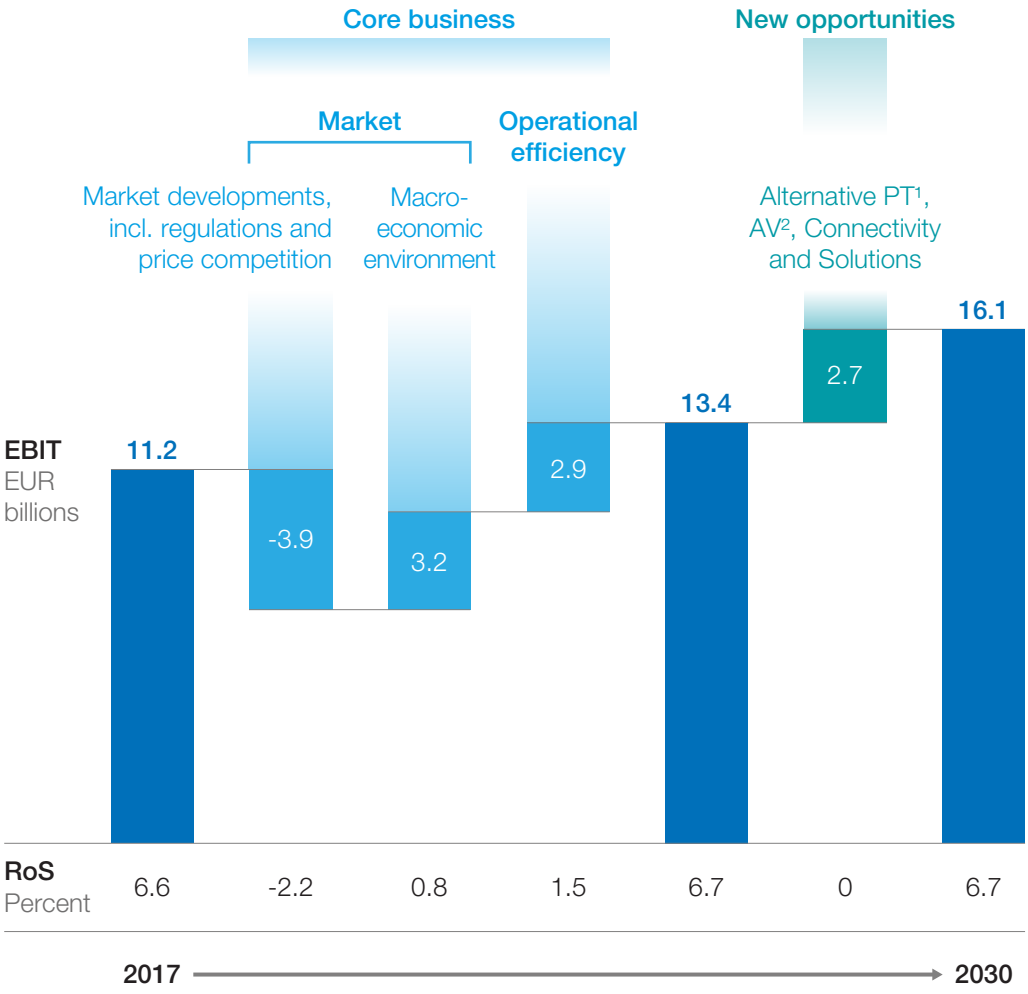
On the one hand, OEMs will continue to profit from the fundamental positive impact of economic growth across the globe resulting in increasing volume demand for trucks until 2030. However, other market-related revenue/profit drivers (mainly price pressure and regulatory measures) are causing significant negative impact on industry profits. The overall effect of these trends is slightly negative.

OEMs have two sources of value creation: increase operational efficiency and succeed in new opportunities

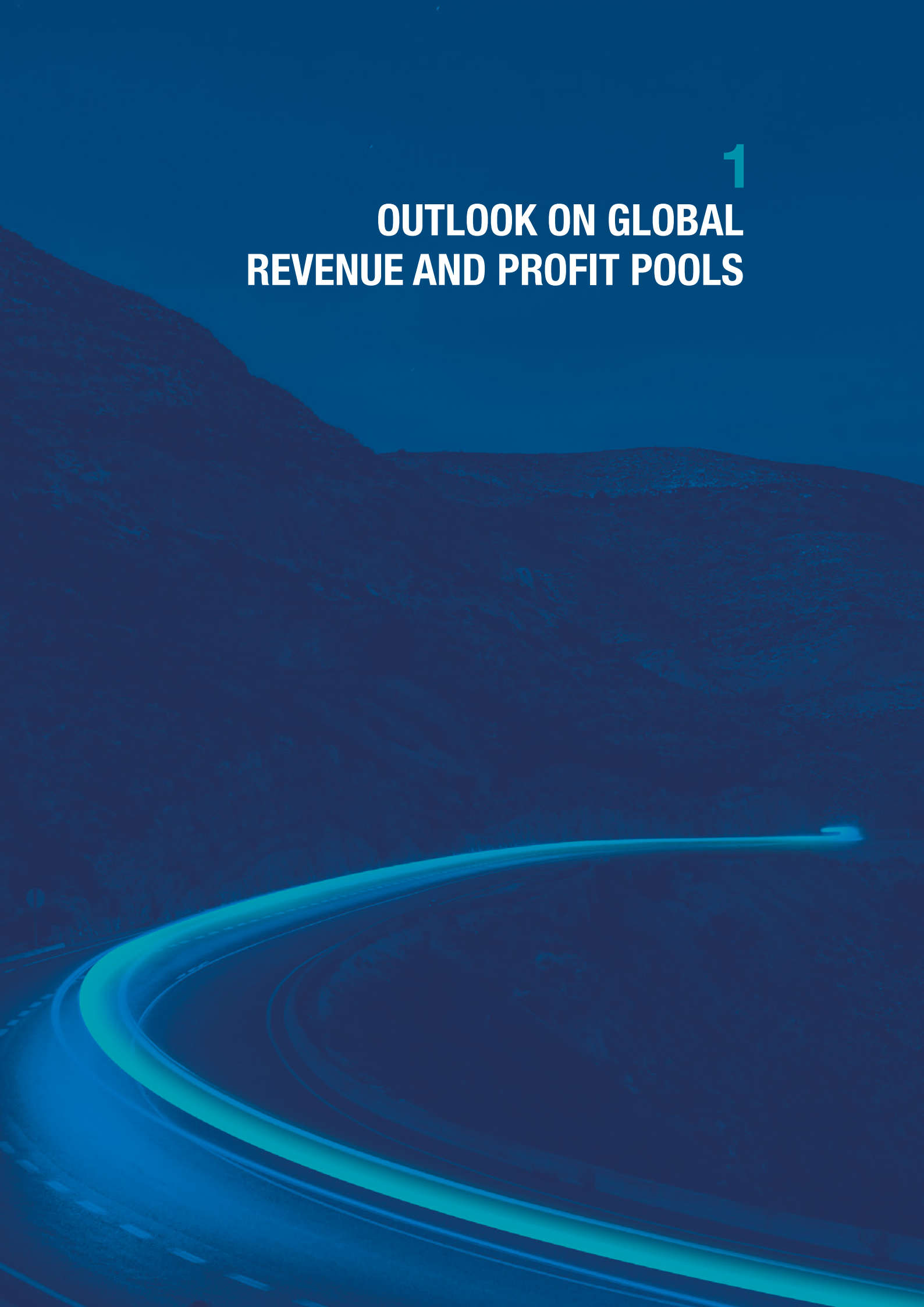
To cushion the negative profit effects from market developments, OEMs need to increasingly focus on operational efficiency and invest in new services and business models. Although OEMs have traditionally put great focus on operational efficiency, new technologies (e.g., advanced analytics, internal digitization) can enable efficiency improvements that lead to a profit pool increase of EUR 2.9 billion. New opportunities, like alternative powertrains, autonomous driving, and Connectivity and Solutions add another EUR 2.7 billion to the profit pool.

1 Price pressure, industry consolidation, emission regulation, EV cannibalization, classic aftersales opportunities

Exhibit 1 – Industry profits will grow by EUR 4.9 billion mainly driven by operational efficiency and new opportunities



1 Powertrain
2 Autonomous vehicles



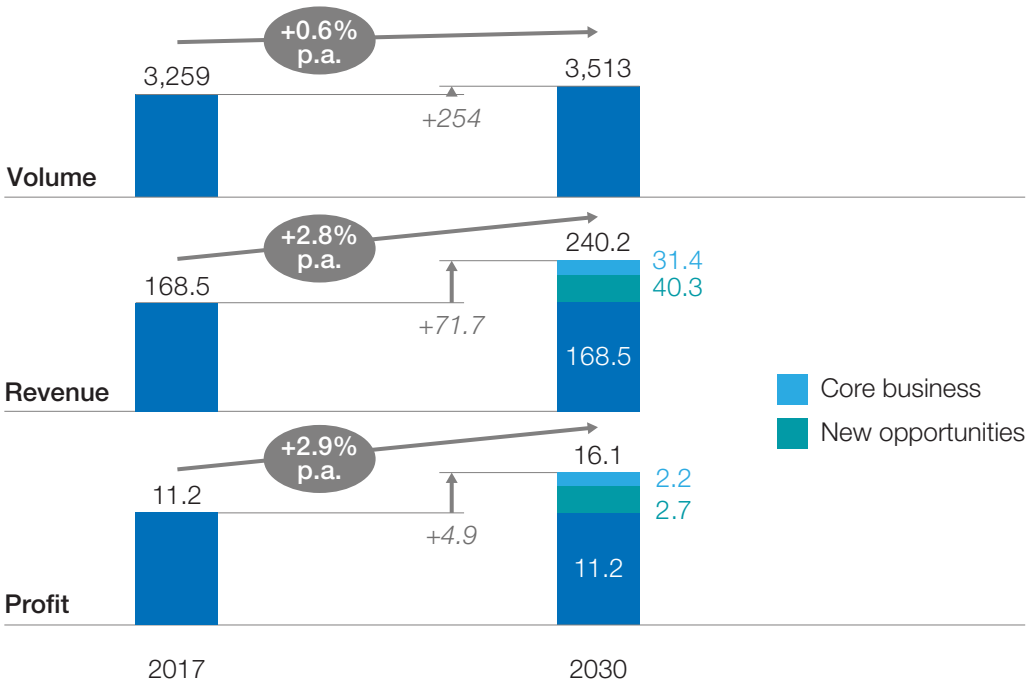
1
OUTLOOK ON GLOBAL REVENUE AND PROFIT POOLS

1.1 Overview of key results

In the following we present the key findings from our 2030 revenues and profit pool calculation (Exhibit 2).

Exhibit 2 – Despite stagnation in volumes, revenues and profits are expected to experience solid growth rates

New-truck sales volume (MDT/HDT) in thousand units; global OEM revenue and profit pool; in EUR billions



Source: McKinsey, IHS

Overall, we see a limited growth dynamic regarding volumes from about 3.3 million units in 2017 to about 3.5 million units in 2030, representing a CAGR of +0.6 percent. Volume data are based on current IHS forecasts. This modest rate of growth is due, in part, to unusual activity between 2015 and 2017, which led to the high 2017 baseline. Specifically, the prospect of regulatory changes in China led to the preponement of truck purchases for many customers. This surge in purchasing drove a steep increase of about 80 percent between 2015 and 2017.

Revenues and profits are expected to grow significantly stronger than unit sales at 2.8 percent and 2.9 percent, respectively. Main drivers for stronger growth of revenues and profits are an increasing share of aftersales business, additional technologies and services, and an overproportionate growth of high-margin segments.

The increase of the total revenue and profits until 2030 (EUR 71.7 billion and EUR 4.9 billion, respectively) will be the aggregate of the impacts of several trends across three industry categories: market developments, operational efficiency, and opportunities from new business models and solutions (Exhibit 3).

Market developments (including structural shifts) such as increasing competition, industry consolidation, higher emission standards, and EV cannibalization (i.e., the replacement of diesel trucks by BEV volumes) have a total negative effect of EUR 3.9 billion on the global profit pool. Combined with a positive effect of EUR 3.2 billion from structural shifts (i.e., volume increases), market developments negatively affect the global profit pool in 2030 by EUR 0.7 billion. Consequently, OEMs cannot rely on the market to "grow them into higher profitability" but rather need to focus on the areas of action that they can address.

Exhibit 3 – 11 major industry trends to shape revenue and profit pools in 2030[1]

EUR billions

Industry trends and respective impact		Revenues	Profits
Macroeconomic environment	Structural shifts	36.6	3.2
Market development	Price pressure	-2.7	-2.7
	Industry consolidation	0	0.5
	Emission regulation[2]	11.7	-1.6
	EV cannibalization	-19.1	-0.9
	Classic aftersales opportunities	4.9	0.8
Operational efficiency	Product cost optimization	0	1.1
	Operational efficiency	0	1.8
New opportunities	Alternative powertrains[3]	29.7	0.9
	Autonomous vehicles[3]	7.0	0.9
	Connectivity and Solutions	3.6	0.9
	Total	**71.7**	**4.9**

-5.2 (Market development, Revenues)
-3.9 (Market development, Profits)
0 (Operational efficiency, Revenues)
2.9 (Operational efficiency, Profits)
40.3 (New opportunities, Revenues)
2.7 (New opportunities, Profits)

1 Excl. inflation
2 Incl. CO_2/fuel efficiency standards
3 Incl. aftersales effect of EVs (- EUR 0.2 million) and AVs (- EUR 0.1 million)

Operational efficiency is and remains the main area of action for OEMs to increase profits. While cost programs have been a core element of the industry for a long time, new technologies (e.g., from digitization, automation, and artificial intelligence) continue to provide potential for cost optimization along the full value chain. Besides "simply" raising profitability, a focus on operational efficiency is also vital to finance required investments into new opportunities.

New opportunities represent the second major source of profit growth for OEMs. While the major trends are not new to the industry, we slowly start to see the impact of these trends on OEMs (e.g., through increasing investments or product launches). Interestingly, the overall profit potential arises in equal parts from the three major trends (alternative powertrains, AV, Connectivity and Solutions) indicating that there is no silver bullet to focus on.

Overall, it becomes evident that OEMs need to focus on operational efficiency programs and new opportunities to maintain their profitability levels.

Macroeconomic growth and demand for logistics services trigger demand for trucks
Reduced potential for price increases by 0 - 2.5% depending on region and new-truck sales/aftersales
Realization of cost synergies of 3% of M&A activities, likelihood of M&A differs by region
Migration costs to new emission and CO_2 norms ranging between EUR 2,000 and 7,000/truck
Loss of ICE volumes/margins through market share gain of BEVs
OEM market share gains of 10 - 15 percentage points at cost of third parties (depending on region); professionalization/digitization of aftersales
Share of modularized parts up by 10 percentage points across all regions reducing variable and R&D costs
Cost improvements across multiple cost types through digitization of operations ranging between 0% (e.g., raw material costs) and 30% (e.g., inventory costs)
Market penetration of alternative powertrains ranging between 5% (in low-profit regions) and 35% (in high-profit regions)
OEM participation in monetization of TCO potential for logistics providers with varying take rates by region and level of autonomy
OEMs profit from increasing connectivity penetration and rising market share vs. third parties capturing a fraction of TCO potential of 5 - 10% from connected services and solutions

1.2 Deep dive "Market Development" – growth-induced profits eaten up by negative market effects

Macroeconomic growth and industry consolidation will increase OEMs' revenues and profits …

Structural shifts. We expect the fundamental drivers for rising logistics demand to remain intact (i.e., macroeconomic growth, e-commerce penetration). This will continue to drive the demand for trucks. The volume growth will be mainly driven by lower-profit regions (i.e., South America, Brazil, India). China as the main volume driver is expected to experience some volatility in unit demand following 2017 regulatory changes while we also see here an overproportionate growth of the higher-margin upper-budget segment.

Industry consolidation. Furthermore, we assume that the industry will also see some consolidation. While we do not see a strong rationale for mergers of global players, we expect that tightening emission regulation (i.e., targets more restrictive than the Euro 6 framework or its equivalents) will increase margin pressure for regional players increasing the likelihood of M&A.

Classic aftersales opportunities. With a profit of EUR 7.0 billion, aftersales will represent 43 percent of the OEMs' profit pool in 2030 (41 percent in 2017). While profitability from new truck sales grows only slowly to 4 percent RoS, aftersales profitability will likely increase even further and deliver a strong 21 percent RoS in 2030. We expect three major drivers for the revenue and profit growth of OEMs:

- **Increasing sales of superstructures** by OEMs lead to additional service business in the captive network.
- **Higher professionalization and digitization** in service will allow for price premiums.
- **Market share of OEM's service networks will increase** in the aftermarket in addition to extended service contracts and new service and solution offers from connectivity.

… but pressure from competition and regulation is eating up positive market effects

Price pressure. We expect competition amongst truck players results in a price pressure that differs by region and segment and ranges up to 2.5 percent, which would reduce the global profit pool by EUR 2.7 billion.

EV cannibalization. A significant impact on profits in the conventional business will be the spread of alternative powertrains. We have explicitly modeled the impact of e-truck distribution resulting in a profit pool reduction of EUR 0.9 billion within classical ICE powertrains. On the other side we see that a profit increase of EUR 0.9 billion through

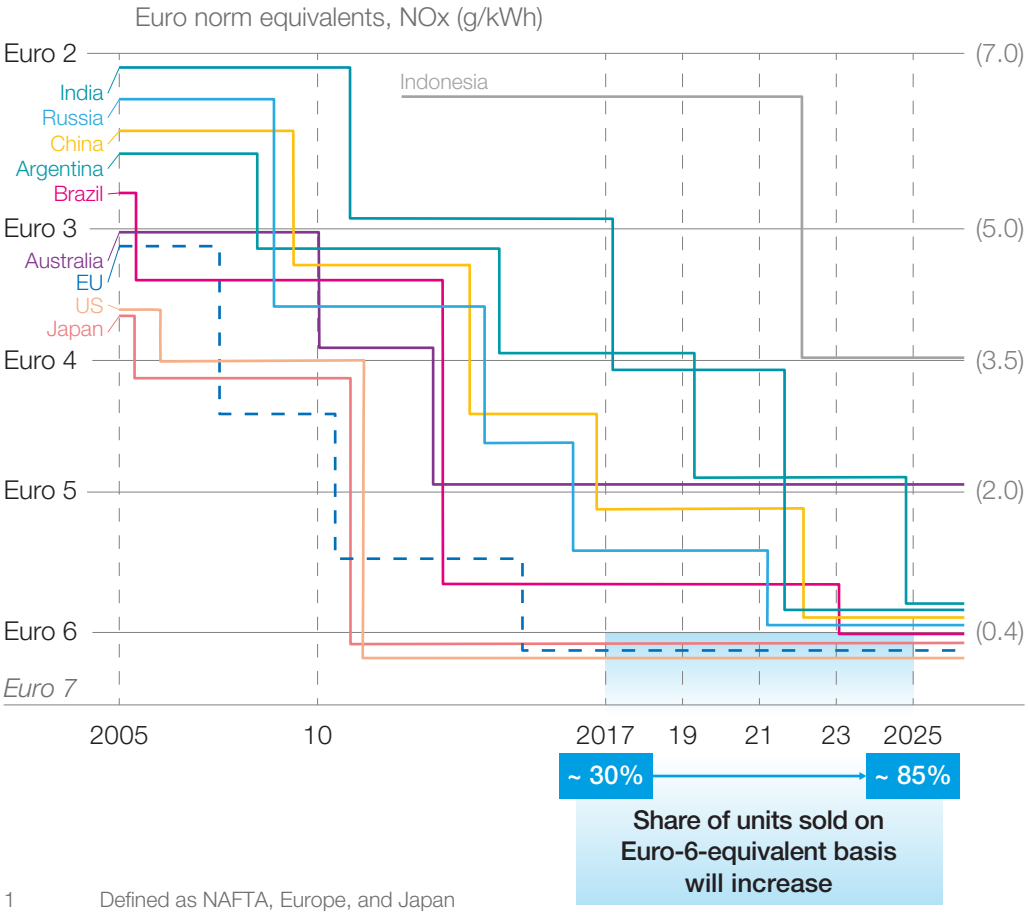
alternative powertrain penetration corresponds to this loss one to one (see Section 1.3 for details). However, the additional EUR 0.9 billion profit from alternative powertrains are at risk for OEMs since new players enter the value chain (e.g., suppliers for battery technology).

Emission regulation. Another trend with a very large impact on revenues and profits in the coming years will be emission regulation regarding NOx and particulates, especially in emerging markets, and fuel efficiency requirements (CO_2). Additional costs for emission compliance cannot be fully passed on to customers, especially in lower price segments. This leads to a positive impact on revenues but a negative effect on the global profit pool of EUR 1.6 billion.

Emission regulation is converging around the globe

More than a decade ago, the US and Japan were the frontrunners in terms of ambitious carbon-reduction regulations. Today, not only have regulations gotten stricter for the US and Japan, but every other region has picked up the pace in ways that put all OEMs in all major regions on a trajectory of adopting the tightest restrictions by 2025 (Exhibit 4).

Exhibit 4 – Ambitious regulation not just a trend in Triad[1] countries as regulation converges globally



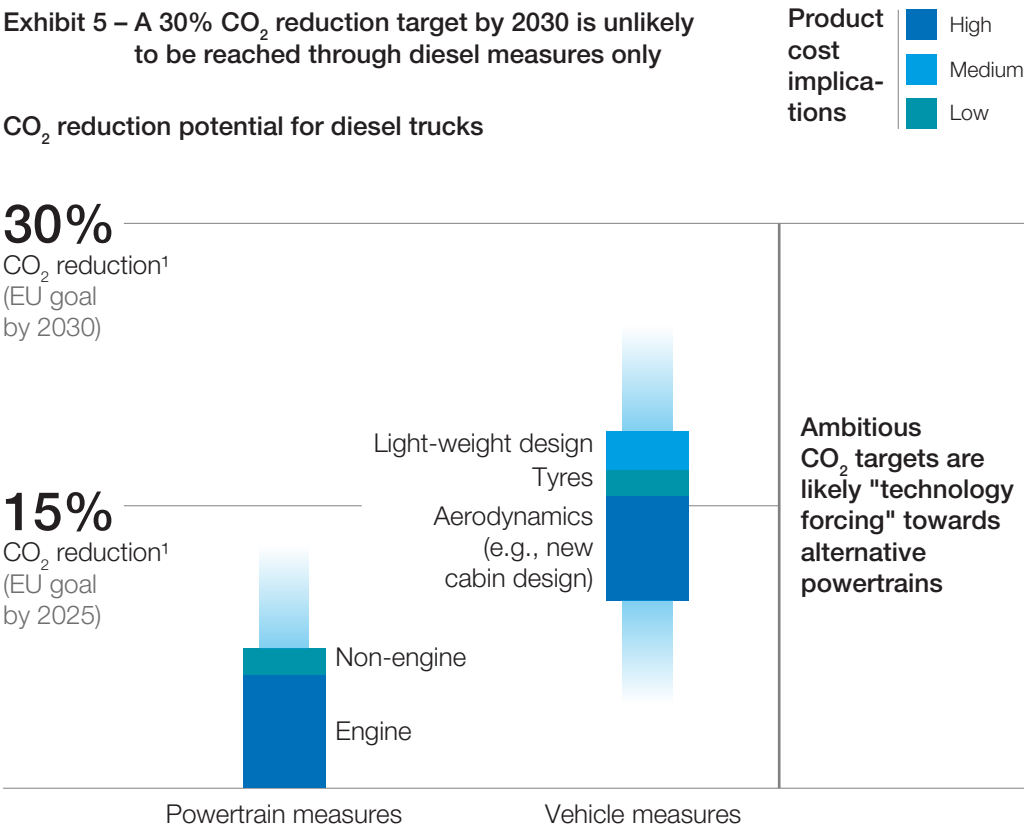
1 Defined as NAFTA, Europe, and Japan

One implication of the widespread adoption of the newest, most ambitious emission regulations is lower cost. Namely, as so many regions have already signed on to the Euro 6 regulatory framework, which limits NOx emissions to 0.4 grams/kilowatt hour, globally operating OEMs will benefit from economies of scale when the time comes to migrate to the next engine platform (Euro 7).

CO_2 targets likely to be "technology forcing"

In addition, CO_2 regulation is tightening, e.g., the EU regulation to reduce HDT CO_2 emission by 30 percent by 2030. With measures to reduce the emissions of conventional powertrain decreasing in efficiency and becoming increasingly costly, it remains questionable whether combustion engines will be able to achieve the ambitious targets (Exhibit 5). Hence, regulation might even have a technology-forcing effect towards alternative powertrains.

Exhibit 5 – A 30% CO_2 reduction target by 2030 is unlikely to be reached through diesel measures only



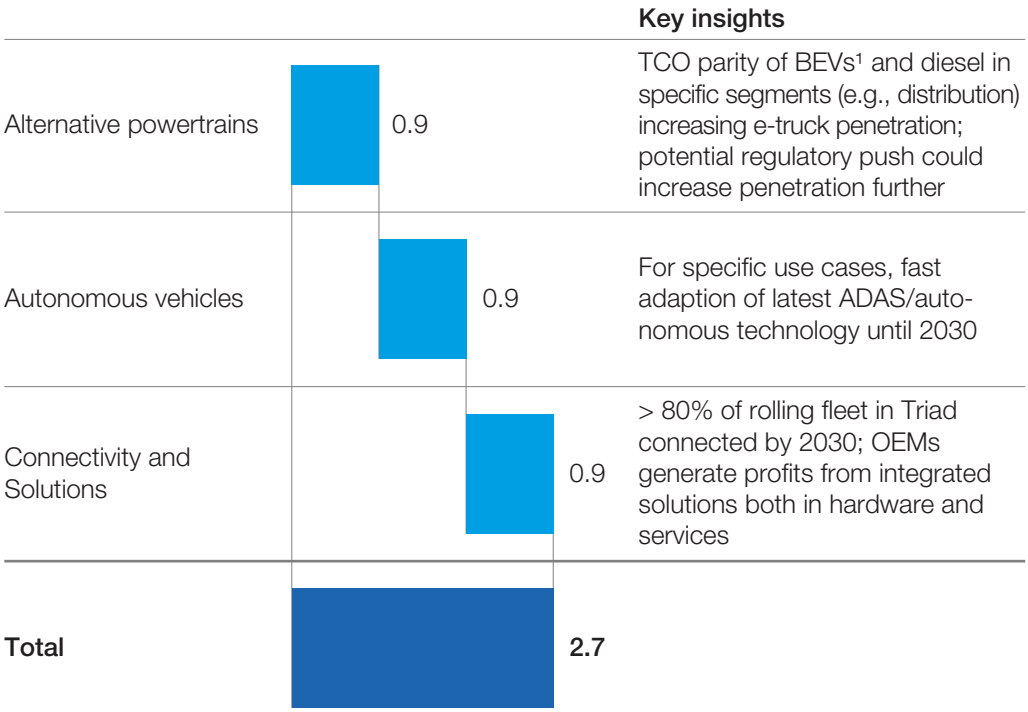
1 Tank to wheel; targets to be reviewed 2022

1.3 Deep dive “New Opportunities” – additional profit pools can be unlocked

New opportunities are driven by three major trends: alternative powertrains, autonomous vehicles, and Connectivity and Solutions (Exhibit 6). In total, these opportunities are expected to contribute EUR 0.9 billion to the profit pool, resulting in a total effect of EUR 2.7 billion in profit growth.

Exhibit 6 – New opportunities across multiple trends

EBIT impact, EUR billions



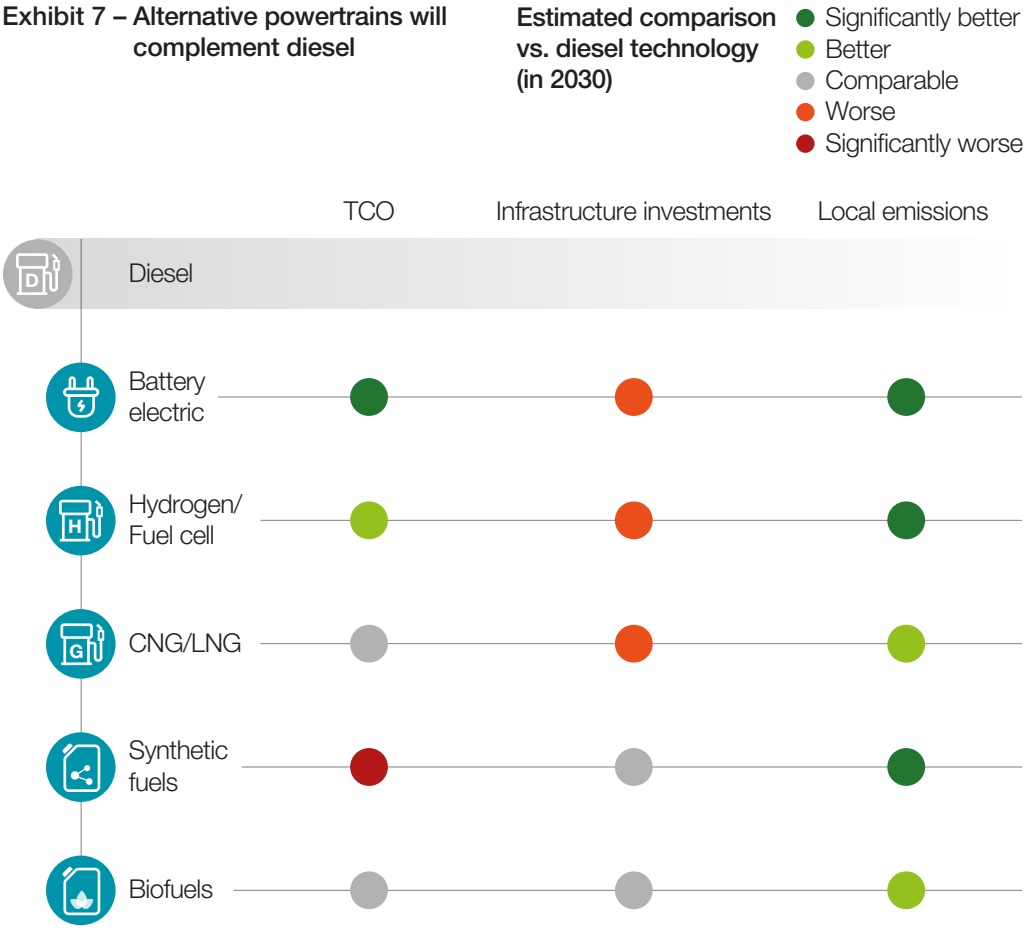
1 Battery Electric Vehicles

Alternative powertrains

Although diesel will remain the "volume and profit engine" for the foreseeable future, diesel efficiency optimization is becoming increasingly challenging (Exhibit 5). Alternative powertrains (battery electric, hydrogen/fuel cell, CNG/LNG, synthetic fuels, biofuels) are likely to gain importance in achieving emission goals and reducing the logistics sector's CO_2 footprint.

Exhibit 7 illustrates that alternative powertrains will complement diesel. We do not foresee complete replacement of diesel by a single technology in the near future, as all alternatives have disadvantages when it comes to selected criteria.

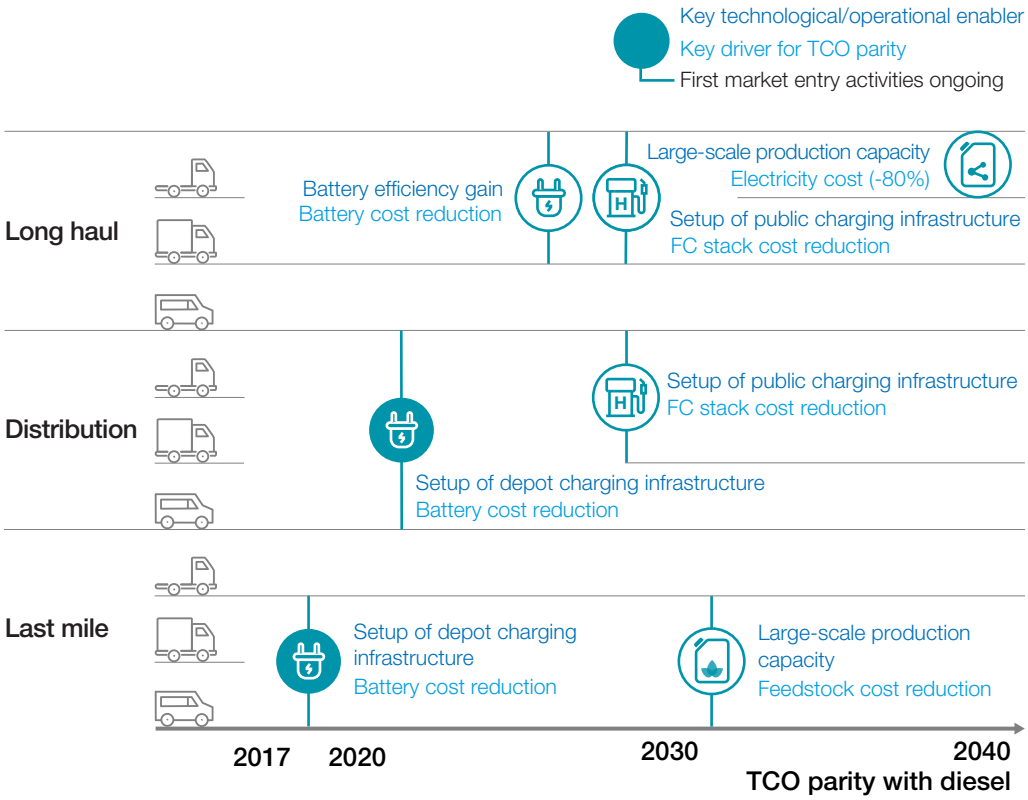
Exhibit 7 – Alternative powertrains will complement diesel



Note: Estimation on all parameters highly dependent on assumptions (e.g., TCO parity of hydrogen with diesel dependent on scale up and industrialization along the value chain (e.g., of electrolyzers, fuel cell stacks))

Instead, we expect different alternative powertrains to penetrate certain market segments. The applicability, however, depends on the use case and the timing as well as the expectation that defined operational and financial prerequisites are met (Exhibit 8).

Exhibit 8 – Applicability of alternative powertrains depends on use case and timing



Battery electric. EVs are likely to be the superior technology in distribution and in city-centric use cases. As the number of product announcements shows, EV has the strongest momentum (i.e., major OEMs and start-ups have announced more than 40 different products since 2015). However, the application of EV technology triggers significant strategic implications for the OEMs' business model (e.g., aftersales, ecosystem partnerships) and a significant number of questions are still to be answered (Exhibit 9).

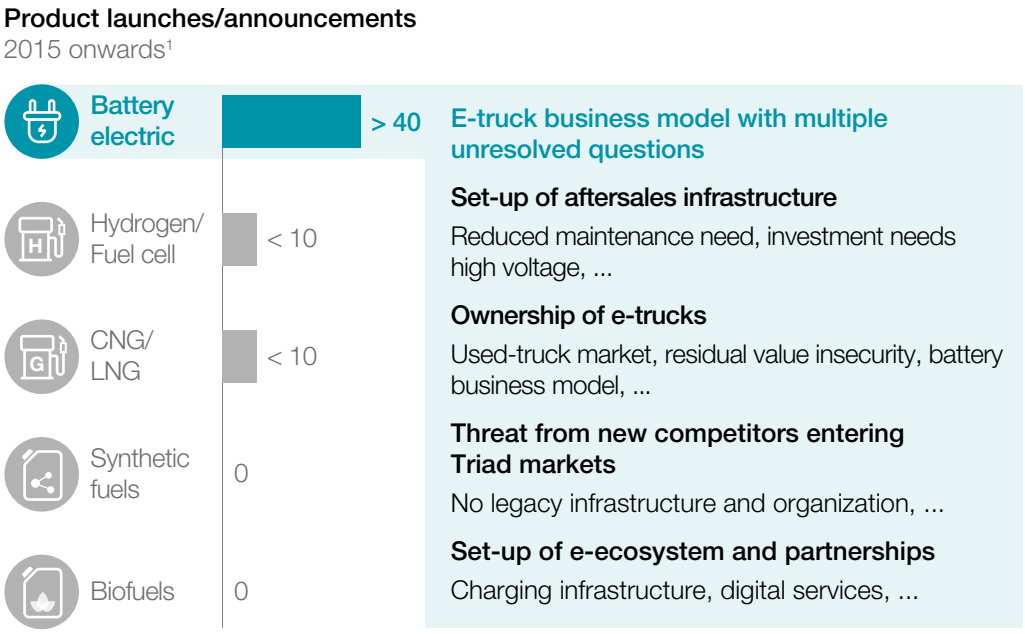
Hydrogen/Fuel cell. We expect hydrogen to be a strong contender, in particular in heavy-duty transport, segments that require long range and high utilization. Technically, it provides the most suitable solution: its higher energy density implies longer range, lower weight, and 10 to 15 times faster refueling than pure BEVs. It also plays a role in the broader energy transition, for integration of renewables, decarbonization of heating, and in industry. Key barriers to adoption are the required scale-up and industrialization along the value chain (e.g., of electrolyzers, fuel cell stacks) and the chicken-and-egg problem of establishing the refueling infrastructure and bringing models to market.

CNG/LNG. CNG/LNG prices fundamentally depend on underlying raw material prices and are thus as exposed to market cyclicalities as diesel. A large-scale deployment of CNG/LNG, however, requires significant investments into infrastructure. In a scenario of a fully emission-free transport in the long-term future, CNG/LNG can only be regarded as a bridge technology.

Synthetic diesel (e-diesel). E-diesel (i.e., synthetic fuels produced from carbon dioxide and water) are still far away from being an economically viable alternative to diesel, as in Germany, the price of 1 liter of e-diesel amounts to about three times that of current diesel prices. Furthermore, the energy used to produce 1 liter of e-diesel is seven times less efficient than if the same amount of energy were to be used in a BEV directly. Consequently, e-diesels are likely to be better deployable in applications with limited potential for electrification of the powertrain (e.g., airplanes).

Biofuel. Biodiesel is produced from multiple different feedstocks. Predictions on the TCO delta vs diesel are highly volatile as they depend on the underlying raw material prices and taxation. Furthermore the burning of biofuels yields local emission advantages but from a well to wheel perspective it remains questionable whether biofuels provide a net advantage over diesel.

Exhibit 9 – BEV with strong momentum but multiple business model questions unresolved



1 MDT, HDT, LDT

Autonomous driving – first use cases hitting the market this year

Of the various technology trends expected to contribute nearly EUR 1 billion to the OEM truck profit pool, autonomous driving will have a unique impact. The ability of autonomous driving to have a significant impact on TCO makes this technology a game changer that has the potential to spur industry consolidation.

The trajectory toward full autonomy is long – more than ten years before trucks are expected to drive on the road fully autonomously – but first use cases are expected to hit the market within the next few years (Exhibit 10). Still, there are many open questions (e.g., legal framework, technological redundancy). On top of that, the autonomous driving playing field will be far from even. Smaller OEMs will find it more difficult to obtain the necessary resources, and the entrance of new, technology-driven market players will intensify competition.

No matter the player, key to success will be the control of key technologies in the technology stack. We have identified six control points that are vital (Exhibit 11).

It will also be important that technological developments in autonomous driving will be made with the specificity of the truck industry in mind. While there is potential for carry-over of tech know-how and hardware between commercial vehicles and passenger cars (e.g., for sensors and especially on the business solutions/cloud side, e.g., HD mapping) autonomous driving technology needs to be developed and adapted to the truck space.

Exhibit 10 – Autonomous driving use cases are starting to hit the market

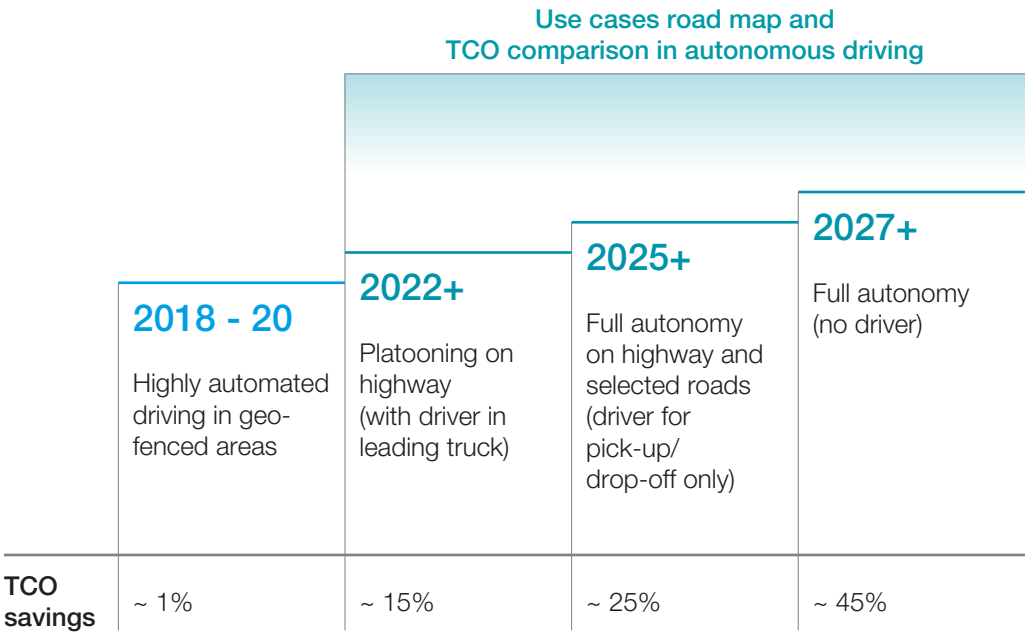
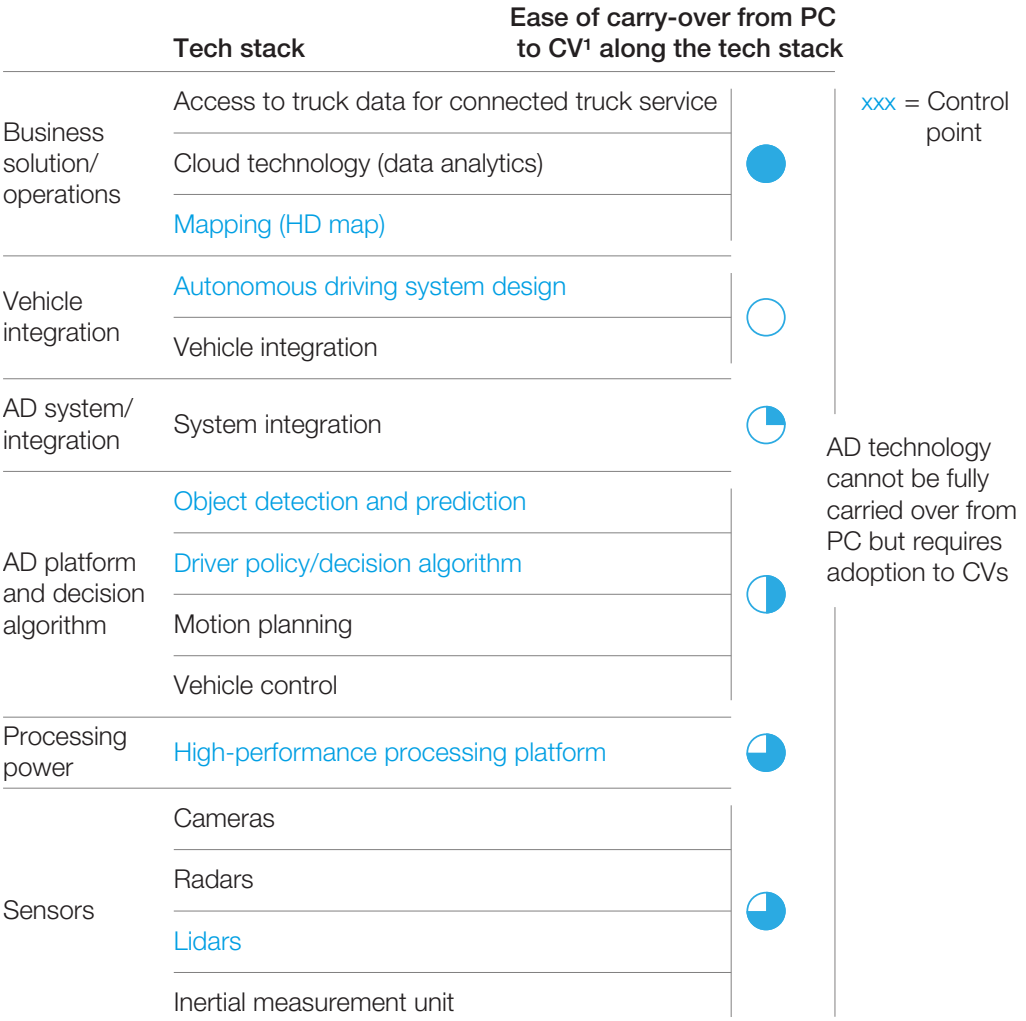


Exhibit 11 – Key to success in autonomous driving (AD) is the occupation of control points

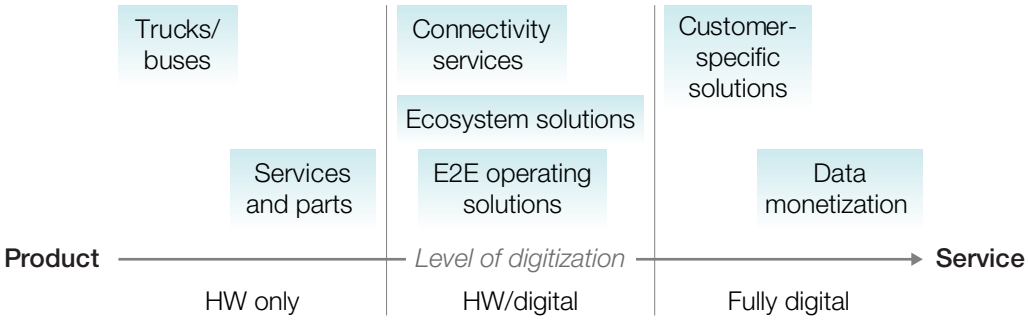


1 PC = passenger cars; CV = commercial vehicles

Connectivity and Solutions

OEMs need to offer a more holistic platform for Connectivity and Solutions to increase the overall profit pool (Exhibit 12). This fosters the development of new business models based on connectivity including hardware and solutions (EUR 0.9 billion profit pool impact in 2030). In 2030, we expect 80 to 90 percent of the rolling fleet in NAFTA, the EU, and Japan to be connected – either via captive or third-party telematics. Besides selling the hardware, OEMs' aftersales business will benefit from connected services and solutions that connect customers with the OEM network. And at the same time, customers benefit from TCO savings that can be partly priced-in by the OEM.

Exhibit 12 – Connectivity and Solutions business



Additional profit opportunities

~ EUR 0.9 billion
(2030)

+2% RoS[1]

Key drivers

Hardware as enabler for connected services (no profit driver)

Profit potential from TCO-relevant services (e.g., maintenance/repair, fleet management)

Additional potential from adjacent solutions/services

1 Depending on industry application

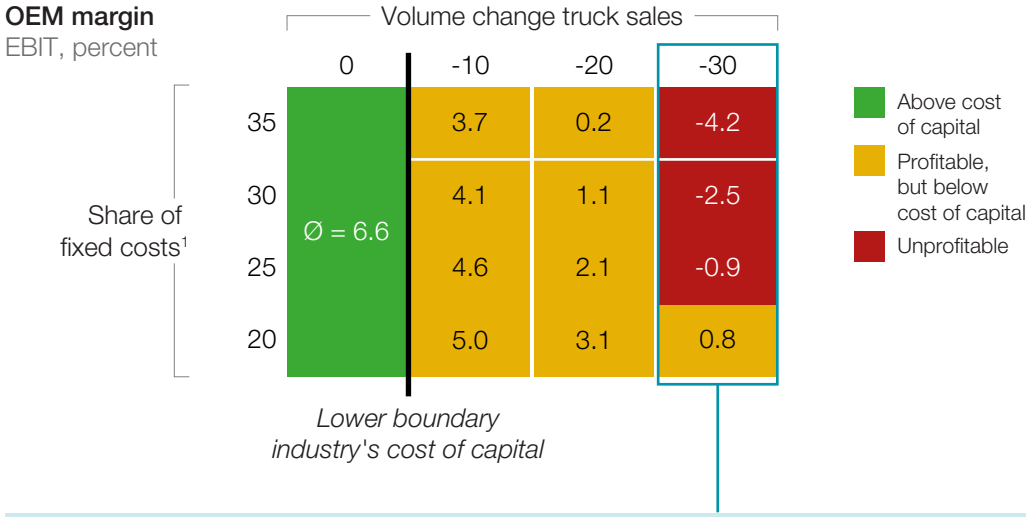
1.4 Deep dive "Operational Efficiency" – key profit driver in core business

With the industry remaining exposed to cyclicality, need for cost focus remains preeminent

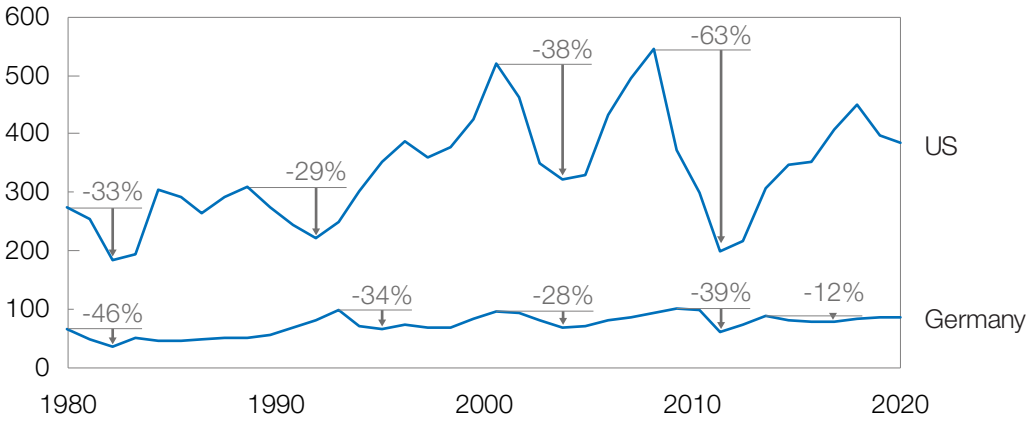
OEMs remain vulnerable to downturns. Traditionally, sales volumes have displayed significant volatility. This is basically true for all markets. The example Germany shows that sales declines even reach levels of up to 50 percent in a two-year period.

Applying a market decline of about 25 percent (in sales) would result in RoS declining almost to zero, assuming a fix cost share of 25 percent of total costs. The negative effect of declining sales on ROS is even further accelerated when the OEM's fixed cost share is larger. With a fix cost share of about 40 percent, a market decline of more than 20 percent (in sales) will already yield a negative ROS. Thus, the persistent sales cyclicality forces OEMs to focus on fix cost optimization to increase robustness to downturns as well as to finance new opportunities (Exhibit 13).

Exhibit 13 – Continued exposure to market volatility and need to finance new opportunities require OEMs to stay cost focused



Historic short-term[2] sales volatility very high (examples)
Unit sales, thousands p.a.

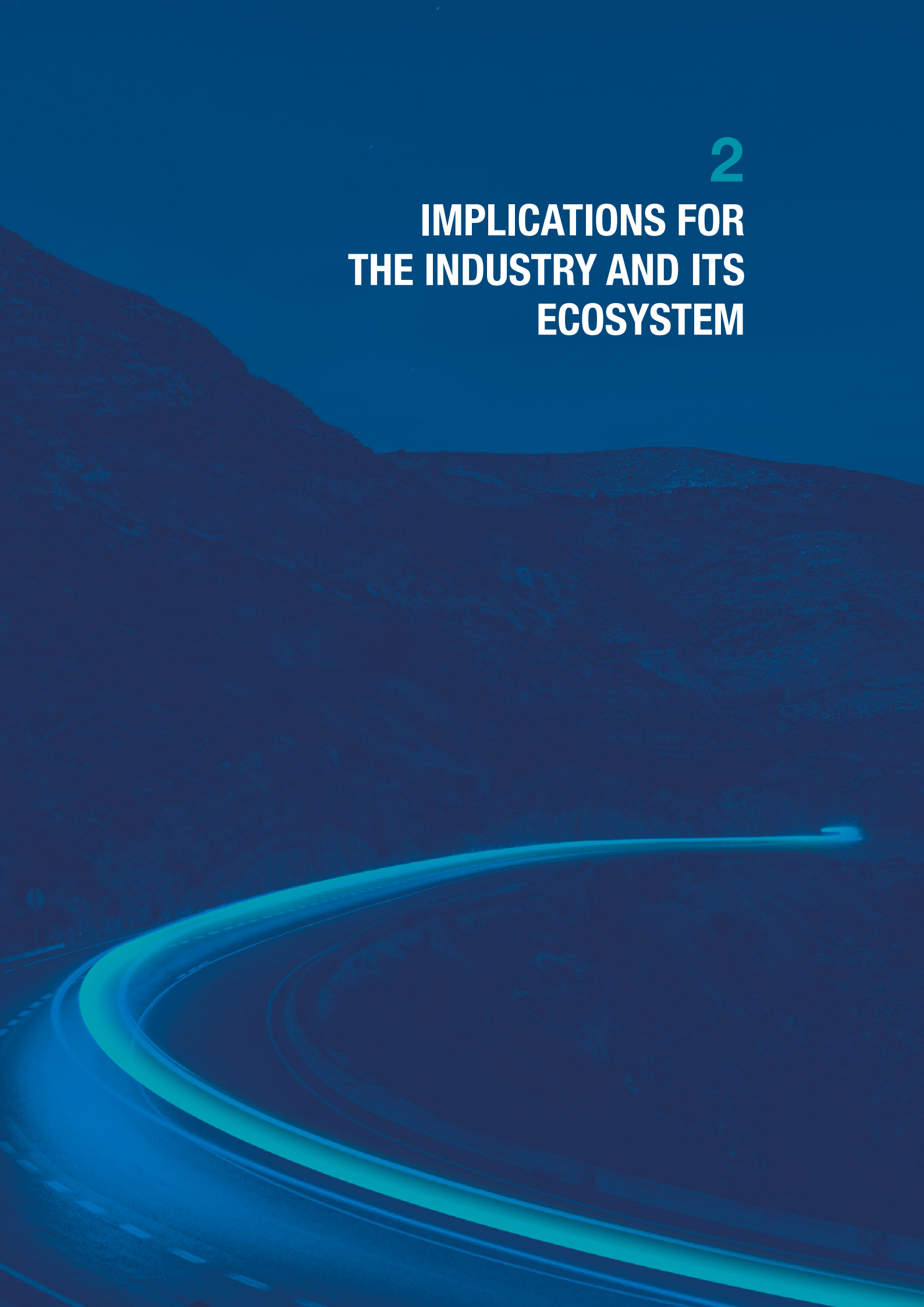


1 Current fixed cost ratio of 25% assumed (COGS: ~ 20% fixed cost share, R&D and SG&A: ~ 80% fixed cost share)

2 Over 2- to 3-year periods

Artificial intelligence (AI) offers significant potential for operational efficiency

While conventional levers are still of importance, new technologies offer significant potential for the next level of efficiency. AI is especially likely to offer significant opportunities in the future. AI describes a set of technologies where machines or algorithms perform cognitive functions such as learning or problem solving. Within AI, machines can process complex data types (e.g., sensor data, text, videos, images) and are able to learn how to classify this data, predict information and even prescribe recommended actions. AI requires an initial training with the use of existing data, after which it is able to apply the learnings to unseen data in the future. In a study in cooperation with Google (and a focus on the passenger car industry) we identified 120 AI use cases that could be applied today or in the near future. The savings potential from these use cases could yield EBIT effects in all steps of the value chain (i.e., ranging from 0.3 percent in aftersales and services to 19 percent of total costs in support functions).



2

IMPLICATIONS FOR THE INDUSTRY AND ITS ECOSYSTEM

Fast-paced change, continuous price pressure, a strong technology orientation, and the near insatiable demand for transporting goods around the globe are the drivers of the commercial vehicle industry. Through an extensive knowledge effort that has sized the truck industry's current revenue and profit pools and explored the impact of several market and technology trends moving forward, we have derived an outlook for the industry until 2030.

Going forward we have distilled a set of factors that we believe are essential to success in the evolving truck industry:

Increase operational efficiency. Key to remaining competitive will be achieving gains in operational efficiency as it makes OEMs more resilient to the ups and downs of persistent market volatility. Operational efficiency will also be fundamental to the OEMs' ability to finance new opportunities.

Monitor alternative powertrain developments. The successful OEMs will closely monitor the development of powertrain technologies. As powertrain applications might become more diverse, given that different use cases can be served better with different powertrain technologies, OEMs should be ready to seize upon the opportunity as an appropriate use case becomes viable.

Invest in autonomous driving. Autonomous driving is likely the most complex of the major technology trends and thus presents many barriers. OEMs need to stay "on their feet" and invest in autonomous driving today. Establishing themselves at specific control points in the technology stack will be key to participating in the profit pools, and this will require early and significant investment.

Understand the competition. An awareness of the changing competitive environment can help OEMs make strategic decisions going forward. For instance, while multiple players are already competing in BEVs, the hydrogen/fuel cell space is significantly less crowded. Regionally speaking, monitoring where competition is coming from, e.g., Chinese players potentially becoming active in other regions, will also be important.

Leverage partnerships. Fundamental shifts to the truck ecosystem mean that the competitors of today might be the partners of tomorrow and vice versa. OEMs should be open to new alliances and cooperative arrangements that reach beyond the traditional borders of the truck industry. Making developments in and capturing value from autonomous driving and connectivity, for example, will require strong partnerships not only with suppliers but with technology and software players as well.

Solutions. Solutions represent a significant opportunity for OEMs to extend their current, vehicle-focused customer offer. With a rising share of the rolling fleet being connected, the potential market size for applying solutions will increase and offers the potential to deepen the relationship between OEMs and their customers along the value chain.

Fast transit: why urban e-buses lead EV growth

Looking for the most successful electric vehicle segment? Take the e-bus.

Urban electric buses (e-buses) do not break many speed records. However, they are passing every other EV segment in terms of growth. In fact, as the fastest-growing EV market (more than 100 percent CAGR since 2013 vs. 60 percent for passenger cars), bus fleets in Europe should largely transition to electric power by 2030 with a proposed target of 75 percent of the buses sold in Europe using electric power that year. One reason for the e-bus penetration advantage is given by the European Commission report that proposes this target. It says markets for low- and zero-emission urban buses feature increased "maturity, whereas markets for low- and zero-emission trucks are at an earlier stage of market development.[1]"

The impetus behind this stellar performance comes from a strong pull from customers, largely composed of public transit operators (PTOs) and city governments. These customers exhibit a high willingness to pay for clean technology due to regulatory and political influence, customer demand, and government subsidies. The attractiveness of e-buses to these customers remains solid even though they will not provide a TCO advantage until the 2025 to 2030 timeframe due to high upfront investments in the bus itself, infrastructure, and the likely need for battery swaps over the lifecycle of a vehicle.

E-bus momentum increases worldwide

China, the world's largest bus maker, has taken the lead in e-buses. It represents the largest market for them, with new urban bus sales already at 90 percent electrification in 2017. Of the 97,000 urban buses sold there last year, 87,000 units feature electric powertrains – as a point of comparison, the entire European urban bus market was about 13,000 units in 2017. In fact, more than two-thirds of all e-buses on the streets worldwide travel on roads in China. One example of this trend is Shenzhen, a major city in Guangdong Province, which electrified its entire bus fleet purchasing over 16,000 new e-buses since 2012. Across Asia, manufacturers have supported this market and are active with local production facilities using synergies from e-truck production. The North American market represents a minor segment of the global e-bus market, where according to analysts sales remained below 500 e-buses in 2017 and will likely increase slowly, except for a few metropolitan areas, where growth is expected to be more robust.

Europe embraces e-buses

In Europe, we expect electric city buses to make up approximately three quarters of annual sales in 2030 and exhibit annual growth of about 18 percent. One proof point for this is the healthy near-term demand with the first urban showcases already existing in London, the Netherlands, and elsewhere. Our research suggests that the demand patterns for e-buses largely reflect the overall trend among cities to embrace electrification and new mobility technologies such as shared mobility and autonomous vehicles.

1 "Proposal for a Directive of the European Parliament and of the Council amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles"

Customer demand, which is primarily a combination of political, regulatory, and cultural pressure, largely drives European city e-bus markets. At this point, economic considerations play a lesser role, given that the e-bus TCO remains significantly higher than that for diesel buses. In Europe's largely stagnant bus market, large cities and "green countries" will likely adopt e-buses first; the former due to the urgency to curb air and noise pollution, the latter to fulfill commitments to safeguard citizens from environmental danger. We expect these areas to adopt e-buses sooner and at higher rates, based on our model of regional urban e-bus uptake. At the same time, Germany will most likely see an accelerated uptake of e-buses, reflecting ongoing discussions concerning harmful diesel emissions.

The e-bus phenomenon presents cities with three major challenges: high technological uncertainty, large upfront investment requirements, and the need for new capabilities. In response, we expect a majority of e-bus sales in Europe will occur as parts of larger transit investments (e.g., e-bus plus infrastructure plus additional services). By taking this kind of holistic approach, cities can effectively outsource many e-bus uncertainties. This is especially true for most small and regional hubs, whereas larger cities will typically be able to leverage their own infrastructure capabilities.

E-buses represent a first step toward future mobility goals

As cities seek to realize their future mobility goals, the first step for many involves moving toward a smart, clean, integrated solution made possible by e-buses. However, to get there, cities need new infrastructure, and they need it now. That means a combination of hardware in the forms of charging stations (often requiring a full redesign of the bus depot) and other required equipment, as well as software solutions that can collect and make use of data concerning driving patterns and vehicle health. The elements of a new infrastructure will go far beyond the currently deployed IT systems, given the significantly greater complexity of e-bus operations, including battery lifecycle monitoring, range calculations, and charging management.

Fortunately, an established network of highly competent companies can help with these challenges. For example, some e-bus manufacturers can assume full system responsibility, partnering with charging infrastructure providers and others to deliver an end-to-end e-bus solution. Others offer comprehensive packages and take full in-house responsibility for the service and maintenance of the complete system. At the same time, several transit operators have core multi-disciplinary teams to manage and execute bids or deliver projects. These teams validate all components of a tender, including contractual clauses, the integration of innovations, operating costs and investments, and quality and safety considerations.

The initial series of e-bus system investments will enable and ease the subsequent introduction of future technologies such as autonomous taxis and shuttles. In many cases, urban planners begin their forays with e-buses incrementally, buying a handful to test the waters and later, with growing confidence, expanding their use as the benefits of cleaner air and quieter streets become apparent.

Consequently, e-bus makers often focus initially on selling few vehicles to cities, then later taking more of a holistic approach, bundling e-buses with tailored charging, maintenance, and traffic management solutions, including value-added opportunities. This is especially the case for smaller cities, which do not have the expertise required (e.g., for high-voltage lines) or the risk appetite to "go it alone." For e-bus OEMs, this may offer the opportunity to become a preferred vendor with a single point of contact, and ultimately evolving into a key partner.

Approached systematically, the transition to e-buses can open a clear pathway to a city's future mobility goals and vision. It is a first and important step change towards a long-term vision of sustainable mobility solutions and emission-free cities. Additionally, a successfully implemented e-bus system can make the transition to the next technological horizon, autonomous transport – which could have a major impact on city mobility –, no longer appear so far away. With that in mind, the systems put in place to handle e-buses should ideally be designed in such a way that they can be extended to also accommodate autonomous buses and facilitate a deeper integration into intermodal transport.

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The e-bus phenomenon represents an exciting new advance in vehicle electrification that points the way for other electric vehicle segments. Representing a strong first step toward realizing their future mobility goal, the e-bus experience can help cities to pilot the transition to a clean, green tomorrow with a minimum of risk and turmoil.

APPENDIX: OUR APPROACH

With this publication, McKinsey has set out to give truck OEMs guidance in defining their journey toward a prosperous future. From a global perspective, we have looked very deeply into worldwide truck market volume, revenue, and profit pool developments for medium- and heavy-duty trucks (MDT/HDT) in all price segments (premium, value, and low) in ten regions – Asia Pacific (APAC, excluding China, Japan/Korea, India), China, Japan/Korea, South America (excluding Brazil), Brazil, Central and Eastern Europe (CEE), India, Middle East and Africa (MEA), NAFTA countries, and Western Europe (WE) – to form our hypotheses and quantitative insights on the commercial vehicle industry in 2030.

For our 2030 global profit pool estimate, we have analyzed market data and annual reports of major truck OEMs covering about 80 percent of the global sales volume in HDTs and MDTs and assessed the impact of 11 key industry trends.

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The authors would like to thank them for their valuable contributions to this report.

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ADDENDUM

We wish to express our appreciation and gratitude to the German Association of the Automotive Industry (VDA) for their support and valuable contributions. In particular, we would like to thank Henry Kuhle and Graham Smethurst from the coordination team “networked and automated driving.”

We would also like to thank our colleagues Timo Möller, Kersten Heineke, and Simon Pautmeier for contributing to this publication.

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McKinsey Center for Future Mobility
September 2018

Design contact Visual Media Europe
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