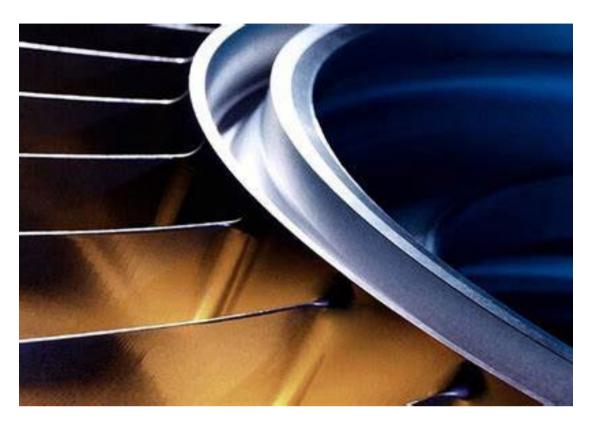
The UK Hydrogen Innovation Opportunity

Dr Katy Milne, Hydrogen Innovation Initiative

30 May 2024

Hydrogen Innovation Initiative

About me



Rolls-Royce / Imperial College



MTC – the Manufacturing Technology Centre



Aerospace Technology Institute - FlyZero



High Value Manufacturing Catapult / Hydrogen Innovation Initiative

MTC – the National Centre for Additive Manufacturing





Our mission is to accelerate critical technologies and supply chains in the UK for the fast-growing global hydrogen economy.

HII is working with >200 companies and 10 sector bodies in the UK, to coordinate innovation in 9 critical technology areas across:



HII is working with industry to drive innovation and supply chain development, working across UK industry and with support from our Industrial Advisory Board:

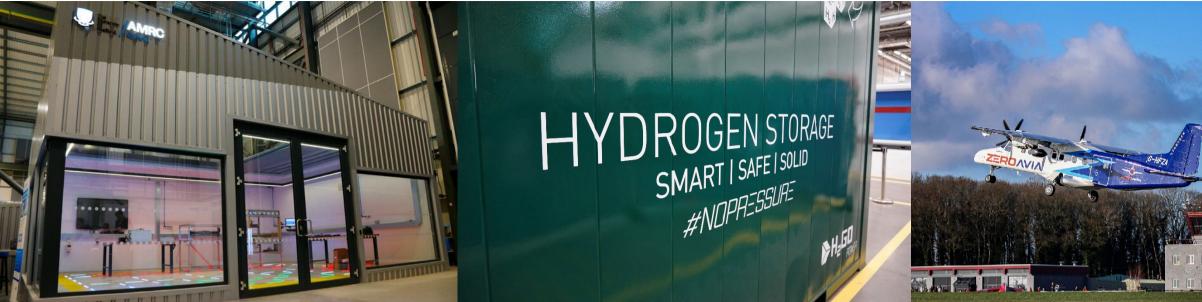
bp, Airbus, Cummins, GKN Aerospace, Glass Futures, H2Go, Hydrogen Energy Association, Hydrogen UK, Johnson Matthey, National Gas, ZeroAvia

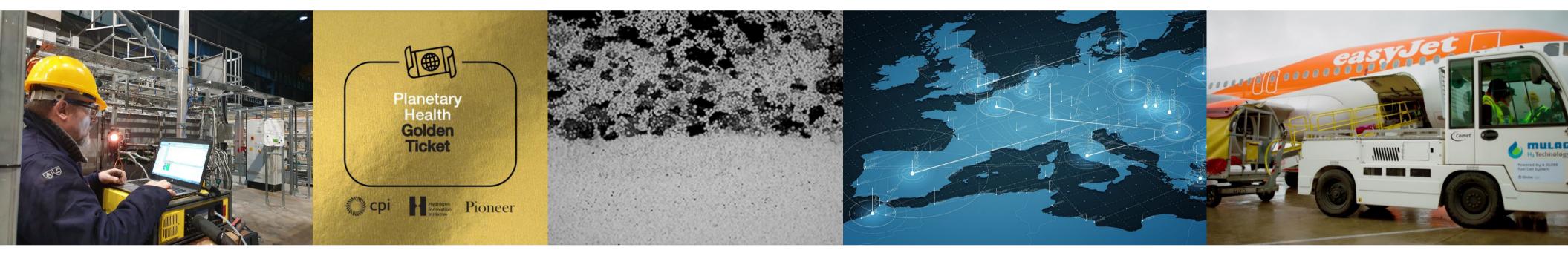
HII is generating **technology roadmaps**, forecasting **sector demand** and **markets**, and mapping **UK capability**.

HII partners:



Our partners are collaborating with industry on hydrogen across multiple sectors....









Hydrogen Innovation Challenge







Unlocking the benefits Anchoring the value

Hydrogen Innovatior Initiative





When both direct and indirect economic benefits are considered, the global hydrogen economy has the potential to be worth \$8 trillion by 2050.

The global hydrogen economy

Direct and indirect economic activity

3 x benefits: Decarbonisation – Economic – Influence





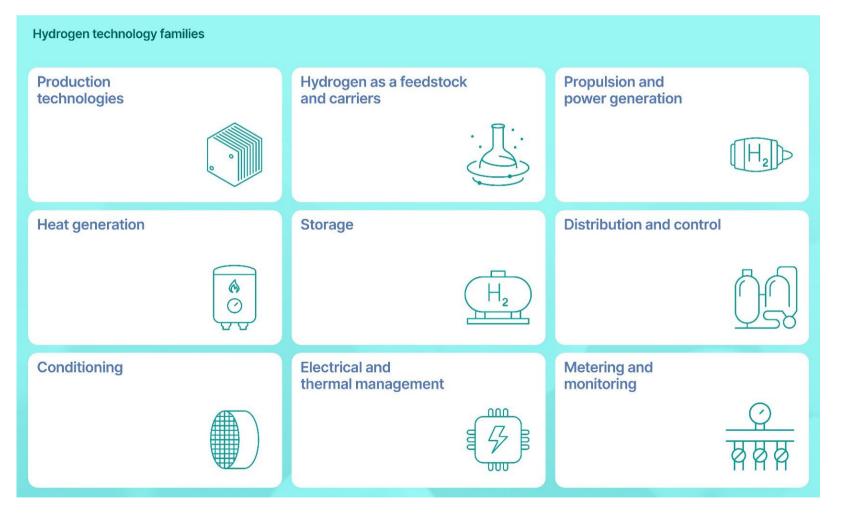


Hydrogen technology market

1 trillion

9 cross-cutting hydrogen technology families

Target a 10% market share of the global market





The UK is starting from a strong base of industrial capability with an established innovation ecosystem. Under the right conditions and with the right strategic investments, this can be catalysed for growth.

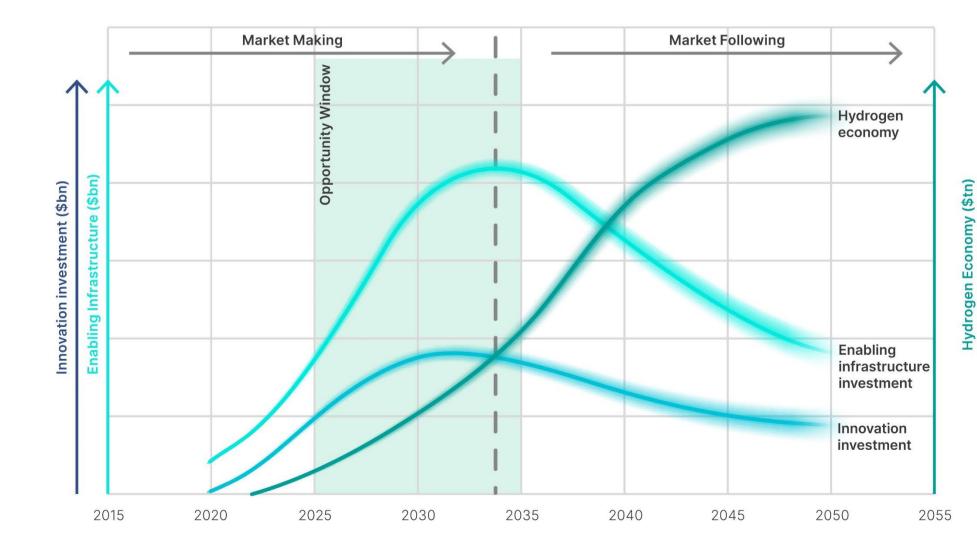


Window of opportunity

To secure a market leading position

Capturing the expected peaks for innovation and infrastructure investment, along with highest growth phase of the global hydrogen economy

of the global hydrog **years**





If the UK is to stay ahead of international competition a strategic approach to investment in hydrogen innovation must be developed and delivered at pace.



Strategic intervention

Representing biggest potential for the UK

Production of hydrogen and conversion into carriers

Propulsion systems for transport

Industrial hydrogen for feedstock, heat and power

End-to-end hydrogen storage

Focus areas

The UK Hydrogen Innovation Opportunity

Innovation creating a space for us to become truly world leading...



The UK Hydrogen Innovation Opportunity in figures



\$8 trillion

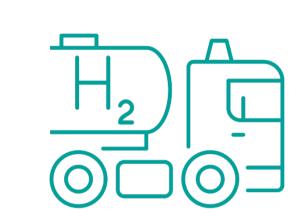
The global hydrogen economy in 2050, considering direct and indirect economic activity



Global hydrogen technology market by 2050 Delivered by 9 cross-cutting technology families





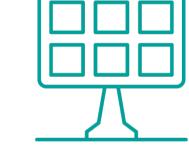




4 areas of focus

Representing the biggest areas of potential for the UK

10 year window



To secure our position as market maker



The UK Hydrogen Innovation Opportunity and supporting reports



The UK Hydrogen **Innovation Opportunity**

UK Capabilities

Hydrogen Innovation Initiative



The UK Hydrogen Innovation Opportunity

Hydrogen technology roadmaps

The UK Hydrogen **Innovation Opportunity**

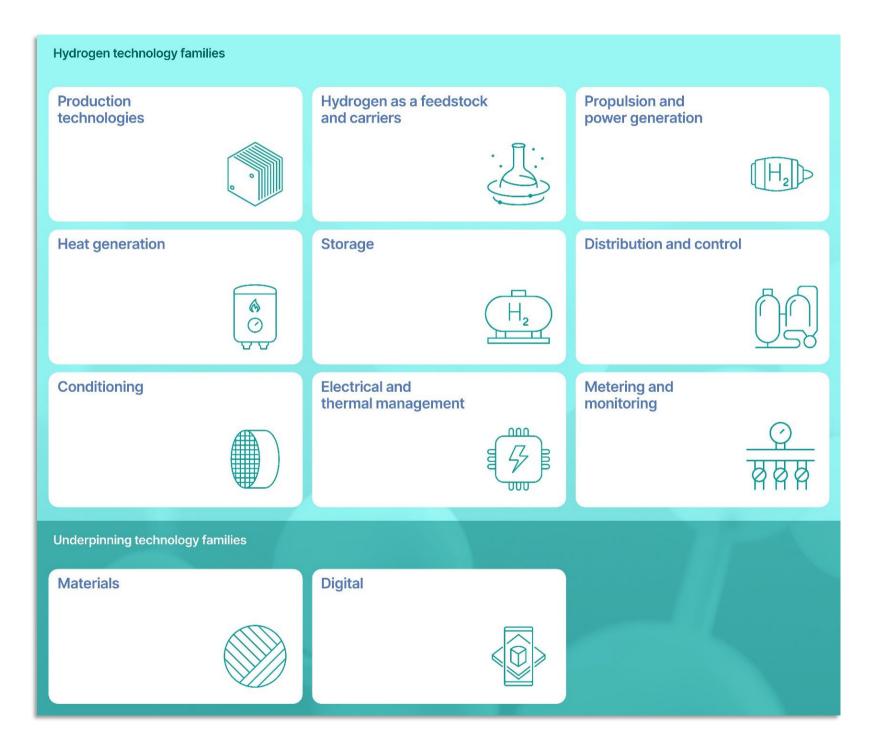
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Techno-economic methodology



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The UK Hydrogen Innovation Opportunity – Hydrogen technology roadmaps



×9 technology roadmaps

Propulsion and power generation

Summary: Three propulsion technologies will see natural deployment into key sectors. Fuel cells and internal combustion engines are typically suited to medium to high-duty demands with long-range requirements and where refuelling can be centralis at key hubs, such as Heavy Good Vehicles (HGVs), and coaches. This is reliant on the availability of efuelling infrastructure and the technology be cost competitive with battery electric vehicles. Fu ells could also see migration into more demandir applications, such as short-range flight, but requi

Fuel cells

Current state: Many fuel cell technologies are mature and readily available. Development is needed to improve durability and efficiency such as through novel hightemperature Proton Exchange Membrane (PEM) fuel cells

Gas turbines

Current state: Hydrogen gas turbine technology maturi varies depending on the blend of hydrogen. Low hydrog encentrations using existing gas turbine designs are the mature with existing designs thought to be suitable. Furthe development is required for higher hydrogen concentratio

Internal combustion engines

Current state: Hydrogen internal combustion engine are being matured, with several leading manufacture bringing products to market; other manufacturers are also developing solutions. Activity is required to improve performance and increase compe

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reliabili	ty. Direct comb	ustion of hydrog			Global and UK market forecasts These tables show forecasts for the annual global				20	030	20	2050	
the key techno of hydr methoo such as	I transition for internal combustion engines, with y advantage being minimal change to the existing ology and supply chains. Direct combustion rogen through turbines is seen as a possible d to decarbonise higher power applications, is power generation or short-medium haul . Hydrogen combustion processes need to be				and UK makes for this technology family. The figures show the neutral (midpoint) scenario from analysis for HII by Markets and Markets [1].				UK \$0.12bn	Global \$8bn	UK \$5.25bn	Global £150bn	
		2025		2027	2028	2029	2030	203	5 20	040	2045	2050	
		e manufacture in	to enable scalab	<u> </u>	m equipment								
s.	Improved integration of balance of system equipment to increase efficiency and reduce cost High temperature/efficient fuel cells reducing mass and increasing operating life												
	o	efficient use of	and membranes, a and development aw materials and j	t of routes to rec	cycle and re-utili		ents	°					
y en	0		modification to e		0	0	ydrogen						
e most her ons.			rameters to mitiga performance @ 1			0	~	0					
	o	ficiency through	trofittable hydrog	ogen combustio	n and waste heat	recovery	0				1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (
	Reduction (of NO _x emission	s through develo	pment of improv	ved abatement sy	ystems	0				<u>+</u> 0		
	KEY: Tech	nology Developm	nent oc	2	Technology Inc	dustrialisation –	o		Н	ydrogen 1	echnology roa	dmaps 20	



The UK Hydrogen Innovation Opportunity – UK capabilities

An accelerating UK hydrogen technology supply chain



Essar Energy Transition Hygen HYRO Locogen Progressive Energy								
OCK Storengy Cadent Gas National Gas National Grid NGN								
Ricardo Wood Group wsp								
2G AFC Energy Airbus Ballard Motive Solutions CAT								
JCB Tevva Toyota ULEMCo Wrightbus ZeroAvia								
skel Logan Energy Lux Industries								
gy Wild Hydrogen Catagen OXCCU Reaction Engines								
Engines Cummins DAF Intelligent Energy ITP Aero Perkins								
Trent Refractories Chesterfield Specialist Cylinders Glacier Energy								
AVK Eaton FT Pipeline Systems Fusion Systems Liberty Steels								
stech Belliss & Morcom Edwards CTI Cryogenics Haskel Howden								
GM Flow HyMet Oxsensis Servomex Synthotech								
•••••••••••••••••••••••••••••••••••••••								
t generation Storage								
Metering and monitoring Mixed								



The routes to success are now clear but the window of opportunity is fast reducing.

Now is the time to unlock the UK hydrogen innovation opportunity.

The UK Hydrogen Innovation Opportunity

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HII partners









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