New reality: electric trucks and their implications on energy demand

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When DHL decided in 2013 that it wanted to upgrade its fleet to electric powertrains, it could not find a suitable vehicle or an original equipment manufacturer willing to develop one. So, they decided to develop a vehicle themselves.

With investment from DHL, StreetScooter—a German university startup—designed a fully electric van and now offers three different models. More recently, DHL teamed up with an original equipment manufacturer (OEM) to develop a larger electric delivery van. While the weight of these vans is just below the light truck classification (3,500 kg), it clearly indicates the viability of electrification for commercial purposes. With the launch of Tesla’s Semi, an electric tractor, in October 2017, the first electric truck (eTruck) will enter the heavy duty truck segment. It is now not a question of whether trucks will electrify, but when.

The adoption of electric vehicle (EV) technology in the freight sector appears to be progressing faster than expected, potentially presenting a major challenge to the diesel-fueled truck market. This article explores how fully-electric trucks could capture a significant share of sales as early as 2030 and the impact this would have on energy markets.

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eTruck market share could reach 15% by 2030

Our latest research reveals that eTrucks could account for 15% of global truck sales by 2030, with favorable segments like urban light duty trucks reaching sales as high as 25-35% in China and Europe.

This is based on adoption curve scenario modeling for the US, China, and Europe and incorporates the trends of three main drivers for electrification.

Three drivers determine the attractiveness of eTrucks

The first driver for eTruck attractiveness is the cost parity of these trucks with diesel alternatives. Once eTrucks have lower total cost of ownership (TCO), many commercially driven business owners are expected to switch their fleets.

The second is electrification readiness, which includes the availability of models on the market and supporting infrastructure, both driven by technology developments and actual investments/production.

Thirdly, local and national regulations are enabling a supportive environment, in the form of stricter emission targets and (local) diesel bans.
The future of the truck market can be analyzed by assessing 27 truck segments (three weight classes with three applications each for China, the US, and Europe, see Exhibit 1) with their own dynamics and average cost parity range. A few key drivers have a significant impact in terms of TCO (per km or mile) between diesel trucks and eTrucks, including battery size and cost, daily driving distances, electricity consumption, and the fuel price differential (i.e., electricity versus diesel). For each segment, the assumed battery size must match the daily average range, with slight overcapacity to deal with capacity degradation over time. In practice, the exact point at which cost parity is reached will depend on application specifics, such as range and typical routes.

Our analyses indicate that the majority of commercial vehicles can reach cost parity with diesel-powered trucks within the next 10 years, assuming we see continued improvements in battery cost and power density. The most cost-effective application seems to be in the light duty truck (LDT) segment that drive a relatively constant distance of 100 to 200 kilometer per day, which is a sufficient range but avoids battery costs being too high. This segment is expected to reach cost parity with diesel in Europe between today (regional application) and 2021 (urban application). For cases like parcel delivery and small retail delivery, we see a clear economic rationale for operating electric trucks as soon as they are on the market. The DHL case illustrates how specific applications with small battery requirements might have already reached cost parity. The heavy duty truck (HDT) segments will be the last to reach parity, with 2027 for at-scale regional applications in Europe. Other regions and applications will reach cost parity beyond 2030.
Regional characteristics determine the different timing of when cost parity will be reached in Europe, the US and China. In the US, cost parity will be later than in Europe, caused by local energy prices (lower price differential between diesel and electricity) and larger battery requirements due to different driving dynamics (higher average speeds and heavier loading). Cost parity is expected latest in China, due to the availability of cheap internal combustion engine (ICE) trucks. Future regulation may increase the cost of ICE trucks in China, but this is not incorporated in our TCO analysis.

Typically, a specific segment can reach cost parity two to five years earlier compared to the average use case with some optimizations. For instance, fleet operators can move the cost parity point closer by introducing intra-day charging as it allows decreasing the battery size, compared to the average use case where we assume only overnight charging. Additional gains can come from ensuring a high vehicle utilization rate and increasing fuel economy, by, for example, avoiding congestion, limiting air-con options, and limiting acceleration.

The illustration of the ‘Race of ePowertrains’ (see Exhibit 2) shows the differences in the timing of cost parity for various applications and weight classes. The shading behind each vehicle indicates how early a specific application can potentially break even when introducing, for instance, intra-day charging.

**Exhibit 2: Race of ePowertrains**

<table>
<thead>
<tr>
<th>Application</th>
<th>Daily distance km</th>
<th>2017</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>Beyond 2030</th>
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<td>Long-haul</td>
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10 years from now we expect the majority of commercial vehicles to reach cost parity between electric and diesel powertrains.
2 Electrification readiness: supply of eTrucks and charging infrastructure unlikely to match demand in the short term

While cost parity with diesel is close or has already been achieved for specific applications, a large-scale switch requires a sufficient number of eTrucks on the market and adequate charging infrastructure.

Supply of eTrucks will likely be the bottleneck for freight transport electrification in the next few years. This will change as new models are launched and production comes online. Several established OEMs have reported that they are developing their first eTruck models and are making significant investments in R&D. The first models on the market are expected in the LDT segment, where differences with passenger cars are the smallest. Along with diesel regulations and customer pull, the introduction of challengers like DHL’s StreetScooter Work XL and Tesla’s Semi will undoubtedly accelerate OEMs’ decisions to build an eTruck portfolio.

The other element of electrification readiness is charging infrastructure. We expect that early adopters will mainly charge their fleet overnight at their own depots or warehouses. Thus, they will not be dependent on public infrastructure. The inability to charge while on the road means battery size needs to match daily range, which pushes vehicle cost up. However, once eTrucks become more mainstream, we expect the roll-out of supercharging infrastructure at distribution centers and along the main highways, enabling long-haul ‘refueling’ along popular routes.

3 Regulation perspective: regulation such as inner-city diesel bans driving electric vehicle adoption

Regulation could accelerate eTruck proliferation beyond the levels expected from reaching cost parity alone. Important regulatory measures include tightening emissions targets for carbon dioxide (CO2) and oxides of nitrogen (NOx) and the likely introduction of diesel bans in many urban areas around the world. Today, there are already over 200 cities with emission and access regulation zones, and some major cities, like Madrid, Paris and Mexico City, are even announcing diesel bans. With both France and the UK recently announcing sales bans on fossil-fuel vehicles from 2040, there may also be more direct regulatory pressure on trucks than previously anticipated. At the country level, several countries are announcing ambitious electric vehicle penetration targets (e.g., Norway and India). A shift away from diesel-fueled conventional ICE vehicles also seems a natural way for countries to meet their commitments to reduce CO2 emissions under the Paris Agreement.

These regulatory forces could lead to a relatively rapid increase in the sales of electrified commercial vehicles. Especially, city diesel bans could have a material impact, as they will force OEMs to consider eTrucks in their portfolio, whereas complying with other emission regulations can often be done with improvements in aerodynamics or ICE efficiency.

200+ cities already have emission and access regulation zones, with major cities announcing diesel bans
Cost-conscious truck owners likely to quickly shift to eTrucks, causing sales to take off between 2025 and 2030

Estimating the future uptake of electric vehicles requires a synthesis of the three factors driving electrification, combined with a perspective on the switching behavior of truck owners based on perceived risks and operational challenges.

To estimate uptake for each weight class and application, we modelled two scenarios for each of the regions: an early adoption and late adoption scenario. The early adoption scenario incorporates stronger regulatory push and more cost-sensitive fleet operators. The late adoption scenario includes challenges related to charging infrastructure, limited availability of eTrucks (especially in the short term), and more conservative switching behavior due to perceived risks.

Our analyses indicate that eTruck uptake in both scenarios is particularly fast beyond 2025 (see Exhibit 3), driven by rapid TCO improvements from battery cost reductions, expected regulatory support, and reduction of perceived risk as operational challenges, like adequate charging infrastructure, are addressed over time.

Exhibit 3
Adoption curves of eTrucks across regions and weight classes
Share of new sales

Weight class definitions US HDT Class 8 (>15t), MDT Class 4-7 (6.4-15t), LDT Class 2-3 (3.5-6.4t) Europe HDT 16t, MDT 7.5-16t, LDT 3.5-7.5t China HDT >14t, MDT 6-14t, LDT 3.5-6t
We expect the first eTrucks to be sold at scale in the LDT segment by 2020. The delay compared to their early cost parity is due to the limited availability of eTrucks on the market in the short-term. The MDT segment is mostly active in urban and regional applications, which will reach cost parity early as well. Uptake of eTrucks in MDT follows shortly after LDT as cost parity is reached a bit later due to larger battery requirements and lower fuel efficiency. Adoption in the HDT segment will be the last because of later cost parity, and because HDT predominantly operates on long-haul routes where charging infrastructure will take longer to establish.

Comparing the three main regions, we expect the largest share of sales of eTrucks in 2030 to be in Europe (with 21 and 29% of total truck sales for the early and late electrification scenario respectively), followed by China (11 and 24%) and finally the US (8 and 13%). This translates to an 8-15% share of global sales as adoption in other regions is expected to be limited until 2030. The differences in sales projections between regions are mainly driven by differences in TCO and anticipated regulations. In Europe, where cost parity will be achieved earliest, additional regulation could also drive higher uptake in the early adoption scenario. In China, we expect uptake to be driven by an anticipated push from the government, especially after China announced mid-September to consider setting a deadline for ending sales of fossil-fuel powered cars. Uncertainty about new regulations lead to a larger range of eTruck sales share between the scenarios in China. The US will lag behind the other regions, because relatively low fuel costs mean the advantage gained from using electricity is less significant, while the regulations in place focus on the improved fuel efficiency of diesel trucks instead of a shift to electric.

Overall, the switching behavior towards electric vehicles is expected to be faster for fleet operators than for consumers who are considering electric passenger cars. There are two main reasons for this. First, commercial vehicle owners are more focused on TCO than passenger car owners.
when making purchasing decisions; they often own multiple vehicles, and the need to reduce operating costs in the competitive logistics sector makes eTrucks attractive. Second, the trucking sector experiences relatively rapid fleet turnover (typically between three and six years; twice the rate of private owners), which enables quicker adoption once switching begins.

While we see strong indicators for fast adoption, there are still several challenges to solve before eTrucks are widely adopted.

Firstly, determining TCO is not always straightforward. To capitalize on TCO benefits, owners need to incorporate uncertainties and calculate the point at which eTrucks begin to outcompete diesel in their particular set of circumstances (e.g., how to deal with variability in driving distances across a fleet of vehicles).

Secondly, investments are higher. Owners need to be willing and able to pay the higher upfront costs for a new eTruck, which will take time to recoup in savings.

Thirdly, operational flexibility is more limited. Freight operators with variable routes and mileage are unlikely to benefit in the same way as those able to closely match battery capacity and daily range requirements.

Fourthly, the operational risks are also new and unknown. Although battery electric vehicle technology is becoming more mainstream for passenger cars, the technology for trucks is still relatively unproven. Reliability could initially suffer from startup issues, although expectations are that reliability of eTrucks will ultimately outcompete that of ICE trucks.

Finally, new technology might require some getting used to. Drivers might initially run out of power, as they may not stick to recharging schedules or know how to conserve energy. OEMs will likely need to train truck operators to operate these new technologies adequately.
What will the impact be on energy markets?

Even though trucks represent only ~5% of the global vehicle stock, they make up more than 20% of road transport fuel demand due to their high fuel consumption and mileage.

Trucks account for over one third of global diesel demand, nearly 9% of global liquids (oil) demand, and ~3% of total global energy demand. Any impact on diesel use by trucks will have a significant impact on overall diesel and liquids demand.

However, it may take some time for the impact of electrification to be felt, because the majority of diesel is consumed in the heavy truck segment, which is expected to be the last to switch to eTrucks. The impact of truck electrification up to 2030 on total oil demand is, therefore, expected to be rather modest, offsetting demand growth in non-OECD countries rather than leading to an overall reduction—the local impact in early adopter regions, like Europe, could hit regional refineries before then. By 2050, the continued uptake of eTrucks could displace ~3.5% of total global liquids demand. In terms of power demand, the switch could add 0.3% to global electricity consumption by 2030, rising to ~3% by 2050.

Electrification impact softened by slower uptake in high-consumption heavy segment

Most of the diesel demand from trucks comes from long-haul heavy-duty trucks (see Exhibit 4). Roughly two thirds of truck diesel consumption in

Exhibit 4
Share of diesel consumption by truck weight class and application
% per region

- Urban – 100km/day
- Regional – 200km/day
- Long-haul – 500km/day
the US and EU originates from this segment, while in China it is close to 50%. This is driven by fuel consumption, which is 2-3 times higher for heavy trucks than for light trucks, while the yearly distance travelled in long-haul applications is three to five times higher than for urban or regional applications.

As heavy trucks are expected to be the last to switch to eTrucks, this will moderate the early impact on diesel demand.

**Electrification offsets diesel growth from non-OECD countries**

Without eTrucks, diesel demand would be expected to continue to grow modestly over the next few years due to population and macro-economic growth in non-OECD regions and as additional fuel efficiency improvements for ICE trucks reach the technological limit in the next decades.

Although it will take time for higher sales to increase the proportion of eTrucks in transport fleets, our research shows electrification in the EU, China, and US causes a tipping point and reverses the global trend of growing diesel demand in the truck sector before 2030 (see Exhibit 5). Beyond 2030, the continued uptake of eTrucks could displace up to 3.5 million barrels per day by 2050 (the equivalent of removing 40% of today’s diesel demand from trucks) and even more in higher uptake scenarios.

**Impact on electricity demand from charging is initially small, but could require local grid upgrades**

Until 2030, the additional power demand from eTrucks is small compared to the expected incremental demand from buildings, industry, and other transport, including electric passenger cars. By 2030, we estimate that electricity demand for eTrucks will be ~30 TWh, representing less than 0.3% of the global electricity demand.

Exhibit 5

**Diesel consumption of trucks with and without electrification**

% based on million barrels per day (MMb/d)

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3.5 MMb/d could be displaced from the demand for diesel by the continued uptake of eTrucks beyond 2030
Beyond 2030, electricity demand from eTrucks will grow rapidly, exceeding 1,000 TWh just before 2050 (or ~3% of total projected electricity demand).

The main challenge for utilities will be how to deal with demand in new locations during peak periods. This will require local grid upgrades around new offtake points, such as those along major highways and in industrial zones for overnight charging. Because motorway stopovers are often located in remote areas, this might prove a challenge for utilities, local governments, and commercial players. In very remote areas, the installation of batteries could be an alternative to expanding the grid, especially in combination with renewables. Beyond 2030, we expect smart charging software in vehicles and charging stations to be in place. This will reduce charging during peak hours.

Implications for energy stakeholders

While the initial impact of eTrucks on diesel demand is modest, as we move beyond 2030 the outlook is more significant and will require the actors involved to rethink their current strategies. National and international oil companies will experience reduced demand for their product; fuel retailers will see their business model dramatically disrupted, requiring a redesign of fuel stations. In the power sector, grid or decentralized generation and storage investments may be needed to capture the additional electricity demand opportunity, while decommissioning of older power plants might need to be postponed in OECD regions to accommodate higher peak loads in the evenings.

Once the eTruck sector begins to mature, the transition could be rapid and opportunities for innovative partnerships and new entrants might quickly dry up, as established OEMs battle for market share. It will be electrifying to see how this disruptive force will change the reality for the freight transport sector. Will new challengers gain significant market share or will established players anticipate timely and be the winners?

Further reading This Energy Insights article is written in collaboration with the McKinsey Center of Future Mobility as part of a series on eMobility. The article ‘What’s sparking electric vehicle adoption in the truck industry?’ presents the implications of eTrucks and key success factors for automotive players.

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