

Date: September 10, 2025

Industry Position - Required Policies

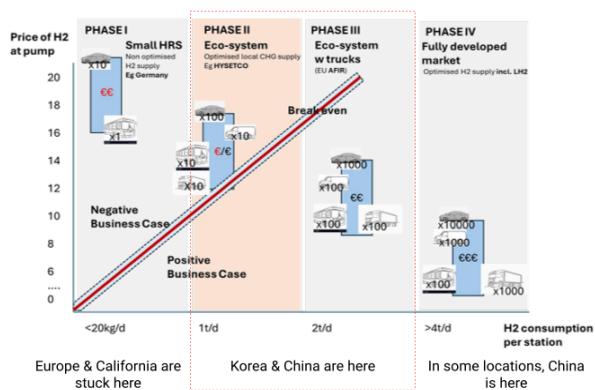
Context

To meet 2030 European CO2 emission regulations, vehicle manufacturers supplying the EU market will have to sell zero-emission vehicles. This will likely be a mix of battery and hydrogen vehicles, especially in the heavy-duty sector which is responsible for most road transport emissions but where full electrification is most challenging. OEM sales projections, gathered by NOW¹ in 2024 (see Appendix 1), suggest close to 40% of European truck sales in 2030 could be battery powered and almost 20% hydrogen (internal combustion and fuel cell). To support vehicle deployment in this market activation period (between 2025 and 2030) and evolve from the current demonstration scale to an economically viable phase, an effective, reliable refuelling infrastructure, at an acceptable price point for HDV and LDV, must be in place. Policies and incentives during this market activation period should focus on the enabling conditions, rather than the endpoint, for the use of hydrogen in mobility.

This picture illustrates the different phases of market development, beginning with small stations targeting limited applications, and developing to much larger scale, lower cost and multi-segment use. Market development requires a shift through these different phases (as we have seen in Asia), but – with a few exceptions – Europe remains locked in Phase 1.

This suggests that European market activation efforts so far have failed. Despite a network of close to 250 Hydrogen Refuelling Stations (HRS), only a few thousand cars and ~1000 buses are on the road.

By contrast, Korea and China have seen rapid deployment, with ~40,000 cars and a rapidly growing bus fleet in Korea, ~8,000 trucks and over 10,000 buses in China. In both cases, the majority of fleets have developed in concentrated ecosystems around industrial basins where low-cost hydrogen is available.



Why is hydrogen mobility struggling to build momentum in Europe today?

TCO, and TCO alone, rules in commercial road transport, where margins are tight and competition is high. Today, the hydrogen price at the nozzle is too high, the hydrogen retail business model is not yet viable (requiring repeated funding rounds), and the vehicle offer is narrow and still at high cost. However, after years of development, the industry is now in sight of establishing the first effective hydrogen mobility ecosystems. These are the precursors to a scale-up which will bring vehicle and clean hydrogen retail costs down significantly, making hydrogen mobility a self-sustaining and competitive solution in complement to battery electrification. **To activate the hydrogen mobility market and reach this end goal, a pragmatic approach should be taken in the three main challenge areas to bridge the current cost gap.**

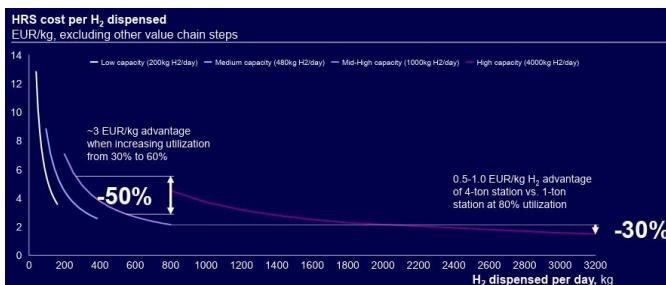
¹ Evaluation of the 2024 Cleanroom Talks with truck manufacturers, Figure 2 [\(LINK\)](#) “Market development of climate-friendly technologies in heavy-duty road freight transport in Germany and Europe”

1. Hydrogen cost at the nozzle and availability concerns

To reach a total cost of ownership (TCO) that is acceptable alongside battery and diesel during today's market activation phase, the heavy-duty ecosystem needs a hydrogen nozzle price at €8/kg, significantly below most pump prices in Europe today. This level can be achieved in certain areas today (but only under ideal conditions).

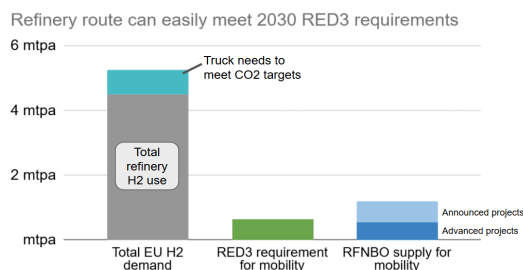
However, to really scale the technology in the market – and fully contribute to meeting European Truck CO2 legislation from 2030 – a hydrogen truck TCO needs to meet parity with the diesel TCO in order to significantly drive end customer uptake. In today's context in Germany, for instance, this would require a pump price of around €6/kg, although this is a function of CO2 pricing to fleet customers which should evolve with the implementation of ETS2. Furthermore, to achieve this price level, initial eco-systems are needed to unlock significant continued investments into large scale production and distribution infrastructure which are essential to provide satisfactory business cases, alongside innovation.

The nozzle price is made up of the hydrogen molecule, its net attribute cost (gross cost minus bioticket / renewable energy credit), conditioning (compression/liquefaction), transport to the station and operation of the HRS itself. This final step is the biggest driver of the nozzle price. Today's state of the art stations, with a loading of 70%+, can achieve operating costs close to €2/kg. But the existing network of smaller stations with low loadings (most operate at <15% of their capacity) can cost €10-20/kg. So **size and loading of the station is critical**.



Working back from the target nozzle price, assuming a loaded supply chain, leaves a 'budget' for the molecule and its attributes of up to €3/kg. This is achievable in some locations in Europe, especially with a pragmatic approach to hydrogen's attribute (as in Korea and China). However, many support schemes (at the Member State level) have required strict adherence to criteria such as use of renewable/RFNBO hydrogen, or in some cases small onsite electrolyzers (typically higher cost with little operational resilience), types of restrictions that are not placed on battery electric mobility. Any programme that seeks widespread station deployment to create a contiguous network locks in both low station loading and high hydrogen cost.

Furthermore, the H₂ mobility ecosystem has justifiable concerns about a lack of renewable/RFNBO hydrogen for mobility markets in 2030. With RFNBO supply likely to be limited, and refineries being a far easier and cheaper route to meet RED3 targets, **little RFNBO is likely to be available for direct mobility**.



Implied 2030 requirements from sector and legislation (when applies)

2. Viable HRS investment cases

A typical HRS cash flow profile assumes around five years of cash outflows before station loading reaches a level high enough to operate profitably. However, a continual shortfall in the number of vehicles on the road extends this period of cash outflow over and over again, requiring ongoing capital injections. (Existing networks face additional challenges of older generation, smaller stations and a shift from LD to HD use cases.) A 1tpd HRS would require a 60% to 70% load, or $\geq 600\text{kg/day}$, to achieve a viable business case at a cost (station alone) of 2.5€/kg. That requires 20 trucks to refuel each day. By 2024 c.170 trucks were on the road across Europe² - this could sustain just ~8.5 HRS.

As a result, **despite the introduction of AFIR** (one of the clearest pieces of clean mobility legislation designed to establish a comprehensive hydrogen refuelling and battery charging infrastructure), **the retail infrastructure network remains patchy at best, with a limited number of players ready to invest significant amounts with still a significant market risk and without any viable business case today.**

3. Vehicle Price and Availability

Truck OEMs see the above challenges (perceived high cost of hydrogen, question of its availability, and lack of a refuelling infrastructure) and have little visibility on potential solutions. Consequently, they are naturally reluctant to depend upon hydrogen for their 2030 regulatory compliance. As a result of this reluctance and the technical delays in the deployment of fuel cell trucks, the number of hydrogen vehicles sold into European markets has been very limited. On the other hand, hydrogen combustion engines (H2 ICE) are now beginning to reach market readiness.

Until OEMs commit to commercial scale in-series production, vehicles that are available are in pre-series or at an earlier commercial stage. This means a high degree of manual production, expensive components and a lot of mechanical support. As a result, costs are high (4x diesel for fuel cell trucks, 3x for H2 ICE) and numbers are very limited (10s to low 100s). Without careful planning and coordination, there will likely be a mismatch between vehicles and infrastructure, to the cost of all players in the supply chain.

Vehicle costs are expected to fall significantly once production of each model reaches 100s and then commercial quantities of 1,000s of trucks, where FCEV trucks could be produced at similar costs to BEV and H2 ICE trucks at even lower costs. All vehicle manufacturers believe that hydrogen must play a role alongside batteries in meeting 2030 CO2 emission regulations (hydrogen vehicle numbers shown below). But without vehicle subsidies and/or encouragement for fleets and shippers to adopt clean transportation, it is difficult to see today how large volumes are encouraged.

2024 NOW Cleanroom thousands of HD trucks sold in the EU	2024	2025	2026	2027	2028	2029	2030	Cumulative per techno
H2 FCEV	0.2	0.5	1.2	3.7	5.3	15.2	27.1	53.2
H2 ICE	0.0	0.3	0.3	1.1	2.6	5.0	12.3	21.6
NEW H2 FCEV & H2 ICE / year	0.2	0.8	1.5	4.8	7.9	20.2	39.4	-
Cumulative (FCEV and ICE)	-	1	2.5	7.3	15.2	35.4	74.8	-

2024 NOW Cleanroom - OEMs planned sales of H2 HD trucks to meet European HD CO2 standards in 2030.

² European Commission - New communication assesses market readiness of heavy-duty road transport vehicles ([LINK](#))

What do we need to unlock the market activation phase? Pragmatism and fast action is critical.

1) Fully recognise the complementarity of battery and hydrogen mobility

Hydrogen mobility must be considered as a clear contributor to the decarbonisation of road transport alongside BEV. The European Automotive Strategy and the European Hydrogen Strategy must re-establish confidence in hydrogen technology (i.e. to equally consider and include H2 mobility in the Eurovignette Amendment, Clean Transport Corridors, etc...).

2) Focus on deployment of hydrogen vehicles and infrastructure independently of H2 supply (in the beginning) while maintaining decarbonisation ambition

We strongly encourage policymakers to repeat the successful approach that has been taken for battery electric vehicles (BEV), in which deployment of battery vehicles and infrastructure has been considered entirely independent of the decarbonisation and renewable penetration of the power grid.

Similarly, deployment of hydrogen vehicles and refuelling infrastructure should be pursued independently of the decarbonisation of hydrogen molecule supply - relying on industrial use-cases to drive the scale up of competitive RFNBO production & demand, at least during the mobility market activation phase. This approach, followed by Asian countries, which focuses first on the deployment of an effective infrastructure and commercialisation of vehicles, will provide the best route towards the final objective: a full deployment of decarbonised hydrogen mobility.

3) Bridge the cost gap to diesel by synchronising deployment and demand activation

Vehicle OEMs, hydrogen refuelling station operators and hydrogen producers require certain production volumes and loading rates to achieve economic viability. As noted above, hydrogen producers can leverage industrial and energy applications in the early stages, but mobility-only parts of the supply chain require targeted efforts.

- A **dedicated hydrogen mobility incentive** that aims to co-develop the HRS network in accordance (at a minimum) with the AFIR regulation, together with dedicated budget for vehicle purchase, securing a minimum of $\geq 50\%$ HRS load (for example, the SWiM subsidy scheme in the Netherlands). This incentive can be complemented with a “capacity payment”³ for those HRS in locations which contribute to a comprehensive network but where dedicated demand is more challenging to predict. Refuelling infrastructure must be planned and built without delay, and measures to increase and extend the network should be quickly addressed as H2 vehicles are deployed.
- As a complement to the incentive scheme, existing policies, such as the Eurovignette (road toll exemption) for zero-emission vehicles and the implementation of the ETS2 are also beneficial in bridging the current cost gap, but they require fast adoption, equal consideration for all ZEV, and extended longevity (beyond 2030).

³ A “capacity payment” aid scheme has been already implemented in Germany to support the deployment of fast charging, validated by the European Commission ([LINK](#)).

Key Policies and incentives in place today

There is already a complex regulatory framework in place for the H2 mobility ecosystem, established long ahead of the market itself. Policies that have been published at the European level now require Member State transposition and concrete implementation plans that must be coupled with financial incentives, especially during the market activation phase.

The current period of “policy implementation” is now creating more uncertainty for hydrogen mobility, since the timeline and scope of policies significantly vary among Member States (e.g. ETS2 and Eurovignette, where only a few countries have fully transposed these directives), jeopardising both project execution (FID delays and project cancellations) and the implementation of competitive business models. The consequence is that all efforts from the sector are concentrated in those very few Member States that have created the most suitable conditions (notably the Netherlands for HD case). Below, we list the key policies that are linked to ZEV deployment in the EU and their missing blocks that impact the emergence of hydrogen mobility.

Legislation/Incentive & Sector	Impact	Requirements	Missing Blocks	Enough?
Strategic Dialogue on the Future of the Automotive Ind./ EU Hydrogen Strategy - H2 mobility Ecosystem / Clean Industrial Deal	High	Eurovignette Amendment, Clean Transport Corridors and Greening Corporate Fleets	Recognize H2 mobility as part of the decarbonization strategy of the transport sector, strengthen European H2 mobility Industry	Not Enough Missing public trust in hydrogen mobility due to lack of public / political support
CO2 standards - Vehicles/OEMs	High	OEMs to decarbonise sales of vehicles. i.e. -45% CO2 in 2030 for HD vehicles	Full recognition of H2 ICE as ZEV (HDV and LDV sectors).	Not Enough Missing incentives on the demand (vehicle acquisition) side
AFIR - HRS infrastructure	High	2030 targets to deploy HRS network in Europe for MS (urban nodes and corridors) to dispense H2 gas at 700 bar	Deployment plan, intermediate targets, extension to the TEN-T comprehensive network and suitable funding schemes	Not Enough It should match demand growth driven by the CO2 standards
RED3 - Fuel suppliers	Moderate	Supply of min 1% RFNBO by 2030 to the transport sector (refinery and mobility)	Needs flexibility to kick start mobility. Instead, a gradual phase-in of LC and REN H2 after the market activation phase.	Not Enough Insufficient flexibility on the H2 supply for mobility. Too high constraints. RFNBO will primarily go to existing industry, not HRS
Eurovignette - Transport	High	Standardise toll fees in Europe and provide toll exemptions/rebates to ZEV	Need long term perspective that zero emission vehicles are exempt from road taxes to help TCO parity with diesel.	Not Enough Uneven transposition among MS. Alone is not enough to encourage ZEV demand
ETS2 - Fuel Suppliers	Moderate	CO2 tax on fuels supplied for transport	Needs enabling conditions, such as accelerated infrastructure deployment, availability of competitive H2	Not Enough Success relies on strong enabling conditions for H2 mobility. It should not be weakened

Hidden factors tilt the playing field towards BEV today

Establishing a level playing field for all three zero-emission technologies in road transport (BEV, FCEV and H2 ICE) is crucial for OEMs to achieve the 2030 European CO2 emission regulations, and to deliver H2 refuelling infrastructure set by AFIR. The unequal implementation of policies and incentives has already proved to impact the cost of, and interest in, developing H2 mobility at the expected pace.

Some examples:

- **Funding programmes:** the BEV ecosystem does not face the same requirements on subsidy schemes as hydrogen. In order to be considered a renewable fuel, hydrogen has to follow the delegated acts for RFNBO production, which present a major constraint on costs and availability. It must be noted that RFNBO requirements for mobility cannot be fully met yet in any of the EU Member States, mainly due to a lack of transposition and missing schemes to valorise biotickets / renewable energy credits.
- **Industrial Automotive Action Plan:** the first proposal for the clean transport corridors initiative for HDV, is focused on BEV charging only; the Commission will present a map of electric HDV charging stations along two transport corridors (excluding HRS)
- **Energy Tax Directive (ETD):** unequal tax treatment of vehicles equipped with H2 ICE (compared to FCEV). It requires vehicle users to pay more per kg of H2 and adds complexity to HRS operations, requiring user segmentation (and tariffs) according to customers' powertrain. If ever agreed upon - would offer a great incentive, with tax-free hydrogen for 10 years (according to the proposal included in the fit-for-55 package).
- **AFIR:** sets an intermediate target for electric recharging infrastructure development in 2027, but not for HRS as the end target is set for 2030.
- **National schemes** designed to ease the introduction of EV charging (e.g. German government commissioning and providing grid connections at around 130 unmanaged motorway rest areas through Autobahn GmbH).

It should be noted that these policy inequalities sit on top of inherent market inequalities, in which:

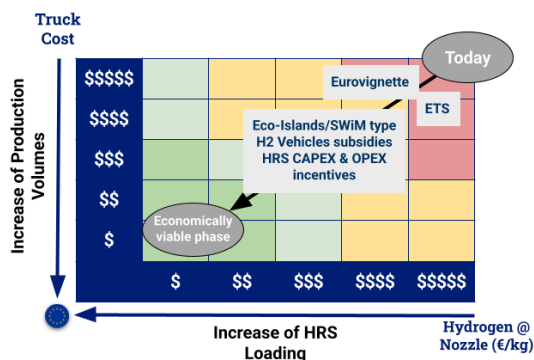
- (i) the cost of managing renewable power intermittency is not yet well reflected in electricity pricing. By contrast, many provinces in China require renewable power generators to install power storage, which integrates the intermittency management value of hydrogen into the renewable electricity price;
- (ii) the cost of upgrading grid infrastructure to support EV charging is mutualised by power utility companies across all users, whereas hydrogen infrastructure costs are borne by the relevant customers

What do we need to initiate market activation?

Successful market activation would lead to commercial in-series production of vehicles and a viable and contiguous refuelling network. The implementation of policies and incentives during the market activation phase should focus on:

- i. bringing down vehicle and H2 costs, and
- ii. increasing HRS loading.

The complementary role of the different policies and incentives should enable the development of a fully economically viable and unsubsidised future for hydrogen mobility, as demand builds and HRS networks grow.



1) ECOSYSTEMS: Ensure that AFIR deployment goes hand in hand with vehicles to create viable business models (involving shippers, logistics companies and transport operators)

A dedicated hydrogen mobility deployment incentive that aims to **co-develop HRS network in accordance (at a minimum) with the AFIR regulation, together with dedicated funding for vehicle purchase**; aiming to secure a minimum HRS loading and vehicle uptake.

Following the **principles of the SWiM programme in the Netherlands (Eco-islands)**, this financial support should be addressed to consortia consisting of transport/logistics companies and HRS operators. This approach helps to create hydrogen mobility ecosystems that guarantee coordination between both sectors and derisk HRS investments by securing a minimum charging/loading rate ($\geq 50\%$ of HRS capacity).

Implementation criteria must be flexible:

- **Vehicle powertrains:** should not impose technological choices/priorities. i.e. new or retrofitted passenger or freight vehicles powered by fuel cells or H2 ICE should be eligible.
- **HRS capabilities:** no limit to larger capacities (for example, 2 tonnes/day), nor the imposition of specific technological solutions (ie 350 bar, 700 bar, liquid-to-gas and liquid-to-liquid stations) to drive improving economies of scale and a competitive cost at the nozzle, as long as they are coupled with sufficient loading.
- **No strict requirement for hydrogen attributes** supplied during the market activation phase. A gradual phase-in of environmental attribute requirements should be adopted, to give the market and ecosystem enough time to develop in line with the scaling-up of renewable and low-carbon hydrogen production (for example, the RFNBO mandate for SWiM starts in 2036).

Successive and predictable funding rounds will provide visibility to project developers and ensure the proper presentation and selection of projects based on their maturity. This will avoid the bottleneck effect of projects of different maturity being submitted due to 'fear of missing out'.

2) **CLEAN TRANSPORT CORRIDORS: Capacity payments for network linking stations**

Ecosystem support should be coupled with a capacity payment in locations where demand is more uncertain and difficult to forecast during the early years of operation. Similar to California’s Hydrogen Refuelling Infrastructure (HRI) payments under its Low Carbon Fuel Standard (LCFS) programme, capacity payments provide OPEX support for stations that struggle to reach loadings sufficient to sustain a viable business model in the early years of activation. These can be phased out as hydrogen mobility becomes increasingly ubiquitous.

3) **GAP BRIDGING POLICIES**

Policies such as the Eurovignette and ETS2 directives palpably contribute to bridging the TCO gap. Nevertheless, as the transposition and implementation relies 100% on the Member State readiness, final rules and timeline can differ among them. The potential incentives stemming from these two directives exhibit a perfect synergy with the CAPEX subsidies allocated for vehicle acquisition. This is because they enhance the economic viability of ZEV during their operational deployment by transporters, through benefits such as avoiding tolls and exemption from CO2 taxes on fossil fuels, thereby necessitating vehicle utilisation. The Port of Los Angeles’ “Clean Truck Express Lane” is another strong initiative⁴; it allows ZE trucks to bypass conventional lanes, significantly improving gate-in times and operational efficiency.

4) **MAINTAIN AND EVOLVE A REGULATORY LANDSCAPE: Encourage investment**

A comprehensive regulatory framework has been developed over the last few years, encompassing both hydrogen and zero-emission mobility. Policymakers must reinforce their commitment to AFIR targets and CO2 emission standards since uncertainty deters investment across the value chain. Prior to any new initiatives, the implementation of this regulatory framework to stimulate demand for zero-emission mobility should be prioritised by all Member States and the European Commission.

Summary of existing and required H2 mobility policies in Europe

	H2 supply	HRS infrastructure	Vehicle fleets
Today / Planned	<p>EU</p> <p>RED3 (1% RFNBO) ETS2</p> <p>MS</p> <p>Lengthy & heterogeneous transpositions</p>	<p>AFIR (HRS # targets) AFIF (HRS capex funding)</p> <p>No implementation plan</p> <p>NL: SWIM (HRS capex & vehicle subsidy) FR: ADEME (HRS & vehicle subsidy, conditioned to RFNBO) GER: NIP (HRS and vehicle subsidy capex subsidy) - interrupted</p>	<p>CO2 standards Eurovignette</p>
Required	<p>H2 origin: gradual LC and REN H2 requirements with pragmatic criteria</p> <p>ETS2: fast adoption in MS & long-term perspective</p>	<p>AFIR: fast implementation mechanisms in MS, properly funded, with interim targets</p> <p>Activation Hubs/Valleys: HRS capex & vehicle subsidy (SWIM-like) Clean Transport Corridors: HRS capex & opex (capacity payment)</p>	<p>CO2 standards: full recognition of H2 ICE as ZEV (HDV and LDV sectors) Eurovignette: fast adoption in all MS & long-term perspective</p>

⁴ Public procurement is another pull mechanism that can be used to encourage shippers and logistics providers to progressively adopt zero-emission vehicles through the use of targets and incentives.

APPENDIX 1: NOW Study: Market Development of Climate-Friendly Technologies in Heavy Duty Road Freight Transport in Germany and Europe

NOW is a German state-owned company providing input on sustainable mobility to the federal authorities. Having started in 2008 with a mission focused on hydrogen and fuel cell technologies, it is now active on all sustainable and low carbon mobility routes - hydrogen, batteries and LNG. It employs around 200 experts in engineering technology, geography, business administration, political, social and communication sciences.

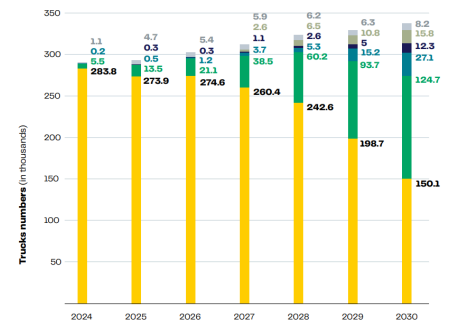
A survey (spring 2024) of HD truck manufacturers representing 99% of the EC market >12t asked for projected sales figures to 2030 in the context of European regulation on CO2 emissions.

Survey results

BEVs are expected to represent 37% of new registrations in 2030:

- Battery electric drivetrain is indispensable
- Market share slightly down on the 2022 survey due to change in funding and uncertainties about the speed of EV charging infrastructure expansion
- Technology and series maturity are already sufficient, even in long haul transport
- Standardisation of MW charging systems nearly complete
- Can meet diesel TCO in relatively short period of time

Forecast sales figures for heavy-duty vehicles (N3/> 12t)
In Europe, according to manufacturer data



Note:
The response rate in relation to the current market shares was 90 percent.
The values have been rounded for better readability.
Due to incomplete information from the manufacturers, no figures are shown for Europe for 2033.

Hydrogen trucks (ICE & FC) are expected to represent 20% of new registrations in 2030

- H2 market share is slightly up on the 2022 survey, manufacturers expect the share to increase further by 2033.
- FC share is down due to delays in technical and market readiness (lack of robustness, efficiency and stability required for long-haul applications). Series production will begin at the end of decade or later.
- ICE has appeared as an option since it was recognised as an emission-free drivetrain. Series production will begin sooner than for fuel cells.
- Almost all OEMs (including those previously relying on battery technology) have added ICE to their portfolio. Some see it as a bridge to fuel cell, others as playing a long-term role in market niches.
- All manufacturers see hydrogen playing a role in heavy duty transport – some see it as necessary to decarbonise all types of application, in particular heavy load and long-haul transport. Others see it more as a very niche application due to renewable hydrogen cost and availability concerns.
- Manufacturers believe that industrial use of renewable hydrogen and international transport will bring costs down significantly. However, some believe that industrial demand could create a shortage of hydrogen for mobility applications.

Key conclusions

Achieving CO2 emission targets will be a considerable challenge, so a range of options will be needed. Battery trucks will take the largest market share, but hydrogen ICE significantly increases the likelihood of the emergence of hydrogen mobility. New drivetrain technologies requiring different servicing creates opportunities for new OEM entrants. Infrastructure will be the bottleneck in coming years, not vehicle availability.