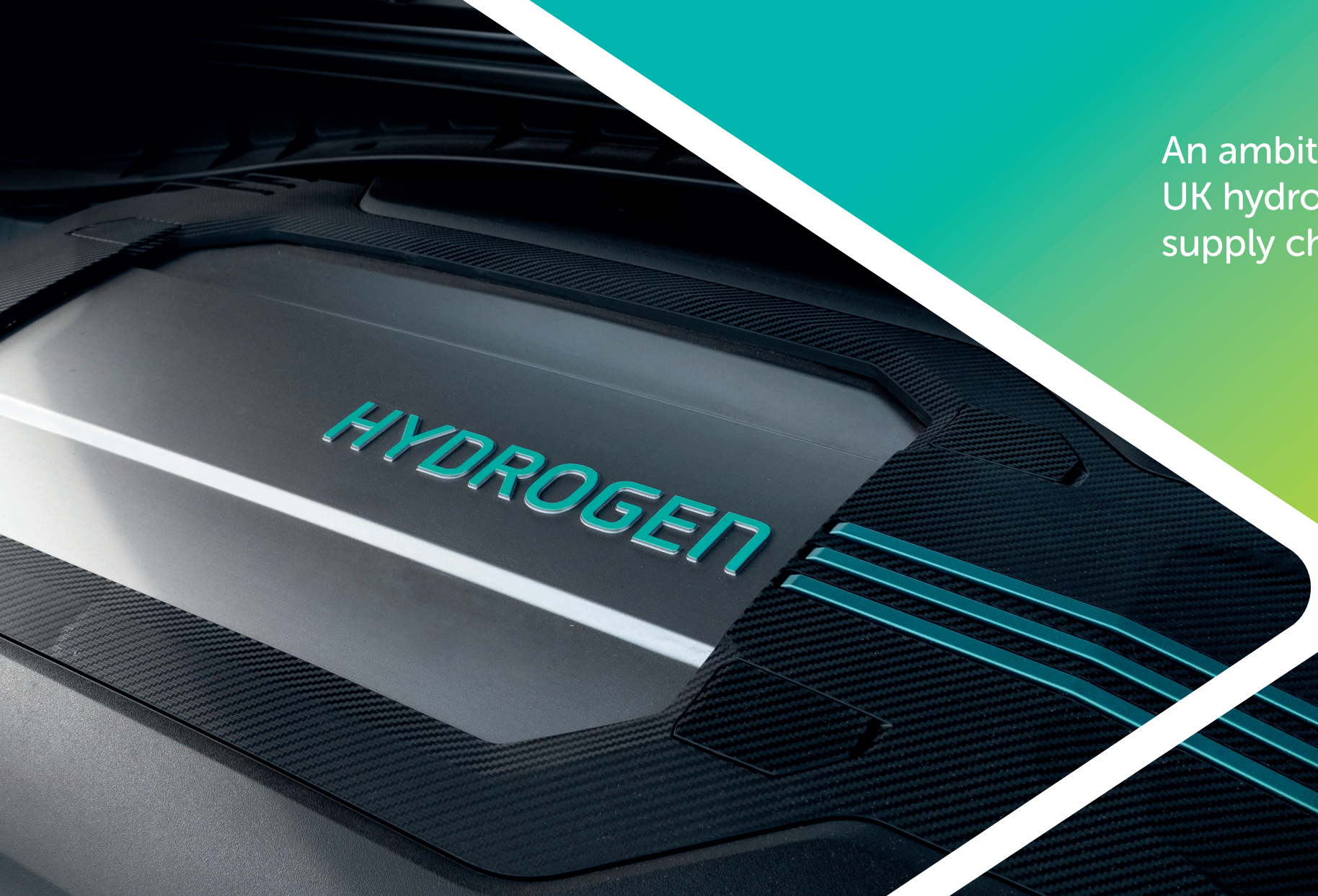
An ambition for the UK hydrogen vehicle supply chain



22 March 2022
House of Commons, Westminster

ADVANCED PROPULSION CENTRE UK
Accelerating Progress

'We have identified a clear ambition for the added value the on-board hydrogen technology sector can bring to the UK.'

Foreword

Ian Constance

CEO, Advanced Propulsion Centre UK

Welcome and thank you for allowing us the opportunity to share with you what we, at the Advanced Propulsion Centre (APC), feel is a game-changing opportunity for the UK. Special thanks also to chair of the APPG for electric vehicles, Matt Western MP, for hosting us.

A changing industry

The APC was formed back in 2013 because the Automotive Council and the coalition government at the time recognised that there was a need to decarbonise transport, and in doing so ensure the UK maintained its leading position developing innovative on-board vehicle technology.

Since then, we have supported 170 low-carbon projects involving 402 partners and helped to develop technology that is either on the roads today, reducing emissions, or is shaping future innovation. Progress is being made, and the latest data from the Office of National Statistics shows that jobs exclusively in low emission vehicles and infrastructure have more than doubled since 2014[1] and many more have been safeguarded as existing industry pivots to cleaner technology.

The importance of automotive manufacturing to the UK's economic prosperity should not be underestimated. Even with the challenges we experienced in 2020, vehicles were still the country's most valuable exported goods and the SMMT estimate the sector as a whole generated a total trade revenue of £74 billion[2]. Hundreds of thousands of people rely on the automotive sector for their livelihoods, and we all have a vested interest in halting and reversing climate change.

However, while the pace of change is rapid, and policy shifts have accelerated that evolution, in many respects the most difficult part is yet to come.

Ambitions to reality

Our unique role between government, industry, and academia gives us an informed outlook – one we can use to share forecasts which we hope will support policymakers and executives when making key strategic decisions.

Hydrogen can be a solution to some of our more difficult transport decarbonisation dilemmas. Hydrogen combustion is a promising net-zero technology that can provide a good route for heavy duty applications and share the same hydrogen refuelling network required for fuel cell vehicles. This technology is already in development and showing net-zero CO_2 and NOx emissions is achievable.

When we mapped out the value chain for on-board hydrogen fuel cell system and hydrogen tanks our intention was to enable industry to see where the opportunities are and how they could grow or diversify. What transpired from that work was a realisation that the UK could hold a strong position in the biggest parts of the fuel cell value chain. It will take investment, collaboration and political will to achieve this, but the UK has strong foundations from which to build.

Through this analysis we have identified a clear ambition for the added value that the on-board hydrogen technology sector can bring to the UK. That ambition aims to give our key stakeholders an understanding of the opportunities, to enable greater collective action in industry and further investment.

I hope what you hear at this event and read in the following pages gives you confidence to explore how it can be achieved and that, through our funding competitions and insight, we are here to support you.

1 From 9,300 in 2014 to 19,100 in 2020. *Low carbon and renewable energy economy estimates*; ONS, 2022

2 UK Automotive Trade Report 2021 – SMMT

Introduction

Matt Western

MP for Warwick and Leamington

It has been an honour and privilege to represent Warwick and Leamington as its Member of Parliament since 2017. I am proud of the wide range of innovative organisations that work either directly, or indirectly, in the immediate region. The Advanced Propulsion Centre UK is a case in point.

In order to address the climate emergency, we need coordinated action across multiple sectors, particularly in the automotive sector, given that surface transport accounts for 28% of the UK's CO_2 emissions.

By facilitating the investment of over £1 billion, the APCUK is doing vital work providing funding and support to enable organisations to develop cutting-edge technologies, build supply chains and invest in the facilities that will help the UK achieve greener transport by 2030.

I have proudly supported the work of the APCUK in recent years. I was delighted to speak at a virtual event they held for COP26 in October.

As the Chair of the APPG for Electric Vehicles, I have been campaigning for greater investment in infrastructure and consumer incentives to drive the transition to zero-emission vehicles. And, as Chair of the Motor APPG, I am pushing for support to assist consumers and manufacturers to accelerate the uptake of EVs.

I am looking forward to continuing to push for greater investment in new technologies and supporting the green transition in creating a future of more sustainable transport.

'The APC is doing vital work providing funding and support to enable organisations to develop cutting-edge technologies'

Speakers

Dr Sam French

Business Development Director
for Hydrogen Technologies
Johnson Matthey

Sam is the Business Development Director for Hydrogen Technologies at Johnson Matthey. Previously he led the development of the strategy and programme for Low Carbon Hydrogen – both Blue and Green at JM.

Previous roles at Johnson Matthey include Technology Manager for the steam reforming catalyst and technology R&D team. After moving from R&D into Business Development, he was tasked with developing a portfolio of new opportunities for processes from new feedstocks, such as biomass, waste and renewable energy. Sam sits on the Hydrogen Council Management Board, Chairs the UK Hydrogen Advisory work group 2020 Deployment Roadmap, as well as representing JM on a number of other organisations focused on solutions to decarbonisation.

Laura Gilmore

Corporate Affairs Director
and Chief of Staff for the
European Region of Cummins

Laura is the Corporate Affairs Director and Chief of Staff for the European Region of Cummins, a Fortune 150 global power technology company. She sits on the Cummins European Board where she also active in promoting diversity and inclusion. Before this role, Laura worked for a British clean-tech company in Campaigns and Public Affairs.

Before her corporate career, Laura worked in politics with her last political role being the Head of the Liberal Democrat House of Lords Whips' Office during the Coalition Government.

Laura is the co-founder of the Women in Public Affairs network which provides training, inspiring events and support to women working in the public affairs industry to help them achieve their potential; and is a Board Trustee of Bright Futures UK, a charity that provides support to children who take time out of education through illness.

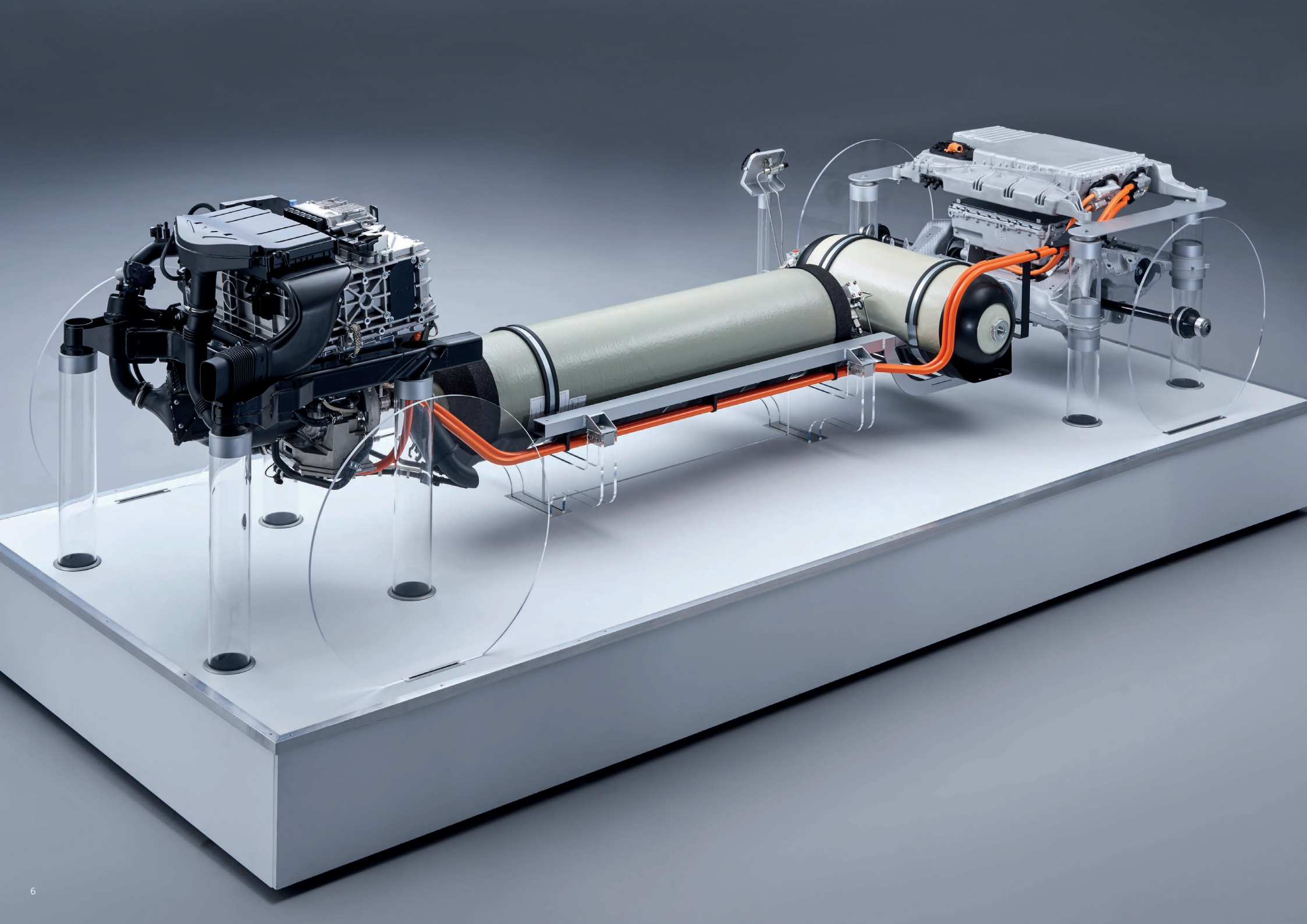
Mark Lawday

Global Sales Director
Luxfer Gas Cylinders

Since joining Luxfer Gas Cylinder in 2005, Mark has held positions in the UK, Italy and the USA and has been instrumental in leading Luxfer's alternative fuel market strategy. While in Italy, from 2008–2012, Mark led strategic growth initiatives that increased Luxfer Gas Cylinders alternative fuel vehicle and bulk gas transportation market. As part of the North America leadership team from 2013–2017, he led a team that doubled revenue in the alternative fuel vehicle sector.

Since returning to Luxfer UK in 2017 Mark has led the commercial and product marketing functions. During this time Luxfer has launched several hydrogen high-pressure storage world firsts in truck, bus, marine, rail, and off-road applications.

From April 2022, Mark will be VP and GM Luxfer Gas Cylinders Europe and lead the European business. Mark has a PhD in Metallurgy and a MEng in Mechanical Design Materials and Manufacturing from The University of Nottingham.



Our ambition:

Helping put the UK in the driving seat for fuel cell and hydrogen vehicle technology

Fuel cells and hydrogen propulsion systems are maturing at a rapid pace, addressing difficult-to-decarbonise vehicle segments.

The UK has a strong footprint in critical elements of fuel cell stack (particularly electrochemistry) and high-pressure tank production with the building blocks of a thriving supply chain, making it the perfect place for investments across these growing value chains to meet domestic and international demand.

Our analysis shows that the UK has the potential to become one of the world's fuel cell system production capitals. Currently UK companies contribute to around 15% of the value-add in a fuel cell system, but by leveraging capability and further investment, **APC believes that ambition could be 65% of the entire fuel cell value chain radiating from UK businesses**.

To identify opportunities for UK suppliers, we have developed two value stream maps to assist technology advancements, collaborations, and investments with the support of industry experts (see overleaf).

Our analysis shows that the UK has the potential to become one of the world's fuel cell system production capitals.

Currently made in the UK

Estimated fuel cell system value-add generated today in the UK

~15%

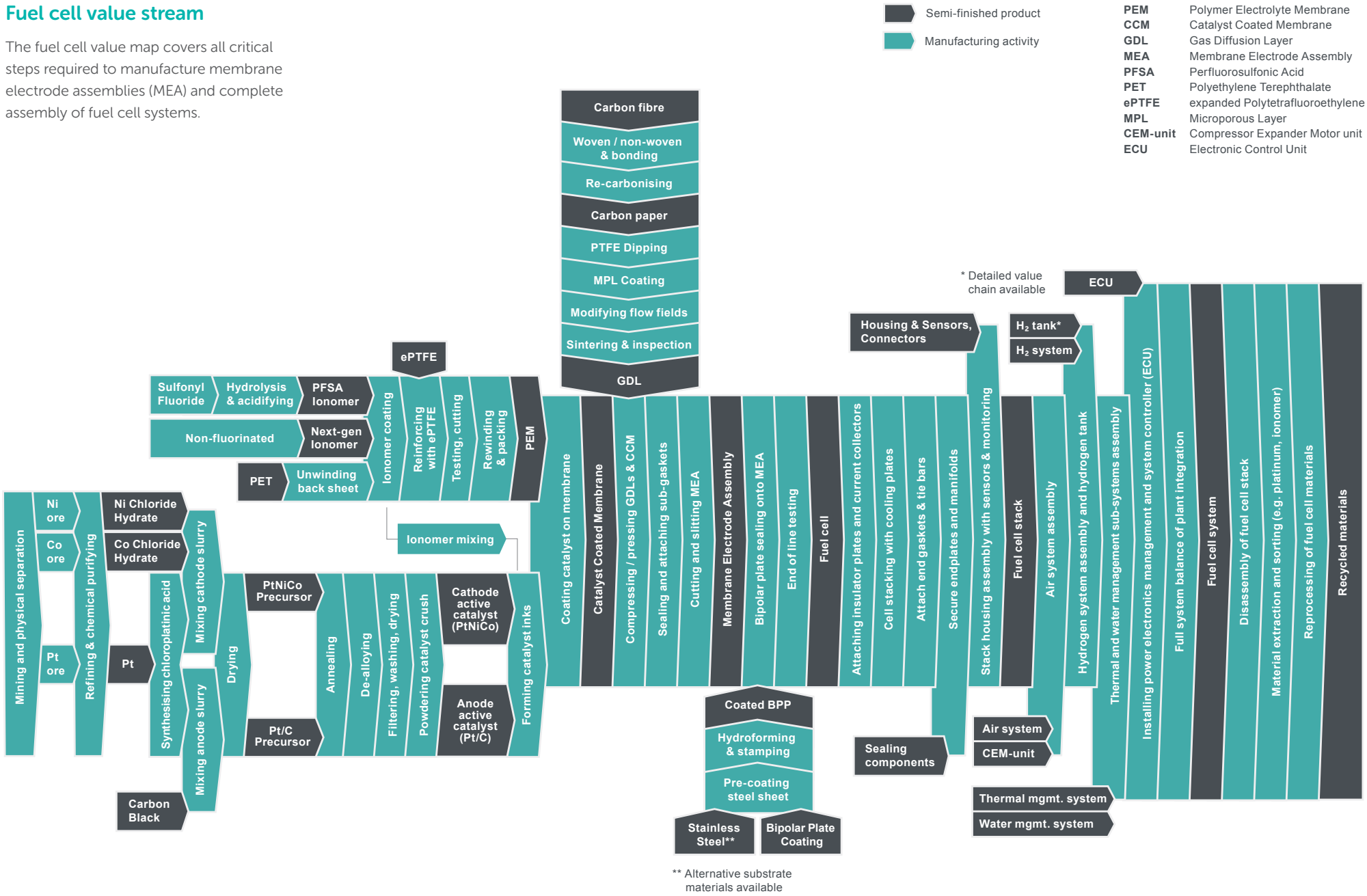
Future ambition

Fuel cell system value-add that the UK is capable of delivering in the future

65%

Fuel cell value stream

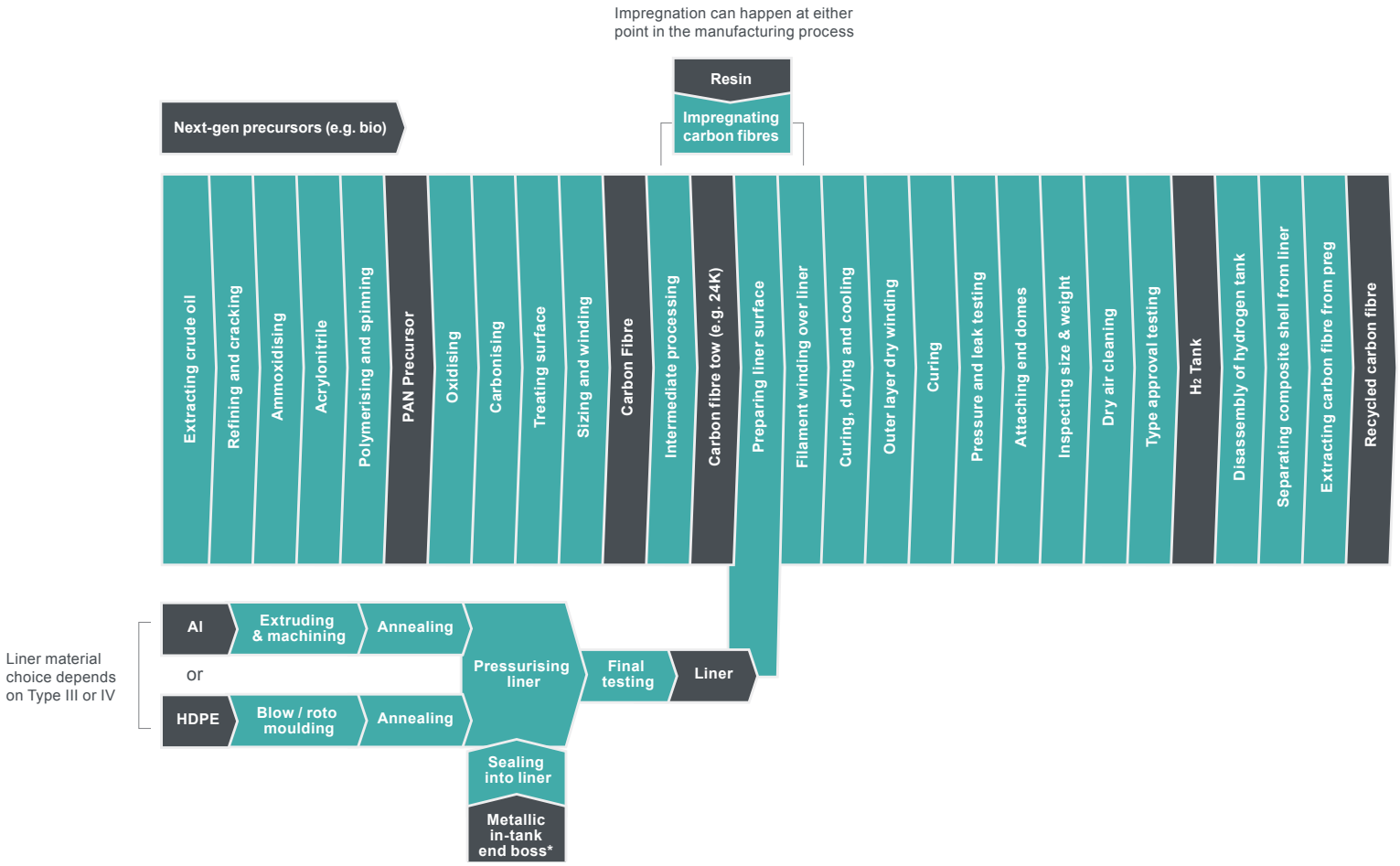
The fuel cell value map covers all critical steps required to manufacture membrane electrode assemblies (MEA) and complete assembly of fuel cell systems.



Source: Value chain developed by the APC Technology Trends Team (2021)

Hydrogen tank value stream

A separate on-board hydrogen tank value map provides the relevant carbon fibre production processes for large-scale tank manufacturing.



Source: Value chain developed by the APC Technology Trends Team (2021)

Fuel cell and hydrogen technologies:

Now is the time to scale-up UK manufacturing

APC CEO Ian Constance (right) with Bernadette Longridge (AVL, centre) and Dennis Witt (Ford, left) and the prototype FCEV Transit van, exhibited at the Low Carbon Vehicle Show 2021

A question we often get asked at the Advanced Propulsion Centre (APC) is 'What's the new big thing in automotive technology?'. Perhaps that question needs to be rephrased; maybe the next 'big thing' isn't new at all.

In fact, for the UK, what we should be looking out for isn't technology, but opportunity – because what we've found in the process of creating our most recent publication – our fuel cell system value chain maps printed on pages 8 and 9 – is that our ambition could be much greater.

The past few years have seen hydrogen gaining momentum as the clean fuel of the future: simple, abundant, reliable.

This shift creates real opportunity for the UK in both the development of net-zero combustion and, perhaps more significantly in the opportunity this creates for the UK to move into a leading position for fuel cells, reacting to strong signals that now is the time to level-up domestic hydrogen and fuel cell industrialisation.

The new generation of proton exchange membrane (PEM) hydrogen fuel cells are compact, lightweight, and offer high power density, making them attractive for vehicle applications – not as a competitor to battery electric vehicles (BEV), but playing a complementary or supplementary role as we're already seeing in heavy goods vehicles and vans.

The cost of automotive fuel cells has fallen by 70% since 2008 and increased production is bringing costs down further. With the Toyota Mirai, Hyundai launching both cars and trucks, joint ventures between Daimler and Volvo, and Stellantis' hydrogen vans coming to the UK in 2023, there's increased focus on bringing this technology to the mass market.

Total cost of ownership (TCO) is critical for heavy duty and commercial applications, where 'time is money' couldn't be more literal. This is where fuel cells become the decarbonisation frontrunner: reliably delivering an enormous amount of energy, without excessively compromising payload and charging downtime – a trifecta that a pure battery electric powertrain cannot yet deliver.

Range versatility is also an appealing proposition for the light commercial and passenger vehicle sector, where we are seeing more powertrain synergies between battery and fuel cell technology. This is already happening for small and mid-sized trucks. For example, new entrant Tevva's 7.5t to 19t delivery trucks run on battery-power supplemented by a fuel cell system for additional range and versatility. The hybrid solution is lighter, more cost effective than a pure BEV and achieves TCO parity with diesel variants within 35,000 miles.

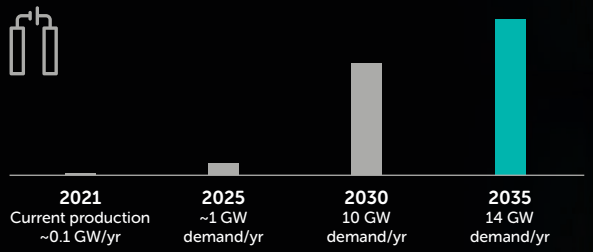
Technological advancements are bringing forward the commercial viability of lighter fuel cell electric vehicles (FCEVs), which then begins to dictate the volumes and ramp-up needed across the industry. We forecast rapid growth in fuel cell platforms for light duty vehicles from 2030 as hydrogen refuelling networks expand and hydrogen at the pump drops to $4–5/kg. We expect that 14GW of on-board fuel stack power and 400,000 hydrogen carbon fibre tanks will be required to meet the demands of FCEV production in the UK alone by 2035. This is where we start to see the green shoots of that 'next big opportunity'[3].

3 From: *How the UK Government hydrogen strategy can succeed for transport*, apcuk.co.uk

'We expect that 14GW of on-board fuel stack power and 400,000 hydrogen carbon fibre will be required to meet the demands of FCEV production in the UK alone by 2035.'

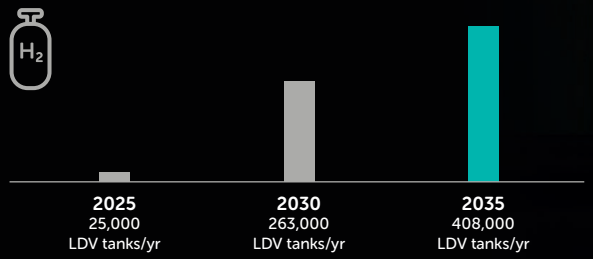
14 GW
of fuel cell stacks

required by UK vehicle manufacturers by 2035 for cars and vans produced in the UK



400,000
hydrogen on-board tanks

required by UK vehicle manufacturers by 2035 for cars and vans produced in the UK



Building on existing strengths for clean combustion

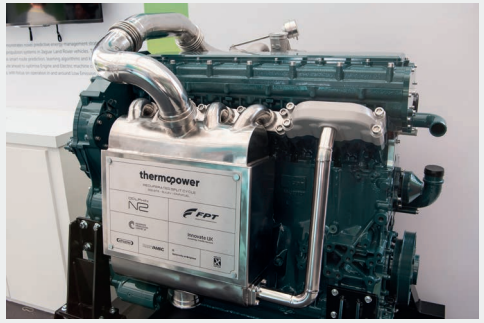
It's a misnomer that realising our net-zero ambitions automatically signals the end of the internal combustion engine (ICE). We forecast hydrogen combustion engines (net-zero ICE) will be required in decarbonising heavy-duty transport to meet the global climate change target of 1.5°C by 2050. This technology is currently in development and seeing promising results for net-zero CO_2 and NOx emissions.

Furthermore, we can safeguard the thousands of UK jobs associated with the engine manufacturing and its supply chain that accounted for £3.6 billion of trade in 2019. The EU remains the biggest destination for engines built in the UK, accounting for 45% of all exports in 2020[4].

Hydrogen combustion, or similar net-zero propulsion, can provide a good route for 7.5t-44t heavy duty goods vehicles, agriculture, and off-highway machines and can share the same hydrogen refuelling network required for fuel cell vehicles.

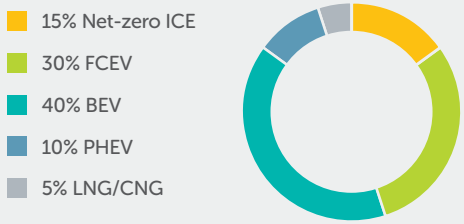
Four large engine suppliers; Westport, Paccar, MAN and Cummins have announced their programs for R&D into hydrogen combustion systems. The most recent of these is Cummins, supported by government funding through the APC. Their aim is to create near zero CO_2 emissions through the tailpipe and near zero levels of NOx. This is an established technology and can be delivered at similar costs to existing diesel engines, offering an immediate route to decarbonising the heavy goods transport sector.

By 2040 we forecast that net-zero ICE will make up 15% of HGV powertrains across Europe, with the majority of the rest (70%) being FCEV and BEV.



Dolphin N2 recuperated split cycle engine demonstrator

APC Europe 2040 powertrain forecast



4 From: *SMMT UK Automotive Trade Report 2021*, smmt.co.uk

Getting ahead of the hydrogen fuel cell growth curve

The fuel cell stack is the heart of a fuel cell power system producing DC current to drive the electric motor. High pressure hydrogen tanks, typically 350 or 700 bar, store the gas in multiple carbon fibre wrapped cylinders on-board the vehicle. The UK has strong grass roots in both fuel cell stacks and carbon fibre technology.

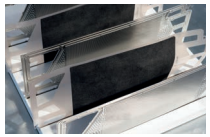
Our analysis shows that the UK has the potential to become one of the world's fuel cell system production capitals. There are three main areas to achieving this goal:

- Membrane electrode assembly
- Fuel cell stacks
- Hydrogen tanks

These are less capital intensive than battery production investments and closely match the skills and expertise of current vehicle and engine manufacturing. Like battery cell manufacturing, localising fuel cell and stack assembly is a key intermediate step that connects the catalyst coated membrane supplier with the OEM.

Since fuel cell stack assemblies are less complex than internal combustion engines, it should be possible to transition some of the UK's rich heritage and capability in engine manufacturing to fuel cells and safeguard hundreds if not thousands of highly skilled jobs.

Fuel cell system – key parts



Membrane electrode assembly

Fuel cell stack

Hydrogen tanks

A big opportunity for the UK

The automotive fuel cell market offers the UK an opportunity to lead in Europe and be recognised internationally as a centre of excellence in fuel cell development and manufacturing. Getting ahead of the curve has proven to be critical in the lithium-ion battery market and this will be the same for fuel cells – first movers have to be ambitious to reap the rewards in the long-term.

To help with this ambition, the APC's fuel cell and hydrogen tank value chain maps enable suppliers to look upstream and downstream from their current capabilities, identifying potential growth opportunities across the value chain.

It is no secret that the UK's current strengths are in the upstream stages of fuel cell system manufacturing – the electrochemical and material processing on the left of the fuel cell value stream map – thanks to the engineering nous of leading players like Johnson Matthey and Technical Fibre Products (TFP).

Johnson Matthey's position in the fuel cell market is unique because they can leverage their world-leading market position in secondary platinum refining and recycling from spent automotive catalytic converters. Platinum is a critical metal used in catalyst coated membranes, the core of the membrane electrode assembly (MEA) .

This, together with the fact they also manufacture their own proton exchange membrane (PEM), means they have in-house manufacturing of most of the high-value ingredients that make up an MEA. Understanding their strengths in fuel cells but also in the wider hydrogen value chain, Johnson Matthey recently pledged £1 billion investment in clean hydrogen technologies by 2030, which signals confidence in the growth to come for UK manufacturing.

Perhaps less well-known, TFP are a major global supplier of carbon paper, which is the advanced material used in the gas diffusion layers of an MEA. They draw on decades of paper-making capability from their parent company James Cropper to manufacture high quality carbon paper already being used in FCEVs on the road today. TFP have recently launched TFP Hydrogen Products, adding catalyst powders and further electrochemical expertise to their offering.

This upstream expertise represents highly valuable intellectual property for the UK – and our mission now is to anchor this in the UK to build a thriving material supply chain that can grow and innovate, maximising opportunities from the growth of fuel cell systems in automotive applications.

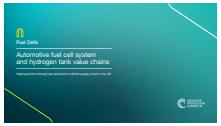
As such, there is value in building towards the right-hand side of the value stream – to the next steps of fuel cell stack and system assembly and the high-pressure carbon fibre cylinder tanks essential to the on-board storage and transportation of hydrogen. APC is working with several companies in these specific areas, piecing together the conversations and learnings across multiple sectors – not just automotive.

For us, collaboration is key, and a vital part of the role we play in the UK's net-zero journey. Thankfully, we are seeing traction; Canadian fuel cell manufacturer Ballard Power's acquisition of UK company Arcola Energy (now Ballard Motive Solutions) in the last quarter of 2021 is a prime example. Arcola has been integrating the Ballard fuel cell systems into buses, refuse trucks and trains for a decade, ultimately attracting Ballard's attention and a $40 million inward investment in UK manufacturing.

Similarly, Intelligent Energy assemble automotive PEM fuel cells and stacks in the UK and are currently active in APC-funded project ESTHER looking to optimise and commercialise their automotive fuel cell stack through collaboration with leading Chinese vehicle manufacturer Changan.

The final element to reach that 65% ambition is to scale up UK manufacturing of automotive hydrogen tanks and carbon fibre, which account for around a third of the total fuel cell system value and are also needed for hydrogen combustion.

UK headquartered Luxfer are currently the leading supplier of automotive hydrogen tank systems in Europe, and they supply into the Hyundai Xcient fuel cell truck programme. Attracting capital investments in UK tank manufacturing relies on strong demand signals from UK vehicle manufacturers, but as we have already established, we are seeing momentum here, particularly in fuel cell electric buses and off-highway machinery.



The Advanced Propulsion Centre's automotive fuel cell and hydrogen tank value chain report can be downloaded on the APC's website. If you want to know more about the APC's supply chain work, please email: luke.bates@apcuk.co.uk.

Next steps

Industry and government are completely aligned, road transport will require both battery electric and hydrogen powertrain solutions to meet our decarbonisation targets. Like batteries, ensuring infrastructure is moving at the same pace as on-vehicle technology is a challenge that needs to be addressed. The UK government hydrogen strategy released in August 2021, provides a clear pathway for blue and green hydrogen production and DfT truck trials are being used to assess the infrastructure required to support future truck fleets. The infrastructure will require significant investment in hydrogen generation, transportation and refuelling stations – this can't all come from the public purse but industry needs the right signals for capital investment.

We will continue to work closely with government, industry, and academia to realise this ambition of 65% value-add in the UK.

The difficult lesson we've learnt in scaling up battery production, after leading battery cells research in the 80's and 90's, is that we could get caught out sleeping-at-the-wheel whilst others overtake us. Early action and investment is needed to retain the UK's leading innovation position and expand this to manufacturing activities if we are to deliver economic benefits to our industrial heartlands.

'We will continue to work closely with government, industry, and academia to realise this ambition of 65% value-add in the UK.'

ADVANCED PROPULSION CENTRE UK | Accelerating Progress

Advanced Propulsion Centre funding opportunities

We are dedicated to supporting the UK's global leadership position in scientific research, automotive engineering and net-zero political ambition by enabling the de-risking of new product and process development, supporting domestic and export markets. Throughout our funding streams our teams of handpicked specialists can offer support for innovative, low carbon technologies that offer significant reductions in CO_2 emissions that will help grow the UK's automotive supply chain in the process.

Collaborative R&D competitions

Our Collaborative R&D competitions are our original funding mechanism.

We fund a range of different technologies that are able to help the UK on the transition to net-zero emission vehicles.

Our funding through the stream supports collaborative R&D projects based in the UK, worth a value of between £5–40 million.

Automotive Transformation Fund

Providing the funding and support to capitalise on at least a £24 billion UK opportunity.

The Automotive Transformation Fund (ATF) is a key enabler of the transition to an electrified future. Through providing support through capital investment and R&D funding, we help those who want to make the most of UK expertise.

Up to £1 billion of funding will be invested in developing a high-value end-to-end electrified automotive supply chain in the UK.

The ATF also enables the APC to seek proposals from single organisations or consortiums for business case feasibility studies up to the value of £1 million.

SME support

Whether you're an established SME, a spin-out, or a technology developer with a great idea, we have a number of ways to support your innovation.

From providing funding, business support and mentoring, opportunities to work with larger OEM's, and helping you put your innovation centre stage at some of the sectors biggest international events, we can help you take your innovation to the next level.

Visit apcuk.co.uk/funding for more information about each of these funding streams and the latest competition openings

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