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Can Hydrogen Mobility Pay its Own Way?

A white paper on the mechanism required to prove whether hydrogen mobility's chicken-and-egg problem can actually be solved

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In Brief

- Twenty years of hydrogen mobility pilots across Europe and the US have shown the technology can work, but none has effectively addressed the key commercial question: whether hydrogen mobility can survive without subsidy. H2 Mobility Germany is closing stations it built, JIVE's bus targets were self-assessed rather than market-tested, and Nikola, Hyzon and HYVIA collapsed within the same week in February 2025.
- Under-capitalisation is the usual explanation. However, California had capital, stations and vehicles in place together, and retail hydrogen still hit a record $34.55/kg in October 2024.
- No programme to date has required every party in the chain, truck maker, fuel supplier, fuel retailer, fleet operator, to commit a real, binding number at the same time. This whitepaper proposes that it is that systemic disconnect, rather than a shortage of funding, which has kept hydrogen mobility's so-called *chicken-and-egg problem* unresolved.

- This paper sets out the Trucking Proof Test: a six-stage framework with decision gates, built to establish whether a commercially viable price for hydrogen trucking exists on industry-defined routes, without relying on subsidy or forecast.

Executive summary

Hydrogen mobility has been piloted for twenty years across Europe and the United States, without an organic inflection point ever having been achieved

H2 Mobility Germany built close to 100 refuelling stations and is now closing or repurposing dozens of them. Whilst Fuel-cell bus programmes reported meeting self-assigned cost and technical targets, no independent commercial buyer ever tested whether those figures held outside the subsidy structure, and no unsubsidised market followed. Nikola, Hyzon and Renault's HYVIA collapsed within the same week in February 2025.

The explanation usually offered is under-capitalisation: not enough money, deployed too slowly, to break the standoff between vehicle numbers and station numbers. As a general account, that explanation is deficient. California's hydrogen network is a pertinent example why. Retail fuel price at stations running near 60 percent utilisation hit a record $34.55/kg in October 2024. Shell, a company with no shortage of capital, walked away from a $40.5 million grant it had already been awarded for a 51-station network, because the unit economics did not work at any scale of investment it was prepared to make. Something more fundamental than a simple funding gap is at work.

Per this paper's central claim: No pilot to date has actually established what a commercially viable price band for hydrogen trucking looks like, because none has required every party in the value chain, truck manufacturer, fuel retailer, fleet-card operator and fleet operator, to commit real commercial numbers simultaneously. What exists instead is two decades of subsidised demonstration, built on the hope that scale would arrive automatically, with no mechanism specifying what would trigger it or who was accountable for the next move.

This paper sets out the **Trucking Proof Test**: a six-stage validation framework built to answer that question properly, once and for all. It targets hydrogen mobility's single best case, long-haul heavy trucking on defined motorway corridors, where hydrogen holds physical advantages over battery electric alternatives. It uses fleet card and route data to concentrate vehicles and stations on the same corridors, and a government-backed contracts-for-difference structure in place of direct industry price coordination, which would otherwise expose participants to serious competition law risk.

Each stage is gated. If the process establishes that no viable economic band exists among the manufacturers, suppliers and retailers tested, it becomes unnecessary to engage in demand aggregation. If a viable band does exist, the process moves on to identify real routes from fleet card data and test viable demand against them.

Methodology and basis for this analysis

This paper draws on a review of publicly available data on hydrogen mobility programmes in Germany, the United Kingdom, France, Switzerland, and California, including company statements and press releases, government and regulatory filings (notably the California Energy Commission's Assembly Bill 126 annual assessments), industry press (Sustainable Bus, electrive, S&P Global Commodity Insights, Hydrogen Fuel News), and EU Clean Hydrogen Partnership and predecessor programme funding disclosures. Figures are cited to their original source where available and flagged where sources conflict. The paper does not draw on non-public data from any commercial party and makes no claim to have surveyed truck manufacturers, fleet operators or hydrogen suppliers directly; the Trucking Proof Test proposed in Section 5 is the mechanism by which that missing data would need to be gathered.

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1. The record: twenty years of pilots that answered the engineering question and left the commercial one open

1.1 H2 Mobility Germany

H2 Mobility Deutschland was formed in 2015 by Air Liquide, Daimler, Linde, OMV, Shell and Total, later joined by Hyundai and the infrastructure fund Hy24. Its founding target was: 100 hydrogen stations across seven metropolitan areas and connecting motorways "in the course of 2020, regardless of vehicle numbers," on the premise that building supply ahead of demand was the way to break the standoff. The network reached roughly 105 stations at peak, with a further €110 million invested in 2022 (€70 million from Hy24, €40 million from existing shareholders) to fund the next phase.

The network has been in retreat since 2024. Six stations closed at the end of that year; a further 22 small, car-oriented 700-bar stations were closed in two waves through mid-2025 (11 by end of March, including Bonn, Flensburg, Ulm and Aachen, each of which lost its only public hydrogen outlet; 11 more by end of June); and a further 14 stations, including sites in Braunschweig, Duisburg, Essen, Ingolstadt and Wendlingen, closed on 31 December 2025, bringing the total closed during 2025 alone to 36. Independent tracking puts the network at roughly 72 stations in early 2026, down from its ~105-station peak.
H2 Mobility's own 2023 accounts show revenue of €7.6 million against operating expenses of roughly €34.5 million, a net loss of approximately €26 million. The company's stated reason for the closures is that the older stations "were originally designed for passenger cars and are no longer aligned with current technical and economic requirements," and it has pivoted explicitly toward 350-bar commercial vehicle refuelling.

In early 2026 the German federal government committed a further €220 million to hydrogen trucks and filling stations, with the transport minister explicitly invoking the need to "resolve the chicken-and-egg problem," a tacit admission that a decade and hundreds of millions of euros of prior investment had not done so.

Milestone	Date	Detail
JV formed	2015	Air Liquide, Daimler, Linde, OMV, Shell, Total
Target	2020	100 stations, built ahead of vehicle demand
Peak network	2021-22	~105 stations
Growth investment	2022	€110m (Hy24 led)
2023 financials	FY2023	€7.6m revenue vs ~€34.5m opex; ~€26m net loss
First closures	Late 2024	6 stations
Major contraction	H1 2025	22 stations closed in two waves
New government funding	Early 2026	€220m for trucks and stations
Network size	Early 2026	~72 stations, pivoted to commercial vehicles

Table 1: H2 Mobility Germany Milestones

1.2 Fuel cell buses: JIVE, JIVE 2, and the Cologne exception

The FCH JU-funded JIVE (from January 2017) and JIVE 2 (from January 2018) programmes deployed close to 290 fuel cell buses across around 15 sites in six countries, the largest coordinated European deployment to date. While the programmes reported meeting their cost and consumption targets, including the €650,000 unit cost for a standard 12-metre bus, this figure was set by the H2Bus Consortium itself around 2020. No city has bought a hydrogen bus fleet unsubsidised. Close to a decade on and with roughly €447 million of EU transport-programme funding behind mobility demonstrations of this kind, JIVE has not produced a single city that ordered and paid for a hydrogen bus fleet at that price without public money underwriting it. The taxpayer funded demonstration did not produce a market. JIVE 2's own Best Practice Report was candid about what still did not work operationally: refuelling station reliability and unstable hydrogen supply left buses unable to refuel, and 2022 energy price instability made green hydrogen "unaffordable without government support."

A 2012 study, Urban Buses: Alternative Powertrains for Europe, commissioned by the FCH JU with analytical support from McKinsey, predates JIVE and forms part of the case later used to justify it. It provides a case-in-point how an industry's homogenised cost projections can become entirely over optimistic.

The study pooled proprietary cost data from more than 40 organisations across the value chain, bus manufacturers including EvoBus, Iveco, MAN, Solaris and Van Hool, operators including Transport for London and RVK Cologne, infrastructure providers including Air Liquide, Air Products and Shell, into a single "clean team" that collected and sanitised over 5,000 data points, with the resulting aggregated figures signed off by all participating organisations. The base case showed the fuel cell bus's total cost of ownership gap to diesel narrowing from roughly 100 percent in 2012 to 17-26 percent by 2030 under a "cross-industry" scenario requiring more than 1,500 buses produced per manufacturer per year, (volumes that did not exist then and do not exist now). Also required were assumed cost reductions of up to 74 percent on the fuel cell stack spilling over from fuel-cell car production at a scale far beyond that which has materialised. Stack every other favourable assumption on top, a higher oil price, a carbon tax that was never introduced, cheaper hydrogen production, and the study's upside case showed the price premium eliminated entirely by 2030.

The study's own "niche scenario", the case where large-scale production did not happen, assumed a floor of 120 buses per manufacturer per year and still showed a 41 percent TCO gap remaining in 2030. Actual 2025 volumes cleared that floor for one manufacturer only: Solaris registered 277 hydrogen buses in Europe, more than double the niche assumption. Wrightbus registered 95 and Mercedes 85, for a European total of 558, none of it approaching the 1,500-per-manufacturer the cross-industry scenario needed. The industry-wide cost curve used to justify continued funding was built from the same organisations, several of them the same named participants, who stood to benefit from the programmes it was used to support. The Trucking Proof Test in Section 5 is built to close this gap, by requiring a firm, committed number from each party rather than a projected one assembled from the most favourable combination of assumptions the group could agree to.

Aberdeen is the clearest documented failure, and it is really two failures layered on top of each other. The city ran 10 Van Hool single-deckers from 2015 to 2020 as an initial trial, then a “world-first” fleet of 25 Wrightbus hydrogen double-deckers from early 2021, a roughly £8.3 million project at approximately £500,000 per bus, funded by the council, Scottish Government and EU sources; at its peak Aberdeen operated 85 hydrogen vehicles in total across buses, council fleet cars and waste trucks. The bus fleet was withdrawn from service in mid-2024 after repeated failures at its two refuelling stations and has been parked for well over a year. Separately, and on a larger scale, the council committed £20 million to a £40 million joint venture with BP, the Aberdeen Hydrogen Hub, intended to produce green hydrogen from solar power at a former landfill site. In early 2026 the council voted to sell the bus fleet outright and begin a “managed exit” from the BP joint venture, with a council spokesperson citing “significant advancements in EV technology” and declining demand for hydrogen in transport.

London’s 20 Wrightbus double-deckers on routes 7 and 245 remain in service, but Transport for London has stated it has no plans to order more, preferring to expand its battery electric fleet instead.

Cologne’s operator RVK is the one genuine scale-up, and unlike the others it actually delivered on its target: the fleet grew from 52 buses in 2021 to 160 by the end of 2025, backed by roughly €34 million in federal subsidy, making it the largest hydrogen bus fleet in Europe. The decisive enabler is due, at least in part, to a geographic accident: cheap industrial by-product hydrogen from chemical plants at Hürth and Leverkusen, previously flared, available at a cost no other city has access to.

Fleet	Buses	Cost	Outcome
Aberdeen	10 (2015-20) then 25 (2021-)	~£8.3m buses; separate £40m BP JV (£20m council share)	Buses withdrawn mid-2024, being sold; exiting BP JV, 2026
London (TfL)	20	Not disclosed	In service, no further orders planned
Cologne (RVK)	52 (2021) to 160 (end-2025, target met)	~€34m federal subsidy	Largest fleet in Europe; dependent on free by-product H2

Table 2: Example Fuel Cell Bus Deployments in Europe

1.3 Techno-commercial Feasibility of Heavy-duty Hydrogen Mobility

Hyundai's XCIENT programme is the sector's clearest technical success. Forty-eight trucks in Switzerland, running from October 2020, reached 10 million kilometres by June 2024. The wider European fleet reached 20 million kilometres with 165 trucks across five countries (Switzerland, Germany, France, Netherlands, Austria) by February 2026, alongside 63 units and roughly 1.6 million kilometres in North America. It is a strong reliability record, built after five years inside subsidised demonstration programmes rather than a self-sustaining commercial fleet.

The contrast is starkest in the failures that followed. Nikola filed for Chapter 11 bankruptcy on 19 February 2025 with roughly $47 million in cash remaining, having produced only around 600 vehicles in total since commercial production began in 2022, against 7,000 pre-orders once claimed and a planned sixty-station HYLA network of which only a handful were ever built. Its 113 remaining Tre trucks, spare parts inventory, software and IP were sold at auction to Hyroad Energy for a reported $3.85 million against an estimated asset value over $114 million (one source puts the hydrogen-specific portion of the sale at $15.3 million; the figures are not fully reconciled across reporting).

Hyzon Motors closed operations the day before, on 18 February 2025, having promised 40,000 trucks for 2025 but having delivered only dozens across its entire history.

Renault's fuel cell joint venture with Plug Power, HYVIA, entered French insolvency proceedings on 10 December 2024 and was placed into court-ordered liquidation on 18 February 2025, the same week as Hyzon's closure. HYVIA's own statement cited "the too slow emergence of hydrogen mobility ecosystems in Europe," and Renault's chief executive, Luca de Meo, told the French National Assembly the vehicles "are not selling due to a lack of demand."

Company	Event	Date	Detail
Hyundai XCIENT	Milestone	Feb 2026	165 trucks, 20m km (Europe); 63 trucks, ~1.6m km (North America)
Nikola	Chapter 11	19 Feb 2025	~$47m cash; 3 of 60 stations built; assets sold to Hyroad Energy
Hyzon Motors	Ceased operations	18 Feb 2025	Promised 40,000 trucks for 2025; delivered dozens historically
HYVIA (Renault/Plug Power)	Court-ordered liquidation	18 Feb 2025	Insolvency filed 10 Dec 2024

Table 3: Hydrogen Fuel-cell Truck Manufacturers and Notable Events

1.4 California

California is the single best-documented hydrogen mobility market and the strongest evidence that capital alone does not solve this. The California Energy Commission invested roughly $174 million in light-duty hydrogen infrastructure. As of September 2025, 50 stations remained open, with a further 11 offline for 30 or more days, at approximately 60 percent average network availability. Shell permanently closed its seven California light-duty stations in February 2024, and in June 2023 cancelled a $40.5 million CEC grant tied to a proposed 51-station network, effectively returning committed capital because it could not see a route to viable station economics. True Zero (FirstElement) closed 10 stations in October 2023.

Retail hydrogen price, rather than falling as the network matured, hit a record $34.55/kg in October 2024, roughly five to twelve times the equivalent BEV energy cost per kilometre. State assessments found network capacity already exceeds vehicle demand (able to serve an estimated 34,300 FCEVs against 14,128 actually registered), yet access is collapsing in the specific places vehicles are, a siting and throughput problem rather than a raw capacity shortfall.

Vehicle demand fell alongside it: Toyota Mirai US sales dropped from 2,737 in 2023 to 499 in 2024 to 210 in 2025; Hyundai sold five Nexos in the US in 2025, down from 94 the year before. Europe's trajectory is worse still: just 14 hydrogen fuel-cell vehicles were sold across the continent in the first half of 2026, down 64 percent from 39 in the same period a year earlier, according to SNE Research.

This is happening as the EU's Alternative Fuels Infrastructure Regulation requires hydrogen stations in every major urban area and every 200km of the TEN-T core network by 2030, roughly 650 stations against 151 installed today.

Table 3: Key Hydrogen Mobility Figures for California

Metric	Figure
CEC infrastructure investment	~$174m
Stations open (Sept 2025)	50 (11 more offline 30+ days)
Average station availability	~60%
Peak retail hydrogen price	$34.55/kg (Oct 2024)
Shell grant cancelled	$40.5m (June 2023)
Toyota Mirai US sales	2,737 (2023) to 210 (2025)

1.5 EU Funding

The FCH JU (2008-2013, roughly €940 million total including €470 million EU funding under FP7), the FCH 2 JU (2014-2020, roughly €1.33 billion total including €646 million EU funding under Horizon 2020), and the Clean Hydrogen Partnership (2021-2027, up to €1 billion EU funding, over €2 billion total) collectively directed an estimated €447 million across 78 transport demonstration projects, including JIVE, H2ME, ZEFER and 3Emotion. Over fifteen years and close to half a billion euros of EU-side mobility funding alone, before national co-funding and private match, essentially none of the flagship demonstrations transitioned to unsubsidised commercial procurement.

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2. Failure Modes

Two explanations are typically offered for such patterns of failure.

Capital was too slow and too limited. The common argument that capital was too slow and too limited is contradicted by the flagship case: H2 Mobility Germany built 100 stations upfront, deliberately ahead of vehicle demand, and is now closing them station by station. Shell had the capital to build a light-duty network in California too, and chose to hand back an already-awarded $40.5 million grant rather than continue, because the unit economics did not work at any scale of investment it judged worth making. A larger, faster tranche of capital does not fix a problem that a well-capitalised major oil company looked at and declined to fund further, or one that a well-funded, deliberately aggressive network build is now being dismantled to escape.

Technical immaturity. The second explanation offered is that the technology itself was not ready. The record does not support this: Hyundai's XCIENT trucks have logged 20 million kilometres reliably across five countries, and JIVE's buses met their own fuel consumption and range targets. The engineering has worked for years. What has not been tested is at what scale would operators pay full price for it if fuelling cost and availability was guaranteed.

Pilots were too small, convoluted and bureaucratic to test anything commercially real. A third explanation holds that pilots would have worked if they had not been so bureaucratically burdened, run by committee across a council, a national government and an EU programme, each with its own reporting requirements. The reporting burden is real, but it is not what distinguishes hydrogen's outcome: battery-electric buses were funded and procured under the same EU mandates and the same reporting constraints, and still reached 11,607 European registrations in 2025.

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3. Trucking as an Industry Validation Exercise

Trucking remains the most commercially feasible application for road-based hydrogen mobility. If it cannot compete effectively against other energy vectors in this space, it is highly unlikely to become commercially viable in other, less advantageous segments.

Long-haul heavy trucking on fixed motorway routes holds physical advantages over battery electric solutions including reduced weight penalties, charging time against refuelling time, and range.

Every trucking pilot to date has tested whether a fixed number of vehicles can operate reliably on a fixed route with subsidised fuel and a subsidised station. Hyundai's XCIENT programme has answered that question well. None has tested the commercial question: whether a fleet operator would buy these trucks and pay for this fuel without subsidy, at a price a manufacturer and a supplier could sustain long-term, because none required a real answer from any party.

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4. Industry Archetypes

Truck manufacturers know, or can calculate precisely, the volume of hydrogen trucks they would need to sell to make a production line commercially worthwhile, and the price at which they would need to sell them.

Fleet operators know their total cost of ownership requirements in detail, calculated against diesel and increasingly against battery electric alternatives, and will not commit fleet capital without a credible, durable guarantee on both vehicle price and fuel availability.

Hydrogen suppliers know their production and delivery cost curve at different volumes. California's price trajectory shows what low-volume delivery does to total cost of ownership: it makes it unworkable.

Fuel retailers and fleet card operators hold granular, route-level data, through existing fuel card relationships, on exactly which motorway corridors carry enough truck traffic to justify a station, and what aggregate fuel demand on those corridors looks like, at what times, for which operators.

Each of these four players is behaving rationally. None will commit first inside a scheme that can be quietly wound down or defunded, because moving first inside a reversible pilot means absorbing the downside alone if the other three do not follow. Twenty years of stalled pilots come down to that: a coordination failure rather than a shortfall in engineering competence or, on its own, in capital.

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5. The Trucking Proof Test™

A six-stage, stage-gated framework, testing hydrogen trucking's commercial feasibility across the value chain, from initial pricing through implementation.

Stage 1: Establish Whether a Viable Range Exists

Actions: Truck manufacturers, fuel retailers and hydrogen suppliers each work out, independently and without reference to each other's figures, the truck price, fuel price and total cost of ownership at which hydrogen trucking would be commercially worthwhile for them at scale. This step establishes, for the first time in the sector's history, whether a range of price and volume exists where every party's numbers overlap, what a manufacturer needs to sell at, what a supplier needs to charge, and what a retailer needs to distribute at, all satisfied at once, the 'band'.

Who is accountable. A neutral convening body, ideally independent of any single commercial party, collects the figures and identifies whether overlap exists, without disclosing any individual party's figures to a competitor.

If it fails. No overlapping band: the process stops here. It means hydrogen trucking cannot currently work commercially on any terms these parties can offer, and resources should not be committed to further pilots until the underlying cost curves change.

Stage 2: Map the Routes

Actions: Fuel retailers and fleet card operators use existing route and refuelling data to identify the specific motorway corridors where truck density is high enough to support a concentrated station network, the hydrogen equivalent of a diesel corridor rather than an isolated station.

The mistake this stage is designed to avoid. Prior hydrogen mobility programmes have repeatedly started from a corridor or hub location chosen in advance, on the assumption that a route which looks obvious on a map, a major freight artery, an existing "hydrogen valley" cluster, a corridor named in an industry roadmap, would generate demand once served. H2 Mobility Germany's station network was built this way, on expectation rather than evidence, and Section 1 shows the outcome. Names like a Rotterdam-Antwerp-Duisburg corridor or a UK M6/A1 corridor circulate in industry discussion as examples of the kind of corridor this applies to, but naming them here is illustrative only, not a starting assumption. The corridors this framework tests have to be the output of fleet card data, generated from where trucks actually run and refuel today, not an input selected because it matches a prior belief about where hydrogen trucking ought to work. Shoehorning the mapping to fit an expected corridor is the same error that produced twenty years of stations built ahead of demand rather than located against it.

Stage 3: Test Fleet Operator Demand

Action: Vehicle OEMs and fuel retailers directly pitch fleet operators along mapped key routes with a commercial proposal.

Core Question: "If provided with a guaranteed fuel supply, fixed pricing structure, and station availability—backed by a risk-free commitment to replace non-performing hydrogen trucks with alternative vehicles at no cost—under what commercial terms (vehicle price, fuel cost, availability uptime) would you commit, and to how many vehicles over what timeframe?"

Accountability: The framework operates as a single, synchronized ratification rather than a series of piecemeal agreements. All commitments remain provisional until a critical mass of stakeholders across the entire value chain—manufacturers, suppliers, retailers, and fleet operators—simultaneously sign on. If participation falls short of the threshold, no commitments are binding and the process dissolves. Once the threshold is met, the complete structure becomes fully binding for all parties at Stage 5.

Stage 4: Reconciliation

Actions: The neutral convening body maps the conditional fleet commitments gathered in Stage 3 against the viable pricing, volume, and margin thresholds established in Stage 1. This step validates whether real-world fleet demand meets the precise volume and price requirements needed for OEMs, fuel suppliers, and retailers to achieve commercial viability along the mapped corridors.

Decision Gate: If no overlap exists, the process stops immediately with the same strategic legitimacy as a Stage 1 failure. This confirms a fundamental mismatch between fleet willingness-to-pay and supply-chain economics that cannot be bridged under current market conditions, preventing premature capital deployment. If sufficient overlap exists, the parties establish a tight midpoint target—fixing the agreed volume, truck price, and fuel tariff—to serve as the definitive commercial baseline for multi-party signing in Stage 5.

Stage 5: Secure Commitments

Actions: Manufacturers calculate the production volume needed to trigger organic scale economies and add a risk margin structured to cover the cost of honouring the replacement guarantee offered in Stage 3 should the refuelling network fail to materialise. This higher, margin-adjusted volume becomes the firm threshold fleet operators are required to sign against, converting Stage 3 expressions of interest into legally binding commitments. Crucially, some operators who provided indicative numbers in Stage 3 may withdraw when faced with binding execution.

Decision Gate: Success depends entirely on whether the total volume committed by remaining operators clears the margin-adjusted threshold, regardless of dropouts from Stage 3. If signed volumes fall short of this bar, the process is paused. If signed volumes clear the threshold, and simultaneous participation across all required value-chain segments satisfies the Stage 3 ratification principle, binding contracts are executed covering guaranteed truck pricing, fuel tariffs, and station availability over a fixed term.

Stage 6: Manage Competition Law

The Antitrust Challenge: Direct price or volume agreements between competing truck manufacturers or fuel suppliers—even if restricted to specific corridors and fixed terms—may constitute horizontal coordination. This creates significant exposure under UK, EU, and US competition law, regardless of the framework's underlying decarbonisation goals.

Primary Mechanism (Government-Backed CFD): To eliminate direct competitor alignment, the framework replaces direct industry agreement with a government counterparty using a Contracts for Difference (CfD) mechanism, mirroring the model that scaled UK offshore wind. Individual manufacturers and fuel suppliers submit confidential, competitive bids into a state-administered auction that establishes strike prices and underwrites the performance guarantees given to fleet operators. Because competitors never negotiate or exchange sensitive commercial terms with one another, antitrust risk is mitigated. Furthermore, state backing provides the institutional enforceability and creditworthiness fleet operators require before deploying private capital into hydrogen assets.

Alternative Mechanism (Sustainability Exemption): Where state intervention or funding is unavailable, parties must rely on statutory antitrust exemptions, such as the UK Competition and Markets Authority's Green Agreements Guidance or the EU's Horizontal Guidelines on sustainability agreements. These provisions permit horizontal coordination where demonstrable environmental benefits outweigh market distortions.

Because legal interpretations in this domain evolve rapidly, both pathways require fresh jurisdiction-specific antitrust evaluations before any commercial terms or data are exchanged.

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6. Conclusion

Hyundai's XCIENT programme has established that hydrogen trucks can be built, refuelled and operated reliably. No pilot has established whether hydrogen trucking can work commercially without subsidy, because no pilot has required every party in the value chain to commit binding commercial numbers at the same time.

The Trucking Proof Test tests that question directly, on the one segment of road transport where hydrogen has a physics advantage: long-haul heavy trucking on defined motorway corridors. A failure at any stage produces a clear result at a fraction of the cost of another decade of subsidised demonstration. Success produces contracted commitments from every party in the chain.

Methodology and verification

Figures in this paper are drawn from primary and named sources: company statements and press releases, court and insolvency filings as reported by electrive, Fleet Transport and Hydrogen Insight, the California Energy Commission's AB126 annual assessments, Hyundai Motor Group's own press releases and infographics, Toyota Motor North America's official sales results, and a direct read of the source documents themselves, including the 2012 FCH JU/McKinsey "Urban buses" study. Where figures vary across reporting outlets, such as the Shell California grant (reported between $40.5 million and $40.8 million, covering 48 to 51 planned stations depending on source), this paper uses the figure given in the California Energy Commission's own regulatory filing.

The regulatory mechanisms discussed in Section 5, Stage 6, in particular the contracts-for-difference structure and the applicability of the UK CMA's Green Agreements Guidance and the EU's Horizontal Guidelines, represent current competition law frameworks as of the time of writing. Competition law in this area continues to evolve, and its application varies by jurisdiction. Any party looking to implement the mechanism described here should obtain a current legal evaluation in the relevant jurisdiction before proceeding; nothing in this paper should be read as legal advice

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Figures are drawn from the sources above and are stated with the dates on which they were reported; where sources conflicted, this is noted in the relevant section.

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