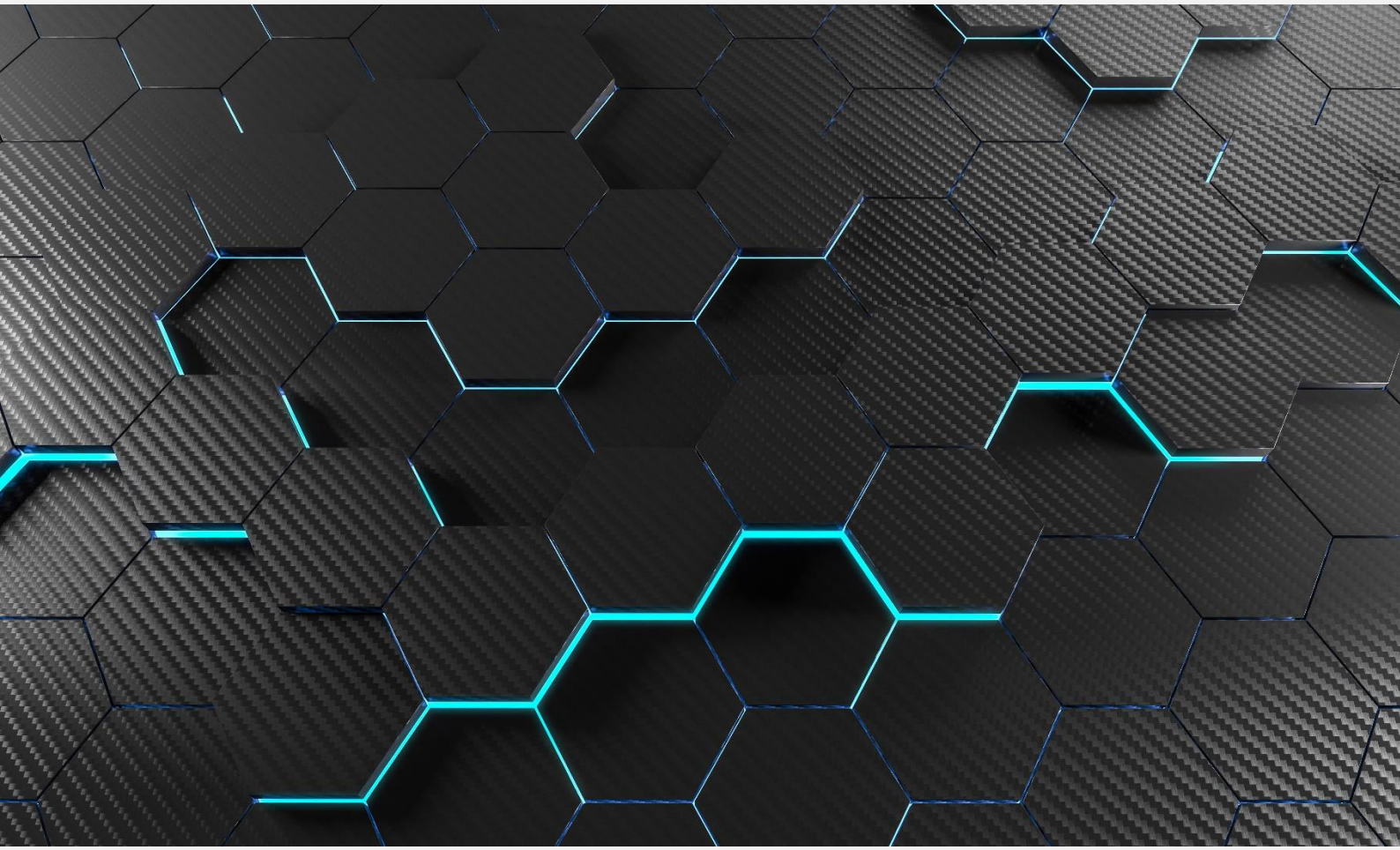

# Unlocking Opportunities for Composites Within the Hydrogen Economy

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17 April 2023

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| Document details | |
|---|---|
| Document title | Unlocking Opportunities for Composites Within the Hydrogen Economy |
| Date | 17 April 2023 |
| Version | 1 |
| Author | E4tech – An ERM Group Company |
| Client Name | National Composites Centre (NCC) |

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# 1. COMPOSITES: AN ESSENTIAL NET ZERO TECHNOLOGY

The UK Government has made a legally binding commitment to achieve net zero by 2050. To deliver this will demand a seismic shift from fossil fuels to low carbon energy sources. Low carbon hydrogen will make a substantive contribution to power, heat and transport.

In its 2021 Hydrogen Strategy the UK Government committed to developing “a thriving low-carbon hydrogen sector in the UK”. In its 2022 British Energy Security Strategy, the government doubled its earlier UK hydrogen production ambition to up to 10GW by 2030; roughly equivalent to the amount of gas consumed by 3 million households per year. Investment in supply chains, workforce transformation, and research and innovation will be fundamental to delivering this ambition.

As hydrogen gas is less dense than conventional fuels, it needs to be stored or transported at either high pressures, as a liquid carrier, or as a cryogenic liquid; pressures can be as high as 700 bar (700 times atmospheric pressure) or temperatures as low as -253°C in liquid state. Metallics remain a viable option for storage and distribution at these extreme pressures and temperatures. However, composites are critical in reducing mass of storage solutions, or speed of deployment for high pressure pipes. An essential technology for enabling decarbonisation and net-zero, composites are lightweight, durable and strong.

The UK is at the forefront of composites innovation; this specialism needs to be capitalised on to deploy technologies and maximise UK market share. The advanced skills, expertise and knowledge possessed in composites puts the UK in a leading position to be able to capitalise on the significant opportunity for hydrogen. The window to accelerate innovation is narrow, the UK needs to act quickly.

# 2. UK COMPOSITES FOR HYDROGEN: GROWTH OPPORTUNITIES SUMMARY

E4tech – an ERM Group Company, has conducted a market analysis to quantify the UK industrial composites opportunity as it relates to hydrogen technologies. A preliminary review of all applications of composite for hydrogen identified three priority product areas: **hydrogen pressure vessels, cryogenic tanks, and distribution pipes.**

## 2.1 Hydrogen pressure vessels for multiple sectors

The use of composites is fundamental to producing lightweight pressure vessels capable of withstanding the high pressures required for some uses, such as mobility applications. The opportunity for the UK composites sector to secure global market share is significant. The most conservative scenario in the E4tech market analysis found that UK-based hydrogen pressure vessel manufacturers could serve a market totalling up to 80,000 tanks per annum by 2030. This represents ~ 20% of the European market demand of vessels for off-highway vehicles, buses, rail, hydrogen refuelling stations (HRS) and tube trailers; 15% for trucks, and 10% for cars and light commercial vehicles.

The production of composite hydrogen vessels in the UK provides an opportunity for the existing composite supply chain and for new market entrants. However, barriers related to cost of certification remains an obstacle, limiting the attractiveness of the opportunity due to the significant upfront investment required. This is a mature technology which is already being manufactured worldwide, however there are numerous innovation opportunities to reduce mass and cost, and improve sustainability of the pressure vessels.

## 2.2 Cryogenic tanks

Major aircraft and propulsion systems manufacturers have recently launched programmes on hydrogen-fuelled aircraft concepts, and liquid hydrogen is envisaged as a leading solution. Notable major programmes include:

- Airbus ZEROe: the programme is focusing on liquid hydrogen-fuelled aircrafts to develop the world's first zero-emission aircraft by 2035.[i] The UK Zero Emission Development Centre (ZEDC) for hydrogen technologies in Bristol will expand Airbus's in-house industrial capabilities to design, develop, test and manufacture cryogenic hydrogen storage tanks and related systems for the ZEROe project across Airbus's four home countries.[ii]
- Energia: Embraer estimated that the Energia programme[iii] could be a platform to serve a market of 4,000 airplanes to carry up to 50 passengers between 2035 and 2040.
- GKN Aerospace's Hydrogen Combustion (H2JET) and Hydrogen Fuel Cell (H2GEAR) technology (supported by EasyJet) explore the options for sub-regional flight demonstration[iv].

Roadmaps for zero emission aircraft indicate the gradual increase in use of composite and novel material-based cryogenic tanks due to potential mass savings, but in the interim, metallic tank performance and production costs have continued to improve through continual research and development. Technology capabilities must be developed to unlock the potential benefits of composites in these applications, with this expertise applicable to many more cryogenic aerospace applications.

The UK is in a strong position to drive innovation in composite cryogenic tank design & manufacture and global leadership in markets such as unmanned aerial vehicles (up to 16,250 tanks per annum by 2030), sub-regional and business jets (concept production by 2030 and 100+ tanks manufactured by 2050). Conversely, the opportunity for UK manufacturers of regional and mid-size airplanes are considered limited as this market segment is expected to be served by EU manufacturers. The development of composites capabilities for cryogenic storage could also be applicable for adjacent sectors and applications (e.g. surface storage and transmission pipeline).

## 2.3 Distribution pipes

It is projected that upstream distribution pipelines for hydrogen (both repurposed and purpose-built) will grow significantly in the coming decades, if plans for hydrogen production and end-use are realised. UK industrial clusters and initiatives are now developing a local hydrogen value chain, which will require the transportation/distribution of hydrogen within the region and between the hydrogen generation, carbon capture and storage infrastructures (e.g. Zero Carbon Humber, H100 Fife, H21 and Hynet North West). Hydrogen pipeline is an effective way to transport/distribute hydrogen. IEA analysis suggests that for distances up to 3,000 kilometres, pipelines are the most cost-effective way to transport hydrogen[v]. The growth of large infrastructures for transportation via pipeline is likely to take place primarily across Europe**.** The European Hydrogen Backbone (EHB) initiative will lead to an operational 53,000-kilometres pipeline by 2040[xi], made of primarily repurposed but also new pipes. This is driven by the anticipated large growth in hydrogen gas demand in Europe which in turn is driven by legislative measures, namely the European Union's Fit for 55 policy package.

Spoolable thermoplastic composite pipes offer a compelling alternative to steel pipes for connecting hydrogen production sites either directly with end users or into hydrogen transmission lines, where operating pressures are above those achievable with pure polymer pipes. They are easier to deploy, lower the risk of leakage from pipe joints and avoid issues around embrittlement of steel. Spoolable composite pipes could be used to connect decentralised electrolysers and collection points offshore or centralised offshore hydrogen production facilities and shore-based points of use. If successful, the manufacture of spoolable composite pipes could be a high-value opportunity for UK composites manufacturers: 2,500 to 5,000 km[vi] of pipe to achieve UK target[xii] with decentralised electrolysis[vii], 500 to 3,000 km[viii] of pipe with centralised offshore production and, 1,000 to 2,500 km[ix] of pipe with onshore production.

There may also be an opportunity for spoolable composite pipes in other parts of the high-pressure distribution network, but this has not been quantified owing to uncertainties over the topology and distances in any future network.

# 3. ENABLING THE UK COMPOSITES OPPORTUNITY FOR HYDROGEN: KEY ACTIONS

## 3.1 Growing a UK supply chain to anchor value and build resilience

**As the demand for hydrogen technologies increases globally, a robust UK 'composites for hydrogen' supply chain needs to be created that will retain long-term value, and build resilience as the demand for pressure vessels in particular increases**.

The UK composites sector is a strategic national asset. A vibrant ecosystem of large and small firms, regionally distributed and supported by world class research and technology organisations, translating R&D successes into commercially viable products.

International competition is increasing: countries such as the US and Canada, China, Japan, India, South Korea, Australia, South Africa and the majority of European countries have published their hydrogen plans**.** Significant investment is already being made by these governments to not only roll out these technologies, but to secure and mature local supply chains to become a future technology exporter. For the UK to capitalise further on its leading position for composites innovation, and to enable the composites opportunity for hydrogen will require investment.

## 3.2 Building a sovereign fibre capability

**The UK's ability to meet growing demand for composite hydrogen pressure vessels will require access to carbon fibre.** The UK does not, however, have a sovereign supply and is reliant on imported material. Securing the volume of carbon fibre needed is likely to become challenging, with demand set to outstrip supply and costs likely to increase[x]. Estimates suggest that the growth in composites for hydrogen will result in a five-fold increase in demand for carbon fibre globally between 2025 and 2030[xiii].

**The UK must invest in creating domestic fibre production and reclamation, and soon, or the opportunity of being an independent global leader in manufacturing of hydrogen system will be lost**. A sovereign fibre capability will be also beneficial for the Wind sector as offshore wind turbine blades require reinforcement with higher strength than glass fibres, but at competitive price.

Chopped carbon fibre is already recycled, but industrial applications for the material are narrow. Establishing a commercial market for reclaimed fibre could ease the pressure on supply chains, enabling the UK to take a leading role in defining a new era for composites consisting of novel technologies, new skills and expertise and shorter path to commercialisation.

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- [vi] Assuming 0.5 to 1 km of pipe/MW of hydrogen
- [vii] Quantity of spoolable composite pipeline for gasification-based hydrogen was not considered. Similarly, using spoolable composite pipes to refurbish existing pipelines was not considered. Transmission via hydrogen backbone pipeline is not considered as a primary market for spoolable composite pipes because of the large diameter required – maximum diameter of spoolable pipes is 8 inches while the EHB pipe diameters range from 20 to 48 inches.
- [viii] Assuming 0.1 to 0.6 km of pipe/MW of hydrogen
- [ix] Assuming 0.2 to 0.5 km of pipe/MW of hydrogen
- [x] "UK Composites Industry Competitiveness and Opportunities", Lucintel, Dec 2020; https://ktn-uk.org/wp-content/uploads/2021/07/Opportunities-in-the-UK-Composites-Industry-Lucintel-Public-Version.pdf [accessed 18/01/2023]
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