The road to net zero

Fuel-choice insights for decarbonising transport, inclusive of the North

Drawing on the Research England Hydrogen Innovation Project (REHIP) Fuel Choice analysis for the Teesside transport sector, this paper translates the project's modelling, lifecycle and stakeholder evidence into decision-oriented insights, setting out what an evidence-based, multi-fuel transition means for transport, and what it implies for the role of hydrogen.

Key background

- The Research England Hydrogen Innovation Project (REHIP) works to advance industrial decarbonisation and hydrogen technologies in the Tees Valley.
- REHIP is part of the Net Zero Industry Innovation Centre (NZIIC), Teesside University.
- The Fuel Choice analysis was delivered by Teesside University with Durham University, comparing low-carbon fuel pathways across the regional transport system to 2050.
- We thank you for taking the time to read this paper, which is offered to help policymakers and industry make confident, evidence-based decisions on transport decarbonisation in the North East.

The REHIP Fuel Choice analysis examined how the Tees Valley can decarbonise transport across road, rail, aviation and port activity in a way that is technically feasible, economically credible and publicly acceptable. To inform decisions on transport fuel and infrastructure, we have translated the project's evidence into policy-oriented analysis and recommendations.

This paper focuses on three themes:

- The evidence for a phased, multi-fuel transition
- Sector readiness constrained by infrastructure
- Skills, governance and sequencing

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Executive Summary

Fuel-choice insights for decarbonising transport, inclusive of the North

Transport fuel-choice recommendations

1. **Adopt a phased, multi-fuel strategy:** Tees Valley should pursue a sequenced portfolio spanning electrification, hydrogen, sustainable aviation fuel, and transitional biofuels, rather than a single-fuel pathway, matching each option to mode, duty cycle, and infrastructure readiness.

2. **Implement whole-system energy mix approach electrifying by default where viable:** Electrification should be the default route wherever it is operationally credible (i.e., depot-based fleets, buses, vans, and predictable-duty applications) because modelling shows it delivers the deepest emissions cuts at the lowest cost per tonne of CO_2 avoided.

3. **Deploy hydrogen strategically in hard-to-electrify transport segments and in clusters:** Hydrogen should be targeted at hard-to-electrify segments such as heavy duty and long-haul transport and concentrated around existing industrial assets, supported by demand aggregation and anchor offtake commitments to make refuelling infrastructure investable.

4. **Leverage hydrogen as part of a complementary energy mix to enhance system resilience.** Strategic deployment of hydrogen where direct electrification is constrained enhances system resilience by enabling storage, grid balancing and integration with alternative decarbonisation pathways.

5. **Provide policy certainty, reform governance and strengthen hydrogen strategy delivery for commercial transport:** Clear, stable signals on timelines, standards and long-term support, together with defined delivery responsibilities, are needed to overcome the coordination failures that currently constrain investment. This must be strengthened by an actionable hydrogen strategy that facilitates deployment through de-risked investment in hard-to-electrify sectors whilst aligning with infrastructure and demand development

6. **Treat skills as transition-critical infrastructure:** Policy makers and industry should invest in workforce capability across key sectors while embedding a just transition approach that ensure accessible, inclusive skilling for affected workers and communities to reduce delivery risk and strengthen investor confidence.

1. A phased, multi-fuel transition: what the evidence shows

A central conclusion of the REHIP Fuel Choice analysis is that the Tees Valley will not decarbonise transport through any single fuel. The regional system spans passenger cars, vans, heavy goods vehicles, buses, rail, aviation and port activity, and no one technology fits every duty cycle. The evidence instead points to a phased, multi-fuel portfolio in which each option is matched to the modes, timescales, and infrastructure conditions in which it performs best [1, 2].

The scale of the challenge is clear. We estimate that in 2023, road transport in the region was responsible for around 780,000 tonnes of CO_2 and about £420 million in annual fuel spend, with rail and aviation adding further emissions and cost. Continuing on a business-as-usual trajectory would cut transport emissions by only about 55% by 2050, leaving the region far short of net-zero and still exposed to volatile fossil-fuel prices.

By contrast, every one of the five designed decarbonisation pathways modelled in the project performed substantially better, achieving gross emissions reductions of around 86–93% by 2050. The difference between them lies not in whether they decarbonise, but in how and at what cost.

An electrification-led pathway delivered the deepest emissions cut and the lowest cost of carbon avoided, at around £376 per tonne of CO_2 where operationally feasible. While hydrogen-led pathway is associated with higher costs and infrastructure needs, our research shows it remains a technically credible and strategically important solution for hard-to-electrify applications and system flexibility.

A balanced pathway combining high but manageable electrification, moderate biofuel use, and selective hydrogen use achieved around a 90% reduction while optimising system resilience and reducing overreliance on any single vector.

No single fuel provides a complete solution. The strongest pathway for the region is electrification-led but pragmatically balanced, sequencing fuels according to operational need, infrastructure readiness and regional assets, rather than technological purity.

These findings carry a direct message for hydrogen policy. Hydrogen can play a role in decarbonising the transport sector, but it is most credible in heavy-duty freight, rail, port equipment and aviation-linked applications where electrification is hardest, and especially where demand can be concentrated near existing industrial hydrogen assets [3]. Deployed indiscriminately across all modes, hydrogen raises system costs and offsets dependence; deployed selectively and in clusters, it complements electrification and adds genuine value.

Crucially, decarbonisation is a non-linear, system-level process. Fuels cannot be assessed in isolation from the infrastructure through which they are supplied and used, and pathways unfold through iterative experimentation, learning and institutional change [4]. This reframes the policy task from picking a winning fuel toward sequencing investment so that the right fuel is available in the right place at the right time.

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2. Sector readiness is constrained by infrastructure, not technology

If the modelling shows where each fuel fits, the project's stakeholder evidence shows what is holding deployment back. Across participatory workshops, operators were consistent: infrastructure and governance constraints, not vehicle performance or technical readiness, are the dominant barriers to deploying hydrogen and other low-carbon fuels in commercial transport. While hydrogen fuel-cell HGVs can offer operational advantages for high-utilisation, long-distance and payload-sensitive freight, the absence of reliable production, storage and refuelling infrastructure continues to inhibit both fleet adoption and infrastructure investment. This challenge is compounded by limited familiarity and confidence among operators and drivers reflecting relatively early stage of real-world deployment and lack of experiential knowledge across the sector [5].

This has produced a self-reinforcing coordination failure. Fleet operators are reluctant to commit capital to hydrogen vehicles without confidence that refuelling infrastructure will be available, competitively priced and supported by reliable offtake over the vehicle lifetime. Conversely, without firm, aggregated demand, investment in refuelling infrastructure remains commercially unattractive. This "chicken-and-egg" dynamic is well documented: hydrogen mobility requires the simultaneous coordination of vehicles, refuelling infrastructure and fuel supply to become viable [3,6]. However, this is not purely an economic co-ordination problem, but a systems challenge that require co-evolution of infrastructure, demand and societal acceptance of hydrogen technologies.

These challenges cannot be resolved by market forces alone. Hydrogen refuelling infrastructure is capital-intensive, spatially fixed and highly sensitive to throughput. Unlike electric-vehicle charging, which can often be deployed incrementally and shared across vehicle classes, hydrogen transport infrastructure requires high and predictable utilisation to achieve acceptable unit costs [6]. Readiness is therefore not simply a question of fuel availability, but of governance, spatial planning, demand aggregation and societal acceptance [4, 5, 8]. Perceptions of risk (often shaped by associations with hydrogen's flammability and low awareness of technology) also influence operator confidence and in turn, public support for infrastructure deployment [5].

Sector readiness is constrained primarily by infrastructure coordination, governance capacity and investment risk, not by vehicle technology. Without place-based governance and careful sequencing, hydrogen HGVs risk remaining confined to pilots despite growing technical maturity.

Hydrogen readiness is, therefore, conditional rather than universal. It becomes most credible where freight movements are spatially concentrated and can be co-located with industrial clusters, ports and logistics hubs, or where depot- and corridor-based operations can support shared refuelling infrastructure. These place-based conditions are not only significant for infrastructure sharing but also societal acceptance since proximity and direct exposure can increase awareness and improve risk perception [5]. This aligns with evidence that hydrogen mobility is increasingly oriented toward fleet-based, hub-and-spoke models and localised systems of provision, rather than dispersed public refuelling networks [9]. Where these spatial and institutional conditions are absent, electrification or transitional low-carbon fuels represent more immediately deployable and lower-risk options.

Sequencing matters because premature or uncoordinated rollout carries its own risks. Building infrastructure ahead of credible demand increases the danger of stranded assets and undermines investor confidence [10, 11]. The task for the Tees Valley is to focus early hydrogen activity on clustered, high-value use cases linked to existing industrial assets, while electrification meets most demand where grid-based solutions are feasible.

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3. Skills, governance and sequencing: operationalising the transition

Translating this evidence into delivery depends on three enablers: skills, governance, and sequencing.

Skills are emerging as a co-limiting factor alongside infrastructure. Even where vehicles and fuel become technically viable, shortages of trained technicians, engineers and safety-qualified staff increase delivery risk and deter investment. In the near term, the rapid scaling of electrification places immediate demand on high-voltage installations, grid connections, depot energy management, and digital charging skills. Clustered hydrogen deployment implies more specialised, place-based requirements in production, storage, safety and system integration. The sequencing logic of the roadmap means hydrogen-specific skills must be developed in step with real deployment opportunities, rather than in advance of infrastructure, to avoid skills leakage and under-utilisation. Skills should therefore be treated as transition-critical infrastructure, coordinated across transport, energy, education and industrial policy [14,15].

The stakeholder evidence also identified policy uncertainty as a greater barrier to investment than the availability of technology. Fragmented governance, unclear institutional responsibilities and mixed signals on standards, mandates and taxation encourage delay even where low-carbon technologies are already available. Addressing this requires the government to act as a market shaper, aligning investment, skills and regional development through stable, credible signals, rather than assuming technological availability alone will drive adoption [6, 12, 13,16].

Operator and public preferences reinforce this picture. Running costs, refuelling convenience and infrastructure availability consistently outweighed abstract environmental preference in fuel choice [17, 19]. Messaging focused solely on climate or air-quality benefits is unlikely to drive adoption on its own; it is most effective when combined with tangible improvements in cost and convenience [20]. Safety concerns around hydrogen are present but only weakly determine actual choices when economic and practical conditions are favourable, underscoring the value of strong safety governance and transparent communication [21].

Clear policy direction, coordinated governance and skills developed in step with deployment will help unlock investment. Without them, low-carbon transport risks reproducing past patterns of delay and stranded ambition.

These conditions point to a clear set of priorities. Early action should focus on no-regret measures, including depot electrification, grid upgrades, smart charging, coordinated planning for sustainable aviation fuels, and early development of hydrogen hubs, which deliver immediate benefits while building capacity for later system integration [17]. Transitional fuels such as biofuels and hybrids should be used only where needed to manage delivery risk and should be governed by clear sustainability standards and sunset dates. And because the Tees Valley already possesses hydrogen production, port, airport, and industrial cluster assets, it is well placed to pursue a place-based strategy, provided infrastructure planning is coordinated across transport, energy, and industry rather than left to evolve through disconnected projects.

Conclusion

The REHIP Fuel Choice analysis offers a clear strategic message. The Tees Valley should pursue a phased, evidence-based, and operationally grounded transition led by electrification where viable, enabled by governance reform, supported by targeted hydrogen and sustainable fuels, and designed around the realities of local fleets and assets. For hydrogen specifically, the project's evidence supports a future-facing but selective role, concentrated in hard-to-abate, clustered use cases with anchored demand, rather than dispersed across the network.

The transition should begin with immediate no-regret investment and policy clarity, move through the selective scale-up of hydrogen and SAF where regional conditions justify them, and end with the managed phase-out of transitional fuels. In this sense, the roadmap is not simply a comparison of fuels, but a practical framework for moving the region from ambition to coordinated delivery.

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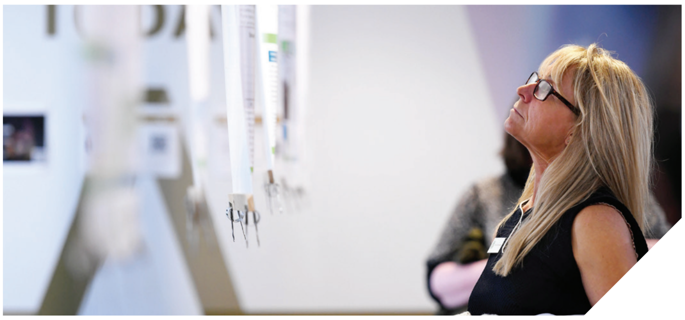

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- **For more information about REHIP and the NZIIC, please visit:** tees.ac.uk/minisites/netzero/rehip.cfm

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