

Why Hydrogen Won't Save The World

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Hydrogen has become attractive as a potential solution because clean hydrogen can be produced from renewable electricity through electrolysis, offering a way to decarbonise hard-to-electrify sectors like steel manufacturing and long-distance shipping. However, the article argues hydrogen has become a 'solution looking for a problem' because renewable electricity is becoming cheaper, energy storage is improving, and economies are electrifying. Many applications where hydrogen is proposed would be better served by direct electrification, energy efficiency improvements, or other renewable energy sources. We assess whether hydrogen or alternative technologies better serve specific industrial applications through transition planning and energy optimisation services.

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The energy landscape is not just changing but completely transforming. With strong commitments from governments and organizations to decarbonize and reduce emissions, industry is racing to find cleaner sources of energy and better ways to use it.

One clean energy option that receives a lot of hype is hydrogen. On the positive side, Hydrogen is already used in fuels and chemicals and has the ability to act as a replacement for natural gas, liquid fuels and coal in existing applications. However, it has become a popular solution looking for a problem to solve.

Despite hydrogen's benefits, renewable energy is bringing down electricity prices, energy storage is becoming cheaper, and the economy is electrifying. While it is a clean-burning fuel, hydrogen has some considerable disadvantages that still make it an uncompetitive solution in many applications:

Hydrogen has poor volumetric energy density

Clean hydrogen is energy and resource intensive

Using hydrogen requires new infrastructure

Hydrogen takes up a lot of space

Although hydrogen is the most energy-rich fuel per unit of mass, hydrogen is not a dense element at ambient temperatures, giving it a low energy to volume ratio at room temperature. Therefore, storing sufficient amounts of hydrogen can be space intensive, or energy-intensive if stored as compressed gas or in liquid form.

Difficulty around hydrogen storage limit its potential to scale up at points of end-use. Complications around storage also make hydrogen fuel disadvantageous in all but the most challenging transportation applications.

Storing and re-using hydrogen could end up only being the domain of large utility or chemical companies. Potential uses might be to support electricity grids in periods of wind or solar droughts,

providing security to hydrogen pipelines, or replacing LNG and coal when shipping large amounts of energy around the globe.

Clean hydrogen is energy and resource intensive

Hydrogen is very abundant, but it mainly exists in compound form with other elements. Isolating the hydrogen elements requires energy. Most of the hydrogen production is done through steam methane reforming (SMR) of methane (CH₄), an energy-intensive process that produces CO₂ and other pollutants.

A small percentage of hydrogen production is currently done through electricity driven electrolysis, which uses electrical current to split water into its oxygen and hydrogen atoms. This process produces clean hydrogen when the electricity generation comes from renewable energy sources such as solar or wind energy. With that said, the financial viability of this process depends on low capital and electricity costs, and high system efficiency.

In addition to electricity, hydrogen production through electrolysis requires freshwater. Estimates suggest that nine litres of freshwater are needed to produce a kilogram of H₂. The energy and water intensity increase if the water needs desalination.

The process of generating electricity from renewable energy sources, converting it to hydrogen for storage and transport, and then reusing the hydrogen results in significant losses. With this supply chain energy loss, it will make sense to use electricity directly if technically possible for many end-use applications.

This is illustrated well in the passenger vehicle example. Starting with a clean electricity source, electric vehicles achieve a 70-90% 'Wind-to-wheel' efficiency compared with 25-35% for hydrogen fuel-cell vehicles. All the other supposed benefits of a hydrogen system will have to out-compete the fundamental driving force of lower operating costs for electric vehicles.

Using hydrogen requires new infrastructure

Hydrogen can be transported using trucks and trains, but the majority of natural gas pipelines are not well-equipped to move hydrogen. As a small molecule, hydrogen can leak through pipes and embrittle metals. In addition to a network of piping, transporting hydrogen will also require investment into technologies that can compress, dispense, and purify the hydrogen.

There is talk of blending hydrogen with natural gas to transport it throughout natural gas pipelines, but due to the lower volumetric energy density of hydrogen and the increased amount of work needed to transport it throughout the pipeline network, this solution hardly makes sense.

The Role of Clean Hydrogen

Considering its downfalls, clean hydrogen will not be desirable for many applications as electrification brings massive improvement in energy efficiency. Nevertheless, there are processes that cannot be electrified, so clean hydrogen will likely have a role to play in the places that electricity cannot reach if we are to become a net-zero carbon society.

Steel manufacturing - The majority of global steel production is made using a blast furnace and basic oxygen furnace. Using carbon as a reducing agent to remove oxygen from iron ore, the blast furnace is the largest source of direct carbon dioxide (CO₂) emissions within the steel production process. Therefore, replacing carbon with hydrogen as the iron ore reducing agent avoids the creation of CO₂ as a byproduct.

In addition to being the reducing agent, hydrogen can be burned to generate the high process heat needed for steel production.

This steel production process using hydrogen as the fuel source and reducing agent - a process known as HYBRIT - is currently being developed in Sweden with aims of producing fossil free steel around 2026.

Chemical feedstocks - Hydrogen is already used as a significant feedstock for the chemical industry, namely for ammonia production and refinery processes. Hydrogen production has increased substantially over the decades and considering the majority of hydrogen is produced through the carbon intensive process of SMR, clean hydrogen could step in as significantly cleaner alternative.

Trends suggest a growing demand for hydrogen, so the best way to decarbonize these chemical manufacturing and refinery processes is through the implementation of clean hydrogen.

Long distance shipping - Hydrogen won't make a great fuel source for aviation based on safety concerns and energy density. Hydrogen can, however, serve as a viable fuel source for long distance shipping. Such vessels are not constrained by the same size parameters, and long-distance shipping routes will be more effectively fueled by burning hydrogen or a hydrogen derivative fuel than by running off electricity and battery storage. Hydrogen may compete most in the new-build space, with biofuels or other e-fuels helping to transition the existing fleet in the shorter term.

Large scale energy carrier - in some chemical form or other, Hydrogen will be an energy carrier between nations. The global LNG trade has proven that inter-country trading of energy benefits energy security. Japan and Korea have significant hydrogen import strategies, whilst countries like Australia have Hydrogen export plans. This should be encouraged, as some countries with few natural resources have little choice but to import additional clean energy in order to meet net zero goals. Building new infrastructure for such large scale, concentrated point-to-point energy transfers makes more sense than trying to distribute hydrogen to households to make hot water , or using it in cars while losing 75% of the energy from the source to end use.

Conclusion

Clean Hydrogen will be used for many applications - for steel, as a chemical feedstock, in very long-distance transport, and as an international energy carrier. This versatility will mean it has a bright future.

For many of our industrial customers, clean hydrogen will never be cheaper or more convenient than energy efficiency improvements, other renewable energy sources, or energy storage (either electric or thermal).

In the end, clean hydrogen will have a major part to play, but it won't be the one solution that saves us all.

At Northmore Gordon, we help businesses navigate the changing energy landscape so that they can make strategic investments that make sense now and over the long run. If you are interested to see how hydrogen fits into your strategic energy plan, make sure to reach out so that your business can be informed and stay competitive.

Using this guidance

Check the site's operating conditions, data quality, project stage and current program settings before turning the dated discussion into a scope or investment decision.

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Why is hydrogen often promoted as a climate solution despite its disadvantages?

Hydrogen has become attractive as a potential solution because clean hydrogen can be produced from renewable electricity through electrolysis, offering a way to decarbonise hard-to-electrify sectors like steel manufacturing and long-distance shipping. However, the article argues hydrogen has become a 'solution looking for a problem' because renewable electricity is becoming cheaper, energy storage is improving, and economies are electrifying. Many applications where hydrogen is proposed would be better served by direct electrification, energy efficiency improvements, or other renewable energy sources. We assess whether hydrogen or alternative technologies better serve specific industrial applications through transition planning and energy optimisation services.

What does the article mean by hydrogen's poor volumetric energy density, and why does this matter?

Although hydrogen is the most energy-rich fuel per unit of mass, it has very low energy density by volume at ambient temperatures. This means storing usable amounts of hydrogen requires either large space or energy-intensive compression and liquefaction. For transportation applications, this volumetric constraint severely limits practicality because vehicles would need oversized storage tanks or require frequent refuelling. The article illustrates this with electric vehicles achieving 70–90% wind-to-wheel efficiency compared to only 25–35% for hydrogen fuel-cell vehicles, showing supply chain losses make hydrogen uncompetitive for most transport. Our process heat and electrification assessments compare these efficiency trade-offs when evaluating fuel alternatives.

What freshwater and energy costs are involved in producing clean hydrogen?

Clean hydrogen is produced through electrolysis, which splits water using electrical current. The process requires approximately nine litres of freshwater to produce one kilogram of hydrogen, representing a significant water demand for large-scale production. Financial viability depends on access to low capital costs, low electricity prices, and high system efficiency—meaning clean hydrogen competes directly with renewable electricity prices. In regions where electricity is expensive or water is scarce, clean hydrogen becomes less feasible. Our energy optimisation and feasibility assessment services evaluate whether hydrogen production economics work at specific sites, particularly for organisations in water-stressed or high-electricity-cost regions considering hydrogen as a decarbonisation pathway.

Why can't hydrogen use existing natural gas pipelines, and what does this mean for infrastructure costs?

Natural gas pipelines cannot reliably transport hydrogen because hydrogen, as a small molecule, can leak through pipe material and cause metal embrittlement, potentially compromising pipeline integrity. Blending hydrogen with natural gas is impractical because hydrogen's low volumetric energy density means more volume must be moved through the network for equivalent energy, increasing transportation work and costs. New dedicated hydrogen infrastructure—including compression, dispensing, purification and transport systems—requires substantial investment. This infrastructure barrier explains why hydrogen adoption is limited to sectors where new infrastructure can be justified, such as industrial clusters or dedicated long-distance shipping routes, rather than widespread distributed applications.

For which industrial applications does the article confirm hydrogen will have a genuine role?

The article identifies four applications where clean hydrogen is economically and technically justified: steel manufacturing (using hydrogen as both fuel and reducing agent in processes like HYBRIT being developed in Sweden), chemical production (particularly ammonia and refinery feedstocks where hydrogen is already essential), long-distance shipping (where hydrogen derivatives suit vessel

requirements better than battery storage), and international energy trade (with countries like Japan, Korea and Australia planning hydrogen imports and exports). These sectors have either no direct electrification alternative, existing hydrogen dependence, or size constraints that make batteries impractical. Our industrial decarbonisation work, demonstrated through the Greenham case study, assesses whether hydrogen fits specific manufacturing contexts or whether alternatives like biomass, cogeneration, or electrification better serve site requirements.

How should organisations decide between hydrogen and electrification for decarbonising their operations?

The article emphasises that direct electrification, energy efficiency improvements, and energy storage typically offer better economics and performance than hydrogen for most applications. The decision should start by mapping thermal loads, operating schedules, and available heat sources—understanding whether high-grade heat, chemical feedstock, or fuel properties are genuinely required. Our process heat and electrification assessments, documented in its technical guidance, provide this investigation framework by comparing complete project options including useful duty, existing performance, heat recovery, electrification, reliability, and economics. For organisations in steel, chemicals, long-distance shipping or export-focused sectors, hydrogen may warrant feasibility study; for most others, energy efficiency and renewable electricity deliver faster payback and lower technical risk.

What is the HYBRIT process, and why does it matter for industrial decarbonisation?

HYBRIT is a steel production method being developed in Sweden that uses hydrogen as both the fuel and the reducing agent in iron ore processing, replacing the carbon-based blast furnace process. This eliminates CO₂ emissions from the chemical reduction step—the largest source in traditional steelmaking. HYBRIT represents a genuine application where hydrogen is essential because steel production requires a chemical reducing agent, not just heat, and hydrogen serves this role without carbon emissions. The process aims for fossil-free steel production around 2026, demonstrating technical feasibility at scale. This contrasts with sectors where hydrogen is proposed merely as a fuel replacement where electrification or other options would be more efficient, illustrating the article's central argument about hydrogen's appropriate versus inappropriate applications.

Why does the article dismiss hydrogen for aviation but accept it for long-distance shipping?

Aircraft are weight and space-constrained, making hydrogen's low volumetric energy density a fatal limitation—fuel tanks would need to be impractically large, reducing payload and safety margins. Aviation requires high energy density per unit volume. Long-distance shipping vessels, by contrast, have ample space and are not constrained by similar weight penalties, so larger fuel tanks and lower volumetric energy density become acceptable trade-offs. Hydrogen or hydrogen-derivative fuels then become competitive alternatives to battery storage, which would be too heavy and voluminous for weeks-long voyages. This distinction exemplifies the article's core message: hydrogen's suitability depends on specific operational constraints, not on whether it is theoretically renewable or low-carbon.

What does the article conclude about hydrogen's overall role in climate solutions?

The article concludes that clean hydrogen will play a significant role in decarbonisation—particularly in steel, chemicals, shipping, and international energy trade—but it will not be a universal climate solution. For most industrial customers, energy efficiency improvements, direct renewable electrification, or energy storage offer better economics, faster implementation, and lower technical risk than hydrogen. Hydrogen competes poorly where these alternatives exist. The article's message is that hydrogen has a bright future in specific hard-to-decarbonise sectors but should not be treated as a catch-all solution. Our transition planning and industrial decarbonisation services, exemplified by the Greenham case, apply this selective logic: assessing whether hydrogen, biomass, electrification, or other pathways best fit each site's operating requirements and commercial constraints.