

Electric trucks' contribution to freight decarbonisation

How T&E's Roadmap to climate-friendly land freight and buses would be impacted by electric tractor-trailer trucks

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Summary

This is an update to T&E's [study](#) on how to decarbonise land freight, published in June 2017. New technology options will soon be on the market, and we analysed how they will contribute to reaching zero emissions by 2050. More specifically, we brought fully-electric long haul trucks into our model, based on best available information. Our original study showed that, even after the implementation of ambitious measures to improve fuel efficiency in trucks above 16 tonnes, use all available and sustainable biofuels and maximise modal shift an important emissions gap would continue to exist.

The key to “filling this gap” is identifying a technically and commercially viable way to deploy green electricity in the trucking sector. The main report assessed partial electrification through catenary lines, hydrogen and power-to-liquids. It concluded that direct charging (through catenary lines) would be much more efficient, and more economical than the hydrogen or PtX pathways. Yet, even with catenary trucks a gap would remain to be filled.

Since the launch of our initial report several truckmakers (Mercedes, MAN, Tesla, VDL) have announced medium to heavy battery electric trucks. In China, BYD is already selling heavy duty electric trucks. Hence, in this update, we have assessed how long range battery electric trucks (up to 500km), in isolation or in combination with catenary lines, could help to achieve the full decarbonisation of land freight by 2050

The main conclusion is that such vehicles have the potential to bring the EU very close to zero emissions (measured at the tailpipe) by 2050. If accompanied by power sector decarbonisation this would put land freight on a Paris-compliant pathway. Moreover, if current assumptions (mainly with regards to battery price and performance) are correct, the transition would also be cost effective for the trucking sector. To stimulate the market for electric heavy duty trucks the EU should introduce a number of measures. These are discussed in more detail in [this paper](#).

1. Background

Earlier this year, Transport & Environment published a study¹ on how to decarbonise land freight and buses in Europe by 2050. The goal of the study was not to show how to achieve it, but to quantify how different policies could contribute towards the final objective. The study showed that certain measures can make **major contributions to reducing the climate change impact of the sector. These “low hanging fruit” measures are possible with today's off-the-shelf technologies and policies.** For instance, fuel efficiency standards for trucks could reduce emissions by one third compared to a business-as-usual scenario by 2050. Such measures are necessary but not - on their own - sufficient to meet the requirements of the Paris Agreement. Therefore, the study also intended to open a debate about the need for a long-term strategy at EU level on how to bring greenhouse gas (GHG) emissions from land freight to zero.

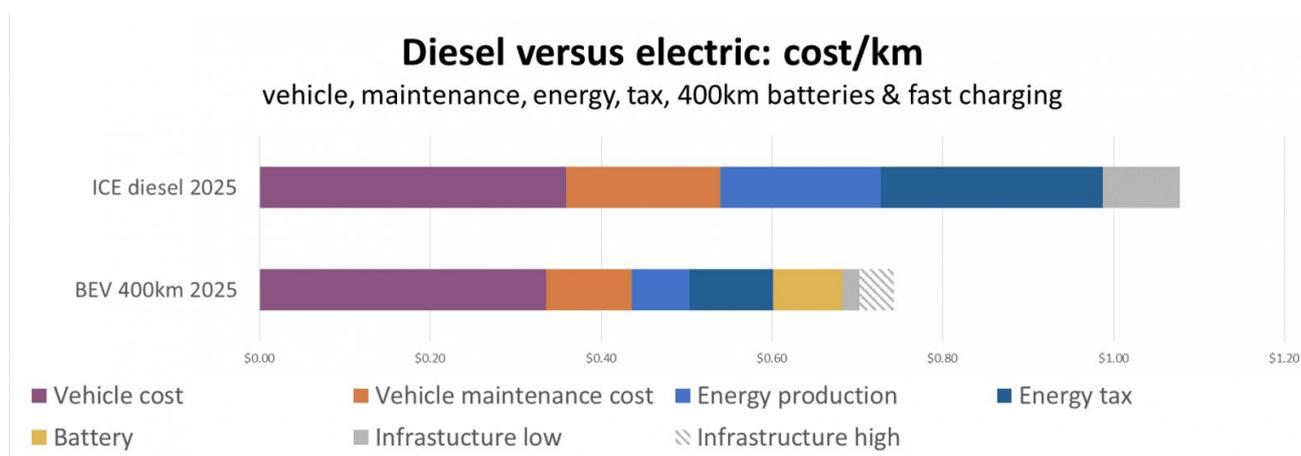
When the research for the study was undertaken, there was no clear evidence that an electric long-haul tractor trailer (above 16t) would be on the market any time soon. The study only looked into technologies with pilot cases available, and the technical potential to become widespread. Since then, we've seen a major announcement, so we complement the analysis in the study to understand the implications that it could have on European land freight.

2. Fully-electric long-haul trucks

In April 2017, Elon Musk, founder of Tesla, the California-based electric automaker, announced the release of a fully electric tractor trailer truck by late 2017.ⁱⁱ This information was later complemented with a specific date: October 26th, 2017.ⁱⁱⁱ Clear details on technical specifications of this model are still not available. For the sake of this analysis we took a set of assumptions based on information that has been publicly reported, as summarised below. Afterwards, those assumptions, together with other data from public sources, were incorporated into T&E's transport modelling tool, the EUTRM (European Union Transport Roadmap Model).

The Tesla Semi will be a class 8 truck, a US-based classification that encompasses trucks with a weight above 15 tonnes (typically a class 8 semi weighs 36 tonnes). European tractor-trailer combinations would fall under this category. The main difference is that EU trucks are generally heavier (40-44 tonnes). When it comes to electric vehicles, range is one of the most important considerations. The range of the Tesla Semi is estimated to be between 200 and 300 miles^{iv} (i.e. 322 to 483 km).

When it comes to price, there is little information as yet. When analysing alternatives, cost to the whole energy-transport system should be considered. In any case, some financial analysts estimate that the truck will be considerably cheaper to operate than a diesel truck with an equivalent payload.^v The price of the battery is the key element. Both Bloomberg^{vi} and McKinsey^{vii} expect battery pack costs to drop below \$100 by 2030, while projections by the ICCT^{viii} are in a similar range. Additionally, electric trucks are cheaper to maintain. Even being conservative on the infrastructure side, fully-electric long haul trucks would still be almost a third cheaper to operate than diesel trucks^{ix}:



For this study, we assumed that a fully-electric long-haul truck would become competitive. Our previous study didn't look into prices of different alternatives in detail, especially not from a vehicle perspective only. The EUTRM is an emissions model and not a cost model.

One common question that comes up regarding fully-electric long-haul trucks is their technical feasibility. In the past, battery limitations were used as an argument to claim that fully electric long-haul trucks are not feasible, mostly due to weight.^x However, recent analysis suggests the opposite. It is estimated that a 40t truck with a 400 km range will need a battery of around 700 kWh.^{xi} With an energy density of 5 kg/kWh (200 Wh/kg)^{xii}, that would add 3.5 tonnes to the truck. That would be partially offset by the lighter powertrain (e.g. an electric motor instead of a diesel engine, no after-treatment, transmission). Regarding charging

times, superfast charging power is becoming available, going up to 350 kW in a recent announcement in Germany.^{xiii} To charge a truck in a short period of time, it is estimated that 450-800 kW would be needed.^{xiv}

3. Main assumption included in EUTRM

In the study published in June, we assumed a share of fully-electric HHGVs (trucks above 16t) sold in the years up to 2050 would be zero throughout the period. With this new development, we had to change the assumption in the EUTRM. We considered range to be one of the main limitations when choosing a truck, and looked at the distribution of trips in the EU by distance, in vehicle-kilometres (VKM). Eurostat finds:

Table 1: Annual road freight transport, by distance class, in 2016^{xv}

Distance travelled	Year 2016 (VKM)	% of total VKM
Less than 50 km	11,193	8%
From 50 to 149 km	26,519	18%
From 150 to 299 km	32,867	22%
From 300 to 499 km	25,626	17%
From 500 to 999 km	28,830	19%
From 1 000 to 1 999 km	17,614	12%
From 2 000 to 5 999 km	5,312	4%
6 000 km or over	35	0%

In principle, a fully-electric truck with a range of 300 km (even more conservative than the worst case scenario for the truck described above) could cover 48% of the trips. If it would be up to 499 km (optimistic scenario), it would cover 65% of the trips. The Eurostat numbers above also cover MHGVs (trucks below 16t) and vans, so not all trips above are performed by HHGVs. Then there are some special trucks, the so-called **class 9 in the USA, which are used for very special duties (like transporting a wind turbine), that won't be electric**. In addition, there will be some trucks that will prefer to have some flexibility regarding the trips they travel. For these reasons, we assumed that the untapped maximum potential is 40% of VKMs by HHGVs by 2035. We used EUTRM to calculate what percentage of shares would deliver those results, up from 1% of new vehicles shares by 2020, equivalent to about 3500 units. In this update, therefore, shares of new diesel trucks would decrease as electric sales increase.

Table 2: new shares of electric HHGVs between 2020 and 2050, including vkm covered

	2015	2020	2025	2030	2035	2050
Sales of new vehicles	0.0%	1.0%	20.0%	40.0%	60.0%	100%
Travel activity (% VKM)	0.0%	0.3%	6.7%	21.0%	38.2%	85.5%

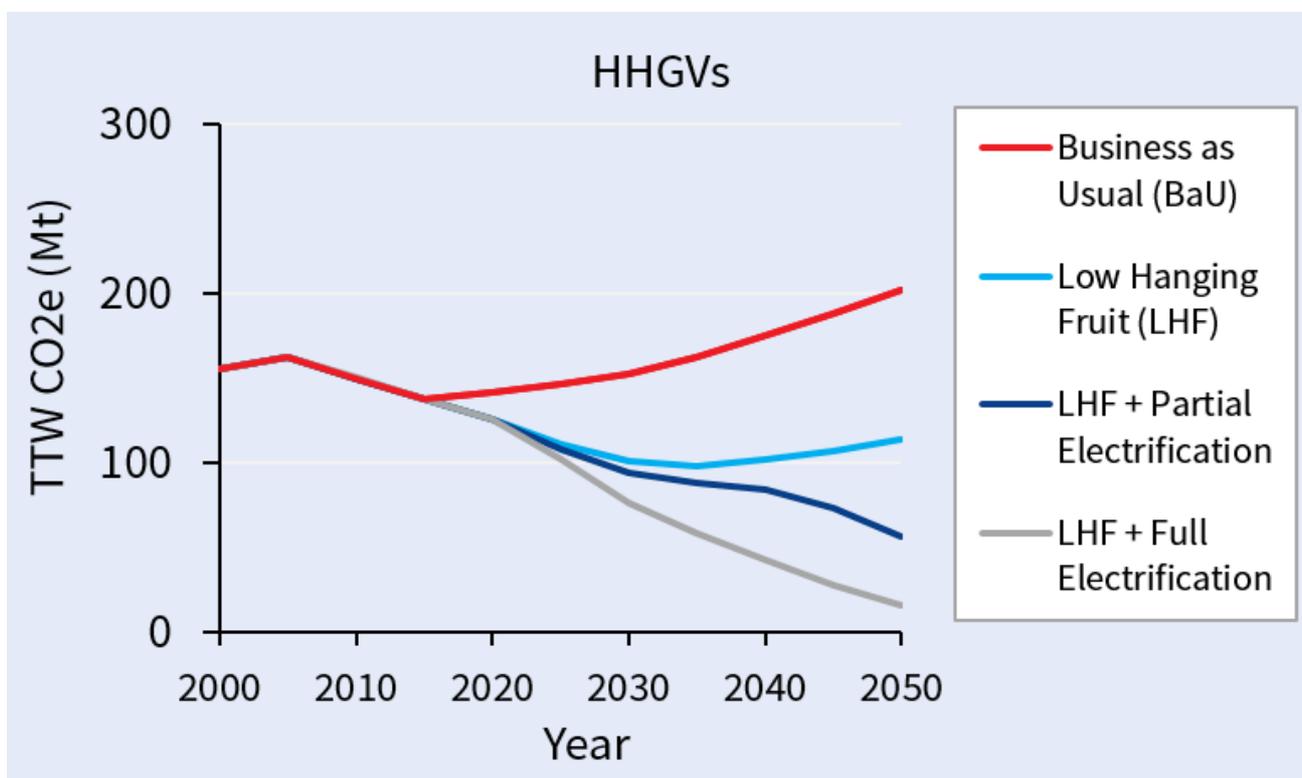
As technology and infrastructure keeps improving, we assumed that by 2050 all sales of HHGVs could be electric, either by fully-electric vehicles or the combination of electric hybrids using catenary lines and batteries when off the highways. Even in trips that go beyond 500 km in the table above (35% of the total VKM), currently trucks need to stop at least 45 minutes after 4.5 hours driving.^{xvi} At an average speed of 90 km/h, a truck would only travel 400 km in that time, which would be within the range of a fully-electric truck.

If trucks become automated, the economics of running the e-trucks under catenary wires become overwhelming, thereby enabling charging while driving.

4. Main results

The graph below shows the main result of incorporating the assumptions above for HHGVs. The red line shows the business-as-usual scenario, which is described in more detail in the original study. The light blue line shows what some low-hanging fruit options, such as fuel efficiency improvements, could deliver, also described in the original study. The dark blue line shows what could be achieved if the low-hanging fruit options would be implemented in combination with partial electrification, which, as explained in the original study, consisted of catenary lines that would cover the main highways, but large trucks would be running on an ICE engine when off the highways. The grey line shows the new full electrification scenario, which assumes that it is technically feasible to have almost all HHGVs running electric by 2050, either by using exclusively fully-electric trucks, or in combination with catenary lines, which then would run on batteries when off the lines.

Even assuming a decarbonisation of the grid, HHGVs would not reach zero emissions by 2050. Even if all sales would be electric by 2050, the fleet would require some time to decarbonise.



New additional renewable electricity would be needed to run the system. New Battery electric HHGVs, in combination or not with catenary lines, would require approximately 0.23×10^6 GWh of additional renewable electricity in 2050, or approximately 25% of 2015 renewable production.

5. Conclusions

If technology, economics and policy are right, the assumptions included in our model showed that it is possible to decarbonise land freight sector, as long as the electricity grid is decarbonised, and once all low-hanging fruit measures are implemented. The key to freight decarbonisation is renewable electricity and the main question is how to get this electricity to power the vehicles.

Using direct charging - either catenary or battery electric - is the most energy efficient alternative, as explained in section 3.2.3 of our study. Using electricity to produce hydrogen or PtL for road is considerably

less energy efficient, and the amount of renewable energy required would increase at least threefold. Only in niche applications where electricity cannot be used directly other alternatives should be explored. But there would be very few applications where that would be required, if our assumptions above are correct.

The Commission will be developing a mid-century decarbonisation strategy in 2018. Land freight transport decarbonisation will be one of the key challenges the strategy needs to address.

Further information

Carlos Calvo Ambel

Transport and Energy Analyst

Transport & Environment

carlos.calvoambel@transportenvironment.org

Tel: +32(0)2 851 213

Endnotes

ⁱ Transport & Environment, 2017. Roadmap to climate-friendly land freight and buses in Europe

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ⁱⁱ Fortune, 2017. Elon Musk Says Tesla Will Unveil an Electric Semi Truck In September

<http://fortune.com/2017/04/14/elon-musk-tesla-truck/>

ⁱⁱⁱ Elon Musk, 2017. <https://twitter.com/elonmusk/status/908108029777686528>

^{iv} Reuters, 2017. Exclusive: Tesla's 'long-haul' electric truck aims for 200 to 300 miles on a charge

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^{xiv} Hoekstra, A., 2017. Electric trucks, chapter 4: energy delivery

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^{xv} Eurostat. Consulted 12 October 2017. Indicator road_go_ta_dc.

^{xvi} Regulation (EC) No 561/2006 on the harmonisation of certain social legislation relating to road transport

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02006R0561-20150302>