ADVANCED PROPULSION CENTRE UK

Government consultation on the phase out of new non-zero emission HGVs

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HGV decarbonisation insights by the APC UK, Technology Trends

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Viable routes to decarbonising HGVs in the UK

The automotive industry continues to make big strides in developing and industrialising net-zero propulsion technologies of the future. Replacing generations of diesel and petrol vehicles is no easy task - with highly optimised production systems, ruthless drive for cost-reductions, well-established refuelling networks, embedded vehicle service and maintenance regimes and a robust used car market.

With battery electric and hydrogen fuel cells at the forefront of future zero-emission vehicle technologies, a cradle-to-grave approach has received laser focus with raw materials and energy required for production central to developing whole life environmentally-viable solutions.

Decarbonising heavy goods vehicles (HGVs) presents a bigger challenge than the light duty sector when moving away from fossil fuels. The fuels we use, vehicle duty cycles and distance travelled are intrinsically linked, allowing products and applications to deliver their function. Logistics operations operate at very lean margins and demanding delivery windows. As consumers, we demand goods at particular times and at keen prices.

The success of future propulsion technologies will depend on three critical factors:

1. The maturity, efficiency and security-of-supply of the new technology
2. A charging / refueling network that allows vehicles to operate at locations and distances needed for goods movement internationally
3. A total cost of ownership (TCO) parity with diesel drivetrains

Technology readiness, production scale-up and industrial supply routes are developing rapidly. On the other hand, charging and refueling for HGVs is not progressing in line with technology introductions. Most UK motorway service station charge points are positioned close the amenities, perfect for company car users, but not at all suitable for the height and width requirements of even an 18 tonne electric truck, let alone anything larger or articulated. .

The most difficult of vehicles to address in this sector is the 44t articulated lorry. These HGVs make up over 35% of new annual registrations and constitute around 25% of the total UK vehicle parc. They experience heavy usage, depreciate over 4-6 years and run for 100,000 to 125,000 kms annually.

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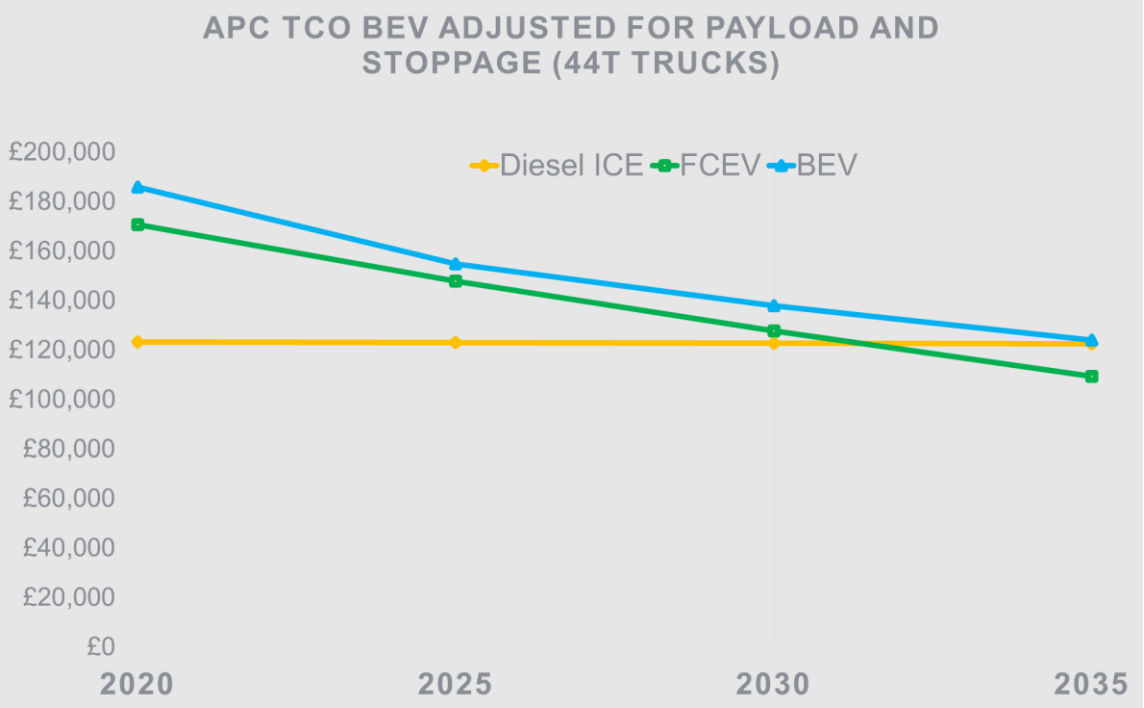
Propulsion technologies that can deliver a net-zero freight transport future

A long-term view to technology adoption is needed for freight transport viability. The APC has conducted an internal review of costs needed to run 44t articulated lorries across Europe.

Against a diesel benchmark, we found both battery electric and fuel cell vehicles can achieve a cost parity by 2035 under favourable conditions, namely technology improvements and reduced production costs from scale-up. For fuel cells, a critical factor will be the price of hydrogen at the pump. But, from the work conducted by the Hydrogen Council, the price of hydrogen is expected to come down to $4-5/kg at the pump and green hydrogen production costs are likely to get to $2/kg.



The analysis considers battery energy density and cost improvements summarised in the Automotive Council Electrical Energy Storage roadmap (https://www.apcuk.co.uk/technology-roadmaps/) with improving chemistries and large-scale production.

For fuel cells, there is greater uncertainly in the forecasts as large volume production data is limited. Nonetheless, international sources across Europe, China, Japan and the US provide a good indication of the potential for this technology. We have used data from the Automotive Council roadmaps again that aggregates this performance and cost forecasts to 2035. More about this can be found at: https://www.apcuk.co.uk/news/behind-the-scenes-the-2020-automotive-fuel-cell-roadmap/

A key point for the BEV cost curve is the weight of batteries on-board the vehicle. This affects its fee-paying payload capacity and hence raises concerns for fleet operators. Our calculations are based on best-in-class technologies available in 2020 and technology forecasts up to 2035. Almost six tonnes of battery mass will be part of a 44t BEV vehicle in 2020, dropping to three tonnes by 2035. This has a significant effect on the costs of goods, profitability and hence viability of adoption. In addition, charging times and stoppages are required within current technology limits. These are factored in. We expect these to improve with time and get close to national and EU rules for driver mandatory breaks, likely by 2040. Nonetheless, these costs add a significant amount to the nascent technology and hence we predict a similar total cost for BEV and FCEV technologies.

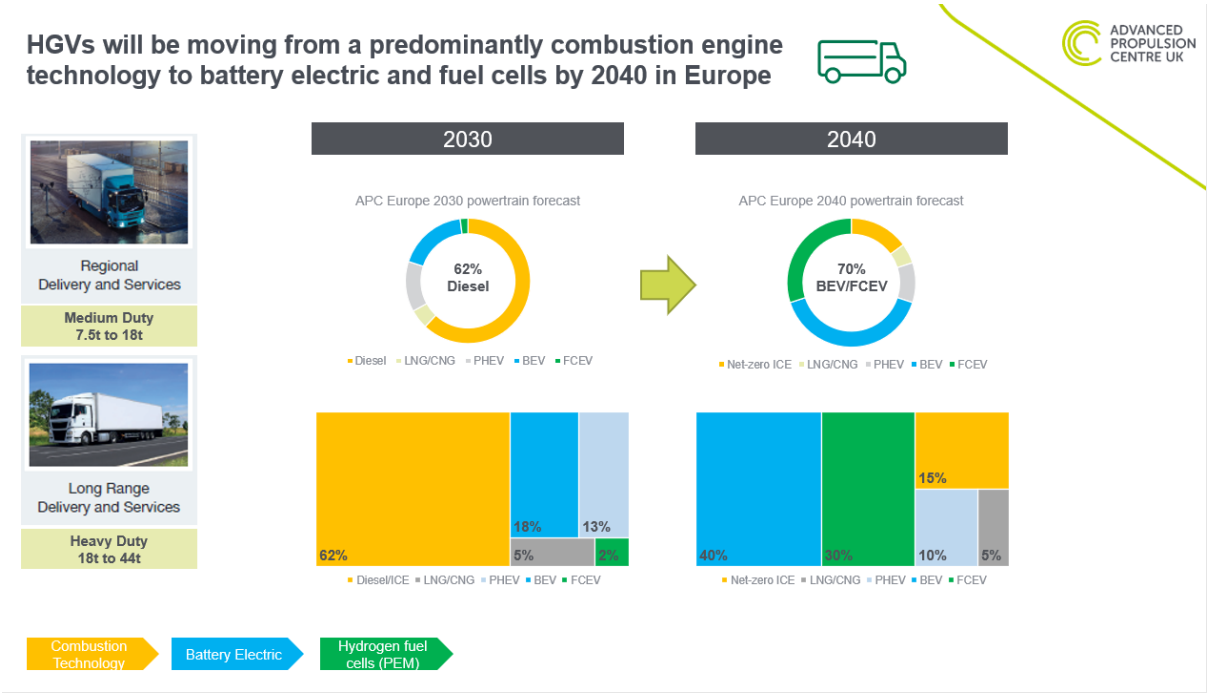
Both BEV and FCEV are capable of achieving cost parity with diesel by 2035 and so a ban on diesel sales by 2040 is plausible and achievable. However, importantly, a charging and refuelling network will need to be established to support this transition.

An inclusive net-zero approach to propulsion systems should include hydrogen combustion

From our work within industry, we see a demand for third propulsion technology, hydrogen combustion systems using known, cost-effective technologies for heavy duty HGV applications. We call this net-zero ICE. Four large engine suppliers; Westport, Paccar, MAN and Cummins have announced their programs for R&D into hydrogen combustion systems. The most recent of these is Cummins, https://www.cummins.com/news/releases/2021/07/13/cummins-begins-testing-hydrogen-fueled-internal-combustion-engine, supported by government funding through the APC. Their aim is to create near zero CO_2 emissions through the tailpipe and near zero levels of NO_x. This is a very promising and commercially viable for many HGVs in the >41t range.

What adoption splits of net-zero technologies can we expect?

Forecasts for battery and fuel cells adoption vary widely across different organisations and publications. The APC has taken these forecasts and developed a modelling approach selecting specific datasets related to the original source's expertise. We then combine the datasets to determine a likely outcome of technology adoption for 2030 and 2040. The chart below shows our predictions for Europe outside of the UK consultation on phase-out dates for new non-zero emission HGVs.



We expect the sale of new diesel HGV and LDV vehicles to drop to 62% by 2030, with battery technologies making large inroads primarily in the <18t medium duty truck sector. These vehicle platforms are maturing, but range and charging limitations still exists making them limited to urban and inner-city use.

By 2040, we forecast a larger transition to ZEV technologies, with battery and fuel cell technology becoming the dominant choice of propulsion systems across Europe. We forecast this to be 70% of

total new sales. By this point our expectation is that charging networking and hydrogen fuelling stations provision will have matured.

Hydrogen combustion, or similar net-zero propulsion, can provide a good route for 41t-44t heavy duty application and share in the same hydrogen refuelling network required for fuel cell vehicles.

Supporting evidence for the HGV weights split introductions

Six key OEMs represent 88% of the total HGV market in Europe: Scania, Iveco, PACCAR DAF, Volvo Trucks, Daimler Trucks and MAN. These are the most dominate trucks you will see on UK roads. All these companies have battery vehicle platforms under development, under-going trials or starting production soon, primarily in the medium-duty weight class of 7.5t to 18t.

A good list of low-carbon trucks is available on https://commercialvehiclefinder.cenex.co.uk/

The Fuso e-Canter, Paneltex Z75 and Tevva eTruck are all examples of market-ready products but have a limited travel range of between 60-150 miles.

Scania's 300 kWh model (P & L), Leyland DAF's electric LF (in production), Volvo's electric FL and Daimler's eActros are all examples of <18t trucks ready for the market, providing a range of 250km.

Austria plans to introduce legislation for 100% zero-emissions vehicles for <18t trucks from 2030 and >18t from 2035. Source: https://theicct.org/blog/staff/global-targets-ice-hdvs-aug21

Based on this, it is plausible to expect <26t truck being market ready by 2035 as stated in the consultation.

Getting ready to scale-up for new HGV powertrains

The APC supports large industrial scale up of heavy-duty propulsion technologies in the UK. Projects with Meritor and Cummins shows UK leadership in electrification, scale-up and net-zero combustion technologies needed to meet the demands of future heavy goods transport.

EPIC (Electric Powertrain Integration for Heavy Commercial Vehicles) – March 2021

The next generation of zero emissions heavy commercial vehicles need lightweight 'smart' powertrains to manage extreme levels of electrical power. The EPIC project, led by Meritor in Cwmbran, integrates the key elements of motor, inverter, gearbox, differential and brakes in a single lightweight system for vehicles up to 44 tonnes and includes coaches, off-highway and construction vehicles.

https://www.apcuk.co.uk/news/apc17-funding-announcement/

The BRUNEL project, Darlington – August 2021

The project will be a catalyst to accelerate the development of hydrogen-fuelled internal combustion engines (H2-ICE) to ensure the UK is at the forefront of this key emerging technology. Cummins will oversee a consortium of leading ICE sub-system suppliers, focused on medium and heavy-duty engines for trucks and construction equipment. The project will make a major contribution to increasing UK self-reliance in the emerging hydrogen economy and a significant uplift in the UK sourced ICE supply chain. A key deliverable will be to demonstrate tailpipe CO2 emissions can be virtually eliminated while retaining diesel-like levels of performance.

https://www.apcuk.co.uk/news/91-7-million-investment-as-uk-automotive-industry-accelerates-towards-net-zero-emissions/

Although the UK has a small HGV manufacturing footprint with Leyland DAF as its main manufacturer for heavy trucks, emerging players like Arrival are working on exciting electric vans for the HGV sector.

A decarbonised HGV industry could bring new e-powertrain supply chains to the UK

Working with DfT (on HGV decarbonised transport policy), BEIS (investments for energy and vehicle manufacturing in the UK) and the DIT (attracting foreign direct investments to the UK), the APC can help build a bigger and greener future for HGV transport in the UK.

Large suppliers like Cummins, Dana, Meritor and Danfoss, to name a few, are strongly positioned to supply heavy duty electrified drivelines using future net-zero propulsion technologies. All of them have an interest in working in the UK and Europe.