



**GREEN
GROWTH**

HYDROGEN TECHNOLOGIES STRATEGY

DECEMBER 2021

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THE POWER OF PARTNERSHIP

The development of this Hydrogen Technologies Strategy for the Midlands Engine has only been made possible by a vast investment of time, open sharing of knowledge and extensive input of expertise by many leading industry partners, academic colleagues and public sector leaders. This work arose from an action point we committed to deliver together, as part of our Ten Point Plan for Green Growth in the Midlands Engine. Together, we are focusing action to pioneer, commercialise and deliver the hydrogen technologies that will connect low carbon hydrogen producers and users, and enable the delivery of the UK government’s Hydrogen Strategy. With thanks again for the valued partnerships which underpin all we do for our region.

FOREWORD BY SIR JOHN PEACE



With exceptional ambition and the utmost urgency, the Midlands Engine partnership is taking the national lead to pioneer, commercialise and deliver the technologies that will unlock low carbon hydrogen opportunities. Our commitment is galvanised by our recognition of the vast scope this presents to accelerate regional economic growth and deliver net zero.

The Midlands is the UK's manufacturing heartland and one of the most important national locations for hydrogen innovation and application. We have a unique blend of diverse manufacturing ingenuity and capability, world-leading commercial, industrial and academic innovation, and ideal geographic location. All of which means we are uniquely placed to make the technologies that connect hydrogen producers and suppliers with end users and consumers - technologies we need to activate the wealth of opportunities offered by low carbon hydrogen.

By championing the role our partners play in pioneering the development of next-generation, cost-effective hydrogen technologies and our proven powerful potential to manufacture and deliver at scale, our Hydrogen Technologies Strategy is a catalyst and focal point around which we will enable our region to address challenge and seize opportunity. As a region and a proactive partnership, we are ready and acting now to deliver on the UK's low carbon hydrogen ambitions.

Sir John Peace, Chairman, Midlands Engine

EXECUTIVE SUMMARY

The UK must unlock the vast potential of hydrogen

Hydrogen technologies made in the Midlands are the key

The UK government's Hydrogen Strategy states an ambition for 5GW of low carbon hydrogen production by 2030, for use across the economy. This new, low carbon hydrogen could help provide cleaner energy to power our economy and our everyday lives, from heating our homes to powering transport - but only if we invest with pace to develop and scale the hydrogen technologies that will enable consumers to access net zero hydrogen solutions.

The Ten Point Plan For Green Growth in the Midlands Engine sets out our region's bold and ambitious actions with the power to create jobs, boost economic growth and reduce carbon impact. Recognising how crucial hydrogen will be in meeting 2050 Climate Change Act targets, our Ten Point Plan includes a specific section on low carbon hydrogen and a key action - to develop a Midlands Engine Hydrogen Technologies Strategy, drawing also on our region's exceptional expertise and capacity in manufacturing. Partners from across our region have responded with speed and purpose to co-author this unified document which articulates the role the Midlands can

play, the capabilities across our region and our plans for the Midlands Engine Hydrogen Technologies Valley - our pan-regional ecosystem of innovation and infrastructure with the power to pioneer, commercialise and deliver hydrogen technologies at scale.

The Midlands is the manufacturing heartland of the UK - home to some of the UK's and the world's most iconic manufacturers and a vibrant supply chain. Through our world-leading universities and the highest number of Catapult Centres in the UK, we are fostering a rich environment of innovation, forging links between concept and commercialisation to drive regional economic prosperity.

By coordinating and connecting transformational opportunities through our region's Hydrogen Technologies Valley, Midlands Engine partners are accelerating combined potential to deliver a wealth of benefits, from high quality job creation and economic growth, to progress against UN Sustainable Development Goals. Our partners WSP and the Midlands Engine Observatory have worked to quantify the impact we will drive through this strategy.

In all of this, time is of the essence and so our strategy recommends ten clear actions that must be mobilised now to capitalise on our phenomenal strengths and clear potential. The climate emergency means we must think differently - the problems of now and the future require different solutions. If the UK is to unlock the potential of hydrogen - and it must - the imperative for a focus on hydrogen technologies in the Midlands, as demonstrated in our strategy, is clear.

MIDLANDS ENGINE STRENGTH IN PARTNERSHIP

The Midlands Engine partnership is a unifying pan-regional force spanning 65 local authorities, one combined authority, 20 universities, nine local enterprise partnerships and over 800,000 businesses. We are working in close collaboration right across our region which spans the UK's heartland - to lead, prioritise and coordinate the green growth action that will safeguard our environment and grow our economy.

The role of the Midlands Engine is to connect, champion and amplify, supporting our partners to work together to pursue shared ambitions and to add value. This Hydrogen Technologies Strategy is published in support of the Ten Point Plan for Green Growth in the Midlands Engine. We will now work with partners to drive delivery of the actions identified in these pages.

The role of the Midlands Engine in Green Growth is to:

- ✓ Highlight and advocate for our region's key role in driving the UK's green recovery
- ✓ Be a strong convening force across our region and an ambassador for our collective work
- ✓ Provide an evidence and intelligence base, underpinning activity, through the Midlands Engine Observatory
- ✓ Engage with policy makers on behalf of the region to influence and shape policies which bring benefits for every part of our region
- ✓ Work in partnership to identify together the most effective routes for action as we mobilise our implementation plan, leveraging the capabilities and knowledge of every part of our partnership
- ✓ Publicise and celebrate the remarkable strengths of partners across our region, raising profile and building awareness of the immense capabilities of our region - across the UK and internationally

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Right now, the Midlands Engine is galvanising efforts, at pace, to shape our region's green future. And our partners agree - this Hydrogen Technologies Strategy has an absolutely critical part to play.

Together, we share an ambitious vision for the Midlands hydrogen opportunity. This is crystallised in the form of the Midlands Engine Hydrogen Technologies Valley proposition which has immense potential to deliver a wealth of benefits in terms of jobs creation, economic growth and progress against UN Sustainable Development Goals - as quantified in this strategy by our Midlands Engine Observatory and our partner, WSP.

In the following pages, we have identified how we can leverage partner capabilities, overcome challenges and capitalise on potentially transformational opportunities as we seek to shift to a hydrogen economy. The Midlands Engine partnership has a key advocacy role to play, working with and between national government and regional partners to help foster opportunity areas, and address and overcome barriers.

This strategy highlights the activities that make up our regional profile and capability through existing initiatives, 'oven ready' projects and feasibility study work for emerging opportunities - spearheaded by industry, our world-leading universities, and by research and technology organisations.

The shared aim of all our partnership's collaborative green growth work is strongly shaped by the need to work with industry and SMEs, which are the entrepreneurial lifeblood of our region. It is how we will activate net zero innovation opportunities, focusing investment into manufacturing and supply chain development across all sectors and every part of our region to protect and create jobs.

Finally, in addition to nurturing organic growth within our region's unique advanced engineering supply chains, this Hydrogen Technologies Strategy will have a key role to play in promoting our shared vision to international and wider UK audiences - acting as a catalyst for economic growth and prosperity through greater collaboration, trade and inward investment.

Rachael Greenwood, Executive Director, Midlands Engine



**MIDLANDS
ENGINE**

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EDF fully supports the Midlands Engine's Ten Point Plan for Green Growth, which is aligned to our ambition to help Britain achieve net zero. As Britain's largest generator of low carbon electricity, with growing expertise in the production and use of green hydrogen, we look forward to continuing collaboration with a number of local stakeholders to support the decarbonisation of the region.



Rebecca Rosling, Head of Smart Customers, EDF Energy

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We see huge potential for creating low carbon hydrogen production clusters in the Midlands, helping to decarbonise homes and businesses.



Sally Brewis, Head of Regional Development, Cadent Gas Ltd

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Intelligent Energy has been the leading UK developer and a global supplier of hydrogen fuel cell technology since it started operations in 2001. Our supply chain is UK-centric and our planned new Gigawatt scale fuel cell production facilities will put the East Midlands at the forefront of zero emission fuel cell power product supply for the global hydrogen economy.



David Woolhouse, CEO, Intelligent Energy

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I believe hydrogen is the future. It's a renewable and transportable zero CO₂ fuel that's capable of storing and delivering large amounts of energy quickly and efficiently, particular in larger, heavier equipment.



Lord Bamford, Chairman, JCB

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The global hydrogen economy has been built by pioneering businesses like Adelan over the last 25 years. Thus the Midlands has shaped hydrogen policies around the world, and I was honoured to be voted the Hydrogen Champion of the UK by Mission Innovation in 2020. We continue to catalyse the hydrogen opportunity, to ensure the delivery of net zero using hydrogen technologies in vehicles, devices and homes.



Michaela Kendall, CEO, Adelan

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When it comes to decarbonisation and the transition to net zero, whichever energy pathway you look at, hydrogen technologies have a role to play.



Ian McCluskey, Head of Technical and Policy, Institute of Gas Engineers

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Hydrogen is an increasingly important energy vector for the Midlands in terms of helping decarbonise energy production, heating and transport, but also in relation to economic growth for the region. We are committed to working with industry to support the commercialisation of new, innovative solutions, develop future energy leaders and address skills gaps.



Professor Martin Freer, Director, Energy Research Accelerator

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The East Midlands Hydrogen Innovation Zone is developing hydrogen technologies projects for ground transport, equipment and aviation at East Midlands Airport, as well as exploring rail freight opportunities, particularly in connection with the East Midlands Global Gateway Freeport development.

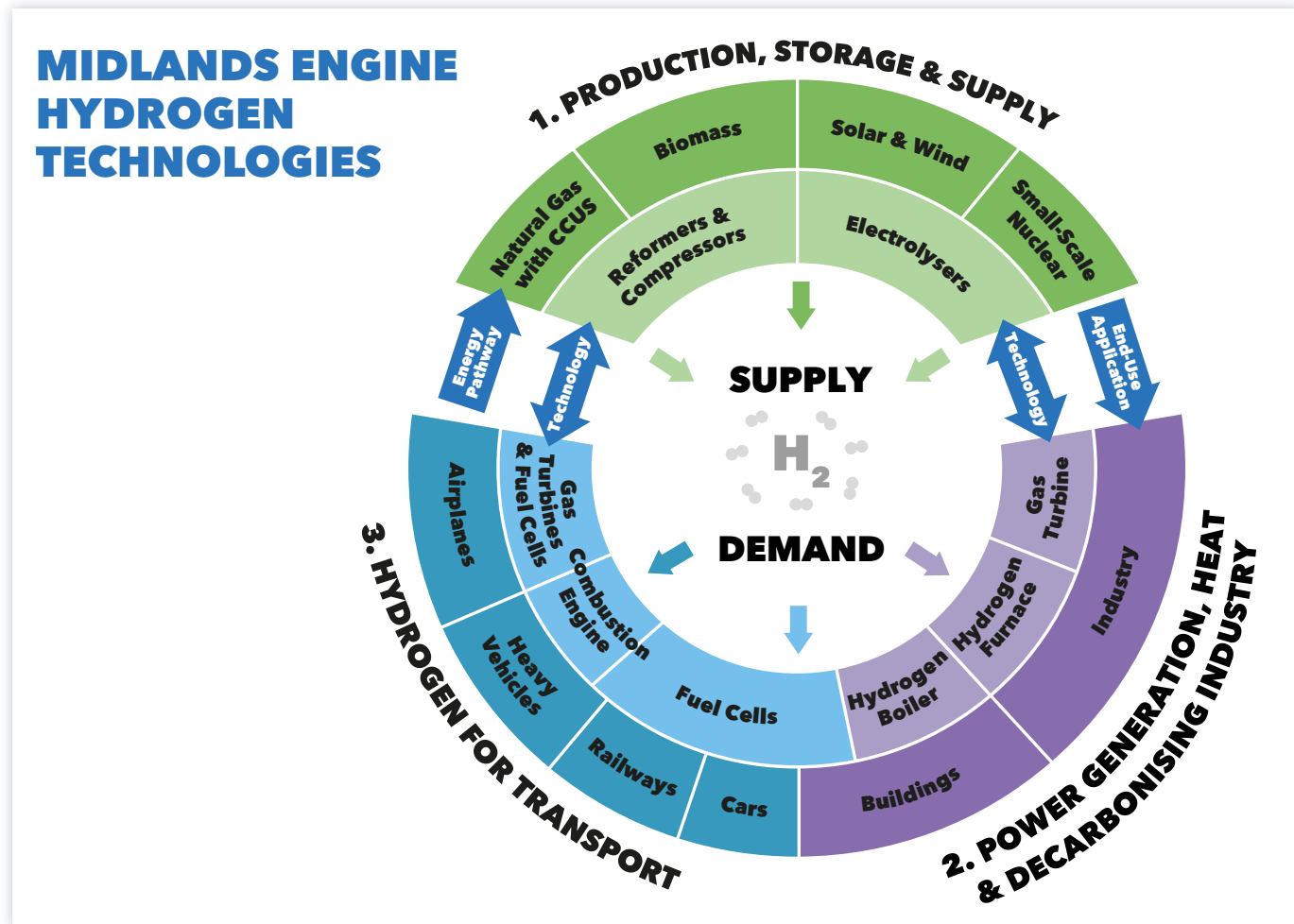


Simon Gerrard, Corporate Partnerships Senior Executive, University of Nottingham

PIONEERING, COMMERCIALISING & DELIVERING HYDROGEN TECHNOLOGIES

As the manufacturing heartland of the UK, the Midlands has unrivalled expertise and capacity to make and apply low carbon hydrogen technologies to deliver net zero. It is hydrogen technologies that have the power to connect hydrogen generators and end users - and it is the Midlands that has the power to make those technologies.

Low carbon hydrogen technologies are beginning to be commercialised in green growth applications in the UK and Europe. There is a huge breadth of applications that can be transitioned to low carbon hydrogen at scale. The Midlands, more than any other region, now has the opportunity to apply our capacity, grow hydrogen technologies and invest in them around the areas shown in the diagram below.



Hydrogen technologies are already used extensively within chemical processes, petroleum refining, and fertiliser and steel production. However, the opportunities for hydrogen in heat, power and transport are still in their infancy in the UK. There are challenges to overcome to realise the potential of hydrogen and supporting hydrogen technologies within our future low-to-net-zero carbon energy systems - but the opportunities and benefits of doing so are unparalleled.

This Midlands Engine Hydrogen Technologies Strategy draws on the work of the UK Hydrogen Task Force and has been developed in consultation with Midlands Engine partners and other key stakeholders. Our strategy highlights how growing consensus around the hydrogen opportunity links with our region's capabilities related to both hydrogen technologies and manufacturing. The outcome is a bold and ambitious plan to position the whole of the Midlands at the forefront of pioneering low carbon hydrogen solutions.

The shared vision and plan of action set out in this strategy builds on the extraordinary wealth of sector expertise, projects and facilities that have been incubated in the Midlands over several decades. It defines the role the Midlands can play, the capabilities across our region and our vision for a Midlands Engine Hydrogen Technologies Valley in support of the UK government's Hydrogen Strategy. As a region and a proactive partnership, we are ready and moving forward to ensure the delivery of the UK's low carbon hydrogen ambitions through a strategic focus on hydrogen technologies.

► **To enable the transition to net zero the Midlands will:**

- Use our unrivalled manufacturing capabilities to deliver critical hydrogen technologies
- Pool hydrogen demand from heavy industry and heavy transport to collectively build the case for a hydrogen pipeline network to connect supply and demand.
- Galvanise our industries into action by promoting the BEIS fuel switching competition and encouraging R&D into what it would take to convert their heavy industrial processes to hydrogen.
- Get behind the provision of hydrogen at our region's multi-modal transport refuelling sites (such as Anstey and East Midlands Airport), attracting local freight operators and bus companies to reach the scale needed to justify the investment.

► **The scope for hydrogen technologies in the Midlands is exceptional and includes advanced materials supply and the engineering of products for:**

- Conversion of hydrogen into useful electrical or mechanical power and heat - including fuel cells, internal combustion engines, boilers and gas turbines.

- Hydrogen supply, distribution and storage equipment - including electrolysers and chemical processes for hydrogen production; compressors, pipework, valves and control systems for gas handling; and materials and vessels for storage.

► **Hydrogen technologies have phenomenal potential to drive down carbon emissions and create employment in sectors including:**

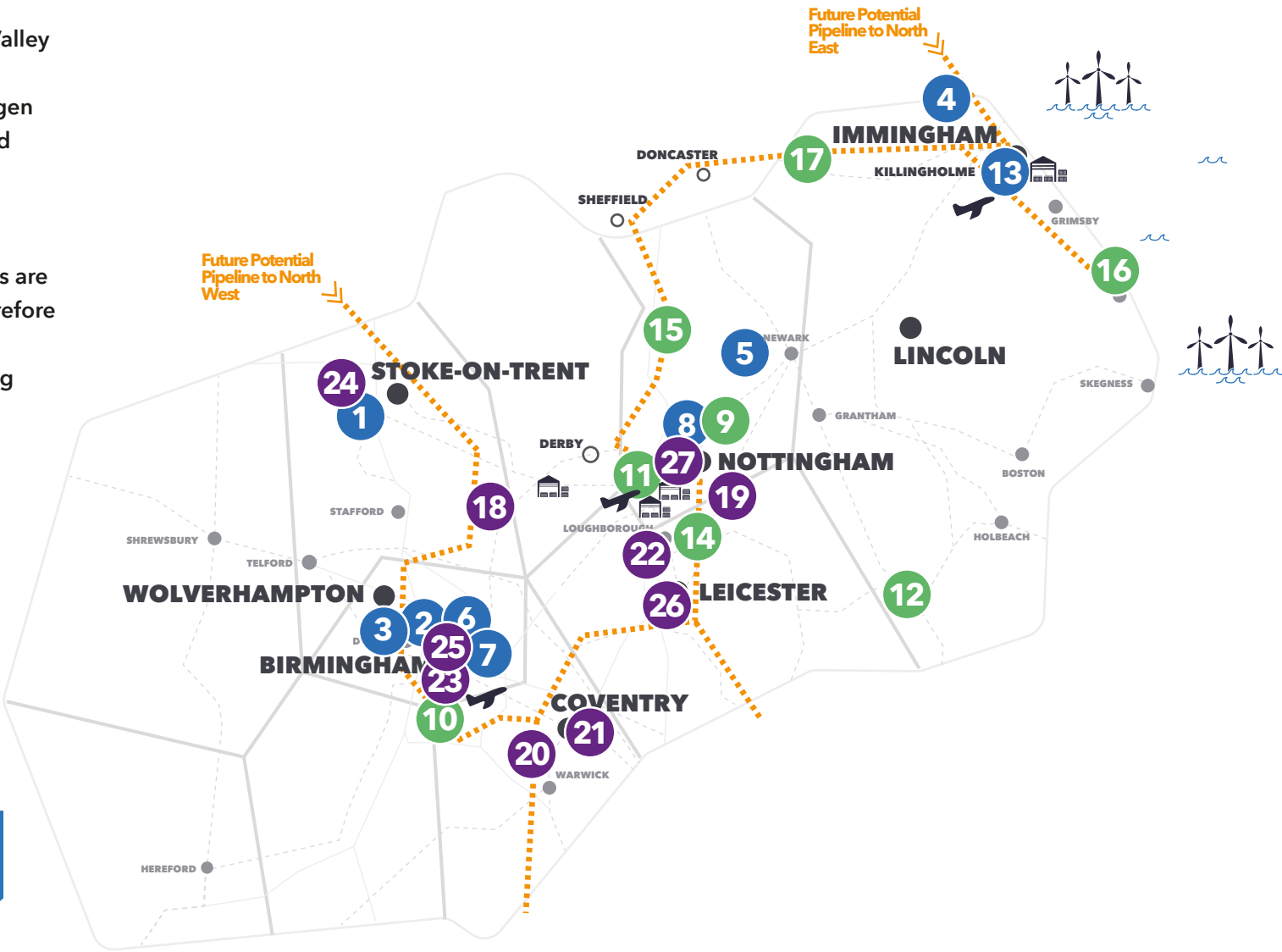
- Domestic and commercial heating
- Low carbon energy generation and supply
- Industrial decarbonisation
- Public transport
- Freight, logistics and construction equipment

► **But to capitalise on our strengths we must act now to overcome barriers and leverage opportunities, including:**

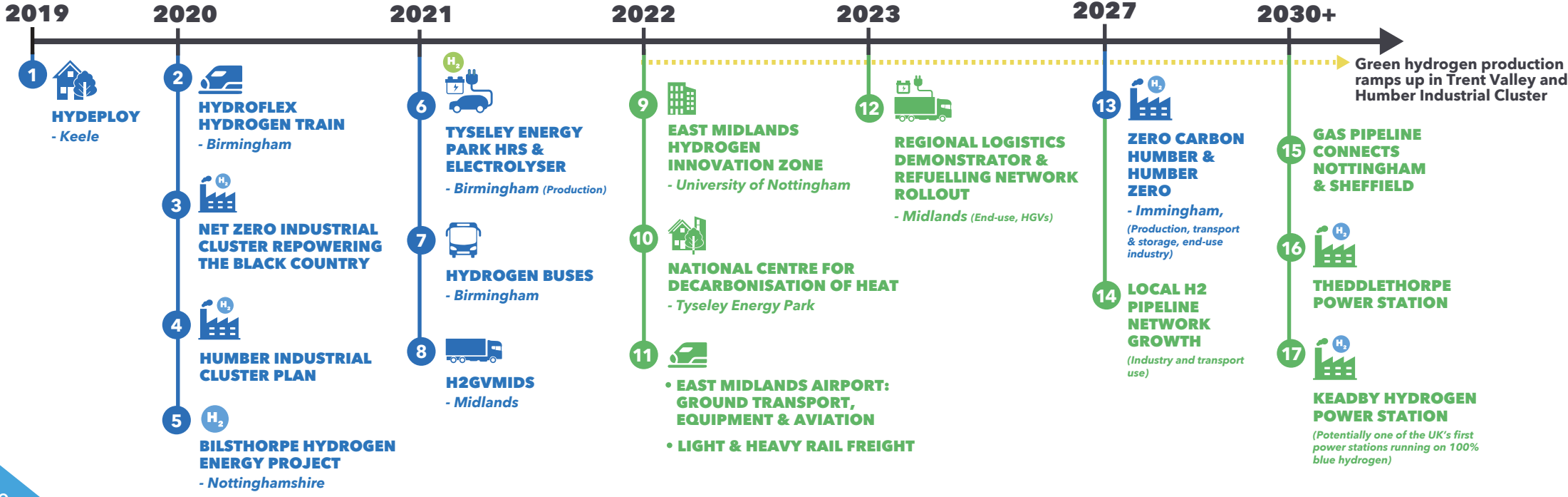
- Developing, demonstrating and commercialising hydrogen technologies.
- Leveraging opportunities to plan the strategic deployment of hydrogen assets at key sites across our region linking hydrogen supply with end use demand.
- Identifying and leveraging opportunities for innovation and industrialisation support to help the market for hydrogen technologies to develop and scale faster.
- Addressing skills gaps that might be a barrier to market development for hydrogen technologies.
- Promoting opportunities and benefits offered by hydrogen technologies to help inform and engage stakeholders in our region, the wider UK and internationally.
- Working together in partnership to take forward these opportunities.

ACCELERATING GROWTH THROUGH THE MIDLANDS ENGINE HYDROGEN TECHNOLOGIES VALLEY

The Midlands Engine Hydrogen Technologies Valley is an ecosystem that links hydrogen production with end users - based on industrialising hydrogen technologies at scale, enabled via academic and supply chain development support. This map showcases a snapshot of our partners and their projects across our region - local clusters that combine to create a regional capability. Partners are moving rapidly to act on opportunities and therefore this map can only show some of the pioneering and high-potential work that is continually being activated in our region.



PURSuing OPPORTUNITIES IN POWER, HEAT & TRANSPORT



Our region is rightly recognised for our advanced engineering expertise and track record of manufacturing excellence. We have the capabilities and strategic intent to develop and industrialise a broad range of hydrogen technologies for power generation, heat and transport applications, as well as extending hydrogen operations across our entire region.

Our Midlands Engine Hydrogen Technologies Valley vision maps the roll out of facilities, demonstration assets and infrastructure along with a supporting innovation ecosystem.

Our partners have identified a host of opportunities to invest in projects that transition our region to a hydrogen-enabled green growth economy. These projects leverage our industrial clusters and transport corridors, as well as the green growth opportunities linked to ongoing investments in clean energy assets.

This willingness to invest is illustrated by a snapshot of example projects in the timeline shown below. The pace of development is rapid with a wide range of opportunities being pursued across power generation, heat and transport.

HYDROGEN FACILITIES & RESEARCH

- 18 ALREWAS GAS COMPRESSOR
- 19 BRITISH GEOLOGICAL SURVEY
- 20 WARWICK MANUFACTURING GROUP
- 21 MANUFACTURING TECHNOLOGY CENTRE
- 22 LOUGHBOROUGH UNIVERSITY
- 23 CENTRE FOR FUEL CELL & HYDROGEN RESEARCH - UNIVERSITY OF BIRMINGHAM
- 24 KEELE UNIVERSITY
- 25 ASTON UNIVERSITY
- 26 UNIVERSITY OF LEICESTER
- 27 UNIVERSITY OF NOTTINGHAM

BENEFITS & OBJECTIVES OF THE MIDLANDS ENGINE HYDROGEN TECHNOLOGIES VALLEY

The benefits of leveraging regional clusters of expertise in hydrogen technologies has been recognised internationally, with the 'hydrogen valleys' concept being promoted in locations across Europe and Asia. For the Midlands Engine region, our hydrogen valley is focused on the opportunity to manufacture as well as to deploy hydrogen technologies - and for this reason ours is a hydrogen technologies valley.

Our Midlands Engine Hydrogen Technologies Valley leverages this concept as a way to:

- Express our bold plans.
- Support all partners and stakeholders through knowledge and innovation policy exchange.
- Act as an exemplar for the international transition to a hydrogen economy.

The Hydrogen Technologies Valley unites Midlands Engine partner organisations around a shared goal to establish and further develop the key enablers of a hydrogen technologies value chain. It will act as a testbed for pathfinder projects and demonstrate the role of hydrogen technologies in a net zero future.

Benefits targeted through the Hydrogen Technologies Valley include:

- Partnership approach to joint prioritisation of supply chain and market development.
- Broader stakeholder engagement, leveraging the nationally significant advanced engineering and manufacturing expertise in the Midlands.
- Raised profile for Midlands capabilities and strategic intent at a regional, national and international level.
- Exceptional opportunity for jobs creation, economic growth and environmental protection.

Together, Midlands Engine partners have identified ambitious goals for our Hydrogen Technologies Valley, including:

For hydrogen production

- To work with partners in the Humber region to support the establishment of a hydrogen-supplied industrial cluster, leveraging large-scale carbon capture use and storage assets.
- To establish a network of electrolyzers for green hydrogen supply at hydrogen energy hubs capable of supporting decarbonisation for dispersed energy-intensive manufacturing and logistics clusters in all parts of our region.

For hydrogen distribution

- To establish a network of new and re-purposed hydrogen pipelines that links hydrogen production sites with end users. The network will connect low carbon hydrogen production in the South Humber with heavy industrial users and transport hubs across the whole of the Midlands, eventually connecting to low carbon hydrogen production in the North West.

For power generation

- To convert power stations in our region to hydrogen blends and on to pure hydrogen. This includes working with gas turbine providers to ensure fully warrantied retrofitting of existing gas turbines that dispatch power to both local industrial power consumers and to the grid. It also includes updating former coal fired power station sites as green growth regeneration projects.

For heat applications

- To provide UK government with evidence to ensure confidence in hydrogen-ready boilers as a valid pathway for decarbonising heat and to then progress heat decarbonisation at scale through establishing hydrogen neighbours, villages and towns in our region.

For transport applications

- To achieve a roll out of hydrogen-fuelled vehicles in fleet applications including taxis, city buses and trucks.
- To develop a region-wide network of hydrogen refuelling stations (HRS), supporting both return-to-depot fleet operations and providing the publicly accessible HRS needed to support long-haul trucking logistics and passenger cars.
- To move from rail freight feasibility studies to conversion of freight facilities in our region to hydrogen operations.
- To support the development and validation of hydrogen technologies in passenger rail services, including for branch lines via heavy rail retrofit and through very light rail systems for new as well as existing routes.
- To align regional capabilities and supply chains for vehicle electrification and connected automated mobility with our hydrogen technologies capabilities, gaining a leadership position in connected automated hydrogen mobility.
- To build on existing world-class research capabilities in the Midlands by scaling up facilities and expertise to support innovation and skills development. This includes support for the new National Centre for the Decarbonisation of Heat and the Very Light Rail National Innovation Centre.

For sector coupling

- To develop hydrogen energy hubs, which leverage co-location of power, heat and transport applications, at key new development and regeneration locations in our region, including the planned Freeports.

For industrialisation

- To establish Gigawatt scale fuel cell and hydrogen storage vessel manufacturing in the Midlands.

- To further develop manufacturing supply chains in our region for automotive, aerospace and rail applications of hydrogen technologies, at Tier 1, 2 and 3 levels.
- To support the repurposing of existing internal combustion engine, gas turbine retrofit and boiler manufacture in our region, to hydrogen-ready.

In support of innovation, supply chain and skills development

- To build on existing world-class research capabilities by scaling up facilities and expertise, supporting innovation and skills development in heat (including the National Centre for the Decarbonisation of Heat), power and transport (including the Very Light Rail National Innovation Centre).
- To engage SMEs in our region to appreciate and act on the opportunities offered by hydrogen technologies.
- To establish the valley as a centre of excellence for the development of technologies for small-scale fuel cells for portable and relocatable power, as well as for drones and robotics.
- To develop regional expertise in whole-life management of hydrogen technologies, from cradle to grave consistent with circular economy principles and emphasising skills development for the service, maintenance, reuse and recycling of hydrogen technologies assets.
- To adopt hydrogen technologies skills training in apprenticeship academies across the Midlands and continue producing graduates and postgraduates with key enabling skills through Centres for Doctoral Training and related energy skills initiatives.
- To attract overseas companies to invest in technical centres and factories, as well as sales and after-sales service and maintenance facilities.

PARTNERSHIP ACTIONS

In creating this Hydrogen Technologies Strategy, our partners have collaborated and shared insights to recommend ten clear actions with the potential to deliver the highest levels of impact, in job creation, CO₂ reduction and economic growth. Together, with aligned effort and investment, we will deliver on these actions, to capitalise on the unique manufacturing strengths of the Midlands that will enable hydrogen technologies to power the lives of our communities, support accelerated business growth and contribute to the clean energy supply, and energy security, of the UK.

NATIONAL IMPACT	
1	<p>Work with government to advance the aims and actions outlined within the UK Hydrogen Strategy.</p> <p>The Midlands Engine partnership will work with key regional stakeholders and government to ensure strong regional engagement to inform national consultations and policy evolution which responds to the needs and opportunities of the Midlands. We will provide evidence-based input to policy development and target the industrialisation of hydrogen technologies, playing to our region's strengths in advanced engineering and manufacturing.</p>
REGIONAL IMPACT	
2	<p>Establish a Midlands Engine Hydrogen Network to actively enable and champion delivery of the Midlands Engine Hydrogen Technologies Strategy.</p> <p>The Network will comprise industry and academic leaders and enabling partners who will actively enable delivery of this strategy, monitor our contribution towards the UK Hydrogen Strategy and work with the Midlands Engine Energy Workforce lead to ensure the skills agenda for green growth develops with centres of excellence in hydrogen technologies. The Network will lead on responsibility for evolving our strategy in line with technical, policy and market developments over time.</p>
3	<p>Complete and publish in-depth, interactive mapping of our region's hydrogen technologies capabilities to support promotion of a Midlands strategic investment portfolio, including pipeline projects which advance the Hydrogen Technologies Valley.</p> <p>This must be informed by value chain opportunities for our region and by sharing knowledge and identifying gaps where growth, investment and developments will be beneficial. The Midlands Engine will facilitate regional analysis and advocate for pan-regional priority areas.</p>
HYDROGEN PRODUCTION, STORAGE AND SUPPLY	
4	<p>Enable analysis and underpinning research to map then foster regional supply chains for technologies and services, to facilitate opportunities in the growth areas of hydrogen production, storage and supply assets as a driver of high-value, high-skilled jobs and economic growth.</p> <p>The Midlands Engine partnership will support research and lead on collaborative initiatives together with partners to advance the cost-effective supply of low carbon hydrogen, at scale, to dispersed energy users across our region.</p>

5	<p>Convene regional partner expertise and advocate for interventions and policies which drive innovation in hydrogen technologies for production, storage and supply.</p> <p>The Midlands Engine partnership is committed to driving forward innovations in regional hydrogen production, storage and supply and will actively contribute to opportunities such as the UK Hydrogen Technology Research and Innovation roadmap, which the government has tasked the Hydrogen Advisory Council Research and Innovation Working Group to develop.</p>
POWER GENERATION, HEAT & DECARBONISING INDUSTRY	
6	<p>Actively draw together and share learnings from industrial decarbonisation, heat and power exemplar projects between stakeholders across the region and nationally.</p> <p>This will enable the Midlands Engine partnership and government stakeholders to identify opportunities linked to hydrogen technologies and where scale up potential exists for the deployment of hydrogen technologies as a route to decarbonisation. Work would aim to address the pathways from 'first-of-a-kind' to replication.</p>
7	<p>Work actively to advance the application and subsequent scale up of hydrogen technologies to decarbonise power and heat supply to energy-intensive industrial clusters, as well as commercial and domestic buildings.</p> <p>Midlands Engine will convene expert partners across our region to highlight technical evidence and advocate for evidence-led investment, responding for instance to the consultation process laid out in the government's Hydrogen Strategy, notably related to the Net Zero Hydrogen Fund and the consultations that will inform policy for the decarbonisation of heat.</p>
HYDROGEN FOR TRANSPORT	
8	<p>Work with partners to bring forward proposals and share knowledge gathered through research and feasibility studies to accelerate exemplar projects for hydrogen and fuel cell mobility technologies across the broad range of transport applications.</p> <p>The Midlands Engine will pursue an active agenda of developing collaborations that foster a partnership approach to transport exemplar projects. Early opportunities for hydrogen vehicle fleets include: regional bus projects, in response to the government's Zero Emission Bus Regional Areas (ZEBRA) funding; a truck logistics demonstrator, informed by the H2GVMids feasibility study; and hydrogen-fuelled refuse collection vehicles.</p>
9	<p>Take forward research to identify and highlight supply chain, job creation and economic growth opportunities that leverage the vast hydrogen technologies and advanced engineering capabilities in our region.</p> <p>Working with the Midlands Engine Observatory, bespoke research will be commissioned to support sector growth and development which will include specific opportunities for the Midlands Engine transport equipment manufacturing sector.</p>
10	<p>Monitor, evaluate and report on the impact of this Hydrogen Technologies Strategy, including the revision of planned actions over time where development or new focus areas are identified as opportunities.</p> <p>Midlands Engine will prepare a Hydrogen Technologies Scorecard through which to baseline and then monitor and report on changes and advancements in the sector, through the life of this strategy.</p>

IMPACT OF OUR ACTIONS ON UK NET ZERO

Published in November 2020, the UK government's Ten Point Plan for a Green Industrial Revolution identified green growth as a central element of efforts to build back better in the aftermath of Covid-19.¹ The growth of low carbon hydrogen is one of the ten points in that plan, targeting 5GW of low carbon hydrogen production in the UK and supporting 8,000 hydrogen technologies jobs by 2030.

In August 2021, the government published its Hydrogen Strategy². Together with the Transport Decarbonisation Plan published in July 2021³ and the Heat and Buildings Strategy published in October 2021⁴, these documents set out government aspirations for green growth, including the role seen for hydrogen across application areas. They help illustrate where hydrogen technologies can support sector decarbonisation (particularly those hard-to-electrify sectors) alongside alternative technologies,

including battery electric vehicles in transport and heat pumps in buildings.

The national Hydrogen Strategy emphasises keeping options open, nurturing UK capabilities and technological expertise, learning by doing and evidence-based policy development in the period to 2030, preparing for scaling up beyond 2030. It acknowledges that the UK's existing hydrogen research base is strong and has tasked the Hydrogen Advisory Council Research and Innovation Working Group to develop a UK Hydrogen Technology Research and Innovation Roadmap. It also includes a commitment to build a world-class supply chain, with input from the UK Energy Supply Chain Task Force.

The Midlands Engine partnership strongly supports the UK Government's approach and we have sought to reflect its strategic aims and actions within this Hydrogen Technologies Strategy.

HOW THE MIDLANDS ENGINE CAN AND WILL SUPPORT NATIONAL AND INTERNATIONAL NEEDS

National and international needs	Midlands Engine leadership & capacity
Strong policy support for hydrogen is required as part of a holistic approach to meeting the challenge of tackling climate change while realising green growth opportunities.	The Ten Point Plan for Green Growth and the linked Midlands Engine Hydrogen Technologies Strategy will help support regional delivery of UK national policy aims.
Further capability development for both technology providers and end users is necessary for the application of hydrogen technologies. This requires learning by doing through first-of-a-kind demonstration followed by replication and industrialisation at scale.	Through Midlands Engine partner capabilities linked to facilities and expertise, our region is well placed to progress exemplar projects for hydrogen technologies that support the critical capability development phase ahead of industrialisation.
Ongoing product development and investment in manufacturing scale-up are required to establish a vibrant and globally competitive supply chain for hydrogen technologies.	Midlands Engine partners can leverage significant existing industrial and academic expertise in advanced engineering and manufacturing to develop hydrogen technologies and build supporting local supply chains.

¹ UK Government, 'The Ten Point Plan for a Green Industrial Revolution', pg.4 [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf (Accessed: August 2021)

² UK Government, 'UK Hydrogen Strategy', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf (Accessed: August 2021)

³ Department for Transport, 'Decarbonising Transport: A Better, Greener Britain', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf (Accessed: August 2021)

⁴ UK Government, 'Heat and Buildings Strategy', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1032119/heat-buildings-strategy.pdf (Accessed: October 2021)

IMPACT OF OUR ACTIONS ON OUR REGION

The impact of the activity identified in this strategy on the people, places and businesses in the Midlands will be significant. Not only will it support the UK in the shift to a hydrogen economy and meeting net zero ambitions, but it will also support levelling up and the closing of our regional productivity gap, increasing prosperity for our communities and enabling economic growth at scale.

The Midlands is a region of innovation and enterprise - the largest regional economy outside of London. But underinvestment over time - in our infrastructure, in R&D, in finance for growth and more, means our true economic potential and the prosperity of our communities is not being realised. Midlands Engine partners recognise that levelling up in the Midlands and positive long-term change, growing opportunities for today's and future generations, can be achieved through collective, planned actions by regional partners, if enabled alongside long-term investment by government.

Our partners at WSP Consulting have assessed the impact of this strategy in terms of:

- Delivering the **net zero** target by 2041
- Closing the £76bn **regional productivity gap** via boosting our employment and business base
- Supporting the **levelling up agenda** by delivery of activity aligned to the UN Sustainable Development Goals.

Within this context, it is estimated that partners' actions which will be driven forward from this strategy have the potential to deliver:

PEOPLE



167,000
NEW OR
SAFEGUARDED JOBS

PLACES






£10bn GVA

PROSPERITY



29% CO₂
REDUCTION
=17 MILLION TONNES

Focus area	Jobs creation	Carbon impact	Economic impact (GVA)
 1. PRODUCTION, STORAGE & SUPPLY	85,800	21% CO ₂ reduction against current levels = 12.2m tonnes per year	£6,729 million
 2. POWER GENERATION, HEAT & DECARBONISATION OF INDUSTRY	14,107	21% CO ₂ reduction against current levels = 12.2m tonnes per year	£1,044 million
 3. HYDROGEN FOR TRANSPORT	67,334	8% CO ₂ reduction against current levels = 4.6m tonnes per year	£2,135 million

Source all: WSP, (2021), 'Impact Piece Calculations: Midlands Engine Hydrogen Technologies Strategy', [report prepared for Midlands Engine].

NEXT STEPS TO MOBILISE AND DELIVER

In creating this Hydrogen Technologies Strategy, Midlands Engine partners have generously given their time to share insights into our region's strengths - in terms of existing capacity and expertise, key challenges and opportunities, and the relevant actions we can and should progress for the benefit of our region. There is a strong shared desire to leverage the low carbon hydrogen technologies opportunity to create and safeguard jobs, boost economic growth and protect the environment.

The Ten Point Plan for Green Growth in the Midlands Engine includes two sets of actions for low carbon hydrogen:

- Establish a Midlands Engine Hydrogen Network and develop this Hydrogen Technologies Strategy with input from Midlands Engine partners
- Advocate for a major hydrogen freight and logistics demonstrator linked to our region's two Freeports

Significant progress against these actions has already been made, demonstrating hugely valued partner support for collaborative regional activity. Our partners' appetite for collaboration to promote our region's hydrogen technologies capabilities is exemplified by H2GVMids which is preparing the ground for a green-hydrogen fuelled 44-tonne truck demonstration programme in the Midlands⁶.

H2GVMids was developed in spring 2021 by the Energy Research Accelerator, with support from EDF Energy, Cenex and Midlands Engine. Working alongside industry partners such as Arcola Energy, Toyota, Intelligent Energy and ITM Motive, the consortium bid successfully for over £500,000 of funding from the Department for Transport's Zero Emission Road Freight Trials programme.

Starting in July 2021, the year-long project involving 18 organisations is developing all the elements necessary for a regional hydrogen logistics ecosystem. This includes developing the technical specification and operational requirements for a 44-tonne hydrogen fuel cell HGV, mapping potential sites for hydrogen refuelling infrastructure, developing the business case and establishing a trial lease system for truck operators. The consortium will begin to deliver its findings in 2022 and the expectation is that its outputs will be used to develop a much larger regional hydrogen logistics programme for the future.

The Ten Point Plan for Green Growth goes much wider than low carbon hydrogen, to include: place-related plans for green buildings and net zero transport; energy-related plans for clean energy and smart energy; and crucial enablers encompassing green innovation, the energy workforce and green finance. This strategy seeks to identify synergies between all elements of the Ten Point Plan as they relate to low carbon hydrogen and the opportunities offered by hydrogen technologies in heat, power and transport.

⁶ Energy Research Accelerator, 'Midlands Bid Secures Funding for Hydrogen Powered HGVs', [online]. Available at <https://www.era.ac.uk/News-and-blogs/midlands-bid-secures-funding-for-hydrogen-powered-hgvs/274351> (Accessed: August 2021)

This strategy provides a unified vision and action plan that will enable Midlands Engine partners to work together to:

- Leverage the wealth of existing capabilities and activities of Midlands Engine partners
- Capitalise on the exceptional range of opportunities offered by hydrogen technologies for regional economic and environmental benefit

We recognise the critical role played by the UK Hydrogen Task Force in providing the insights and evidence base that underpins the UK Government's Hydrogen Strategy, as well as the governance role the Hydrogen Advisory Council will play in overseeing implementation of the strategy. For this reason, the Midlands Engine partnership has committed in our Ten Point Plan for Green Growth to establish our own Midlands Engine Hydrogen Network.

Our Network will comprise organisations with sector-based expertise reflecting the key areas, themes and opportunities identified in this strategy and will:

- Oversee and enable delivery of the Midlands Engine Hydrogen Technologies Strategy
- Act as a vehicle through which actions can be tracked and partner progress fed back
- Support the work of the Midlands Engine Green Growth Board as a call-off panel of experts

A unified pan-regional vision and strategy for realising the potential of Midlands hydrogen technologies, achieving net zero and leveraging exceptional low carbon opportunities for our economy and our environment.

July 2021



COLLABORATE & CREATE

The Hydrogen Technologies Strategy preliminary document is created with partner input

October - November 2021 December 2021 onwards



CONSULT & FINALISE

Stakeholders are given the opportunity to provide further input into the final Hydrogen Technologies Strategy



PUBLISH & PROMOTE

The Hydrogen Technologies Strategy is launched publicly to media, parliamentarians and other regional stakeholders



ACT & ACCELERATE

We will be successful through our collective effort, with each partner working to their own strengths, supporting and complementing each other to add value.

TEN POINT PLAN FOR GREEN GROWTH IN THE MIDLANDS ENGINE

Point five of our Ten Point Plan for Green Growth sets out our partnership ambitions and consensus around low carbon hydrogen, with a key action to develop this Hydrogen Technologies Strategy.



LOW CARBON HYDROGEN

Pioneer, commercialise and deliver hydrogen solutions

Thanks to exceptional business, industry and academic innovation, the Midlands is already pioneering next generation, cost-effective hydrogen technologies, with powerful potential to scale up. A pan regional hydrogen task force will ensure that the Midlands Engine capitalises on the opportunities presented by hydrogen, playing a national leadership role in decarbonising transport, logistics and heating, creating jobs and accelerating net zero UK.

AIMS

- ✓ **Reduce greenhouse gas emissions**
- ✓ **Capitalise on regional, world-leading hydrogen expertise**
- ✓ **Reduce energy costs and imports**
- ✓ **Improve energy security**
- ✓ **Create high-value jobs**
- ✓ **Increase public and private investment opportunities**
- ✓ **Strengthen regional leadership in transport, logistics and heating sectors**

PIONEER, COMMERCIALISE AND DELIVER HYDROGEN TECHNOLOGIES

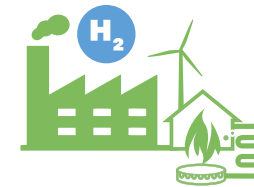
Together, we will identify and advance opportunities for pioneering, commercialising and delivering hydrogen technologies in three key areas, as outlined in the rest of this strategy and as identified in the UK government Hydrogen Strategy.



1. PRODUCTION, STORAGE AND SUPPLY

There is a fundamental need to develop domestic hydrogen production rather than relying on imports, based on both green hydrogen (generated from renewable electricity) and blue hydrogen (derived from steam methane reforming of natural gas in combination with carbon capture, usage and storage).

Initiatives supporting the development of low carbon hydrogen production include the launch of a £240 million Net Zero Hydrogen Fund in 2022⁷ for co-investment in early hydrogen production projects. In addition, a consultation on a Hydrogen Business Model⁸ will provide longer-term revenue support to hydrogen producers to overcome the cost gap between low carbon hydrogen and higher carbon alternatives.



2. POWER GENERATION, HEAT AND DECARBONISING INDUSTRY

Decarbonisation of industrial processes is anticipated to be a lead sector for hydrogen demonstration projects. Consequently, hydrogen industrial decarbonisation initiatives already underway, such as the £315 million Industrial Energy Transformation Fund⁹, will be joined by a new £55 million Industrial Fuel Switching competition¹⁰ to develop and demonstrate innovative solutions for industry to switch to low carbon fuels such as hydrogen.

The potential for hydrogen to decarbonise heat for domestic homes is also recognised and a timetable for safety testing and policy review has been proposed by government.



3. HYDROGEN FOR TRANSPORT

Hydrogen is viewed as the most viable decarbonisation option for heavy duty transport in cases where battery electric operation is not practical. Competitions to investigate and compare hydrogen and other low carbon options in buses, HGVs and shipping are underway. The government Hydrogen Strategy notes that hydrogen could play a role in rail where electrification is not cost-effective and, in the longer term, in decarbonising aviation¹¹.

⁷ Department for Business, Energy & Industrial Strategy, 'Designing the Net Zero Hydrogen Fund - Consultation', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011468/Designing_the_Net_Zero_Hydrogen_Fund.pdf [Accessed: September 2021]

⁸ Department for Business, Energy & Industrial Strategy, 'Low Carbon Hydrogen Business Model: consultation on a business model for low carbon hydrogen', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011469/Consultation_on_a_business_model_for_low_carbon_hydrogen.pdf [Accessed: September 2021]

⁹ Department for Business, Energy & Industrial Strategy, 'Industrial Energy Transformation Fund', [online]. Available at <https://www.gov.uk/government/collections/industrial-energy-transformation-fund> [Accessed September 2021]

¹⁰ Department for Business, Energy & Industrial Strategy, 'Apply for the Industrial Fuel Switching competition', [online]. Available at <https://www.gov.uk/government/publications/industrial-fuel-switching-competition> [Accessed: September 2021]

¹¹ 'UK Hydrogen Strategy', pg. 64

1 HYDROGEN PRODUCTION, STORAGE AND SUPPLY

Hydrogen is set to play a central role in the net zero transition. UK Government analysis suggests 250-460TWh of hydrogen could be needed in 2050, making up 20-35% of UK final energy consumption¹². For the Midlands, partners have identified opportunities for hydrogen technologies associated with low carbon hydrogen production, storage and supply.



OPPORTUNITY & REGIONAL ASSETS

The government has set a target of 5GW of low carbon hydrogen production capacity by 2030¹³. The government's Hydrogen Strategy has a twin track approach to low carbon hydrogen production, supporting both electrolytic green hydrogen and blue hydrogen derived from natural gas in combination with carbon capture, usage and storage (CCUS). The government strategy also notes the need to foster new novel pathways for producing hydrogen through research and innovation¹⁴.

Midlands Engine partners are developing the technologies to enable the production, storage and distribution of low carbon hydrogen in our region - essential for connecting supply with demand.

► Green hydrogen production

Electrolyser technology offers a means of harnessing renewable or other low carbon electricity to split water into hydrogen and oxygen. As well as supporting decarbonisation, electrolyzers can be installed on customer sites and are modular, so they can be sized to meet current demand. Electrolyzers also produce high purity hydrogen at fuel cell grade. They are being deployed both within industrial processes and at hydrogen refuelling stations, where high purity hydrogen is valued.

Both the University of Nottingham and Tyseley Energy Park have collaborated with Sheffield-based ITM Power to set up electrolyzers for hydrogen refuelling station (HRS) operations for transport applications in our region.

In support of the Midlands Engine Hydrogen Technologies Valley, the ex-coal-fired power stations along the Trent Valley provide excellent electricity grid access needed for importing renewable electricity, and water from the River Trent can be converted to green hydrogen by electrolysis.

Additional projects planned for the region include the Bilsthorpe hydrogen energy project, where a 1.25 MW electrolyser will use green electricity from an onsite solar farm, and the Gigastack project at Immingham, where a large-scale electrolyser will use offshore wind to provide green hydrogen to the Phillips 66 refinery.

Another pathway to low carbon hydrogen is to pair small modular nuclear reactors with electrolyzers. The development of this scale of nuclear reactor has been prioritised within the UK government's Ten Point Plan for a Green Industrial Revolution³ and the Midlands hosts relevant expertise in nuclear through Rolls-Royce and a branch of the Nuclear Advanced Manufacturing Research Centre, both located in Derby.

► Blue hydrogen production at scale

Midlands Engine partner organisations are actively collaborating in the Humber Zero project, which is targeting large-scale hydrogen generation to decarbonise industrial processes on the Humber Estuary. The Delphynus project is another example of a GW-scale blue hydrogen production project under development. These projects will use natural gas from the North Sea with CO₂ emissions captured at source and then directed to storage in depleted gas wells off the North Sea coast.

► Novel means of producing low carbon hydrogen

Low carbon hydrogen can be produced from biomass, or from fossil fuels but using novel chemical processes.

Severn Trent Water and Coventry University have a project to capture ammonia from wastewater as a pathway to hydrogen. Also, Kew Technology has developed novel thermal conversion technology that can convert non-recyclable resources and low-grade biomass into hydrogen. Loughborough University is studying hydrogen generation from methane cracking as an alternative to steam methane reforming, with the benefit that this captures solid carbon. Meanwhile, Aston University and University of Birmingham have research expertise in hydrogen production from different types of biomass including using waste materials from food production. This expertise has been developed concurrently with successful Centres

for Doctoral Training (CDTs), with highly skilled post-graduates going on to work within the UK hydrogen community.

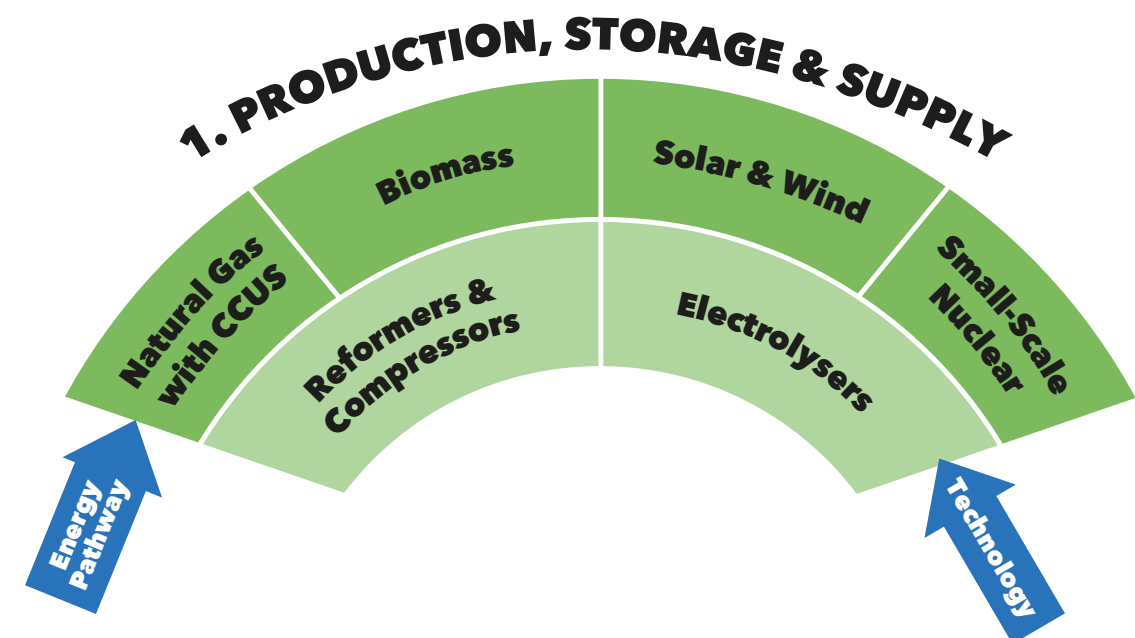
► Hydrogen storage at a national scale

Our region contains significant underground gas storage assets - operating, proposed and potential. Oil and gas fields nearing depletion onshore in the region, as well as salt cavern deposits, could be re-used for gas storage. The total volume of storage potential needs to be assessed but represents a national scale storage potential.

Nottingham-based Luxfer Gas Cylinders is a leading developer of hydrogen storage cylinders. whilst novel metal hydride storage material research is ongoing in region, with University of Birmingham having longstanding expertise in this area. Storage technologies are expected to play a significant role in aiding the above ground distributed storage of hydrogen.

► Future deployment of hydrogen pipelines

Currently, hydrogen is either produced onsite, where it is consumed, or at centralised facilities and then transported by road or rail in gaseous or liquefied form. As supply and demand scale, the business case for hydrogen pipeline networks becomes increasingly attractive. Cadent Gas and National Grid are studying the options for a UK network of hydrogen pipelines, including in the Midlands.



¹² UK Hydrogen Strategy, pg. 9 | ¹³ UK Hydrogen Strategy, pg. 2 | ¹⁴ UK Hydrogen Strategy, pg. 10

SUCCESS FACTORS

TECHNOLOGY ENABLERS	REGIONAL PROGRESS	PARTNERSHIP PROSPECTS
Low carbon hydrogen supply capabilities at scale.	Midlands Engine partners are active in the Humber Zero project, which will be a key exemplar for blue hydrogen production. Cadent Gas is conducting a feasibility study planning on gas transmission for hydrogen blends and dedicated hydrogen pipeline investments in the late 2020s.	Midlands Engine partnership collaboration and co-investment can drive forward the economies of scale needed for low cost hydrogen supply through industrial-scale blue and green hydrogen production and pipeline distribution. Partners have expertise in novel means of producing hydrogen that can be advanced through ongoing R&D.
Dispersed green hydrogen supply based on green electricity from renewables.	Midlands Engine partner projects to-date include the electrolyser deployment at Tyseley Energy Park and plans for the Featherstone House Farm electrolyser in Bilsthorpe. Energy Capital is assessing opportunities for electrolyser-based HRS as part of an Infrastructure for Zero Emission Vehicles (IZEV) Strategy for the West Midlands.	Onsite hydrogen production via electrolyser projects offers a key means to decarbonise transport and energy hubs across the region. The central location (in the UK) of the Midlands as a transport corridor points toward the scale of the green hydrogen opportunity once hydrogen transport takes off.

IMPACT POTENTIAL

Focus area	Jobs creation	Carbon impact	Economic impact (GVA)
GREEN HYDROGEN PRODUCTION	➤ 1,588 ➤	[captured within distribution network emissions]	➤ £103 million ➤
BLUE HYDROGEN PRODUCTION	➤ 73,420 ➤	[captured within distribution network emissions]	➤ £5938 million ➤
CONVERSION - DISTRIBUTION NETWORK	➤ 9,570 ➤	21% CO ₂ reduction against current emissions = 12.2m tonnes per year	➤ £615 million ➤
CONVERSION - TRANSMISSION NETWORK	➤ 436 ➤	0.04% CO ₂ reduction against current emissions = 34,478 tonnes per year	➤ £28 million ➤
STORAGE	➤ 687 ➤	N/A	➤ £45 million ➤

WSP (2021), 'Impact Piece Calculations'

CASE STUDIES

TYSELEY ENERGY PARK

Tyseley Energy Park hosts the UK's largest hydrogen refuelling station, opened in 2021. Fed by a 3 MW ITM Power electrolyser, it is capable of refuelling 50 buses with plans for scaling up by a factor of ten-fold. The first customers of the Tyseley Park hydrogen refuelling station will be Birmingham City Council's 20 hydrogen buses purchased as part of the Council's Clean Air Hydrogen Bus Pilot.



Image credit: ITM Power and Tyseley Energy Park

"Tyseley Energy Park (TEP) is committed to delivering low and zero carbon power, transport, heat, waste and recycling solutions for a greener, cleaner, healthier Birmingham. Since 2015 we have been working with ITM power and Birmingham City Council to deliver a hydrogen refuelling facility on TEP."

David Horsfall, Director of Property, Tyseley Energy Park

CADENT GAS

Cadent Gas manages natural gas distribution assets in the Midlands. As well as anticipating the opportunity offered by low carbon hydrogen to help decarbonise heat, Cadent Gas has been studying the feasibility of establishing a new dedicated pipeline to distribute hydrogen produced in and out of our region to consumers in the East Midlands. Cadent Gas has also started planning the connection of a hydrogen network through the West Midlands, linking to their HyNet North West Network.



Image credit: Cadent Gas

"As our feasibility study for an East Midlands Hydrogen Pipeline Network draws to a successful conclusion, we are looking to the next stage of development. This work will involve engaging with heavy transport and industrial gas users that need hydrogen to decarbonise and creating a series of engineering designs that identify the optimal pipeline routing to meet their needs."

Sally Brewis, Head of Regional Development, East and London, Cadent Gas

SUSTAINABLE HYDROGEN CENTRE FOR DOCTORAL TRAINING

The EPSRC Sustainable Hydrogen Centre for Doctoral Training (CDT) is a collaboration between the universities of Nottingham, Loughborough, Birmingham and Ulster. It aims to deliver 67 industry-ready doctoral students in five cohorts with a comprehensive skill set and experiences. The research themes for the students are production, storage, distribution and systems integration. Industry partners include Arcola Energy, BP, Bosch, Intelligent Energy, ITM Power and Shell.



Image credit: Centre for Doctoral Training

"It's an exciting time to be researching hydrogen technologies as we work to address big changes in the energy system over the next five to ten years. By training the next generation of hydrogen research leaders we will deliver such world-leading technologies into the energy system and help secure the UK's low-carbon economy."

Professor Gavin Walker, CDT Director, Nottingham University

2 POWER GENERATION, HEAT AND DECARBONISING INDUSTRY

The UK government's Hydrogen Strategy states that domestic hydrogen demand, initially led by the need to decarbonise industrial processes, could reach 38TWh by 2030, not including use of hydrogen for blending into the gas grid. This has the potential to rise rapidly to 55-165TWh by 2035 depending on the level of deployment of hydrogen technologies in heating, power generation and transport¹⁶.



OPPORTUNITY & REGIONAL ASSETS

The national Industrial Decarbonisation Strategy sets out a minimum target of 20TWh per year of fossil fuel use to be replaced with low carbon alternatives by 2030¹⁷. Hydrogen is expected to play a role in decarbonising power and heat demand for energy intensive industrial manufacturing processes, as a key component of the transition to net zero.

The UK power sector needs to decarbonise by 2035 if the 2050 net zero target is to be reached.¹⁸ Low carbon hydrogen can play two key roles in this transition: by offering flexible generation ('gas to power') when combusted in a turbine; or by system flexibility ('power to gas') using excess renewable electricity to generate hydrogen for later use in other sectors.

Heating comprises 74% of building emissions in the UK.¹⁹ The government's Hydrogen Strategy outlines a route map to hydrogen use in decarbonising heat, including consulting on the feasibility and timescales to be able to introduce a 20% blend of hydrogen into the gas distribution network. Further pilot projects are planned, including a hydrogen neighbourhood demonstrator by 2023 and a large hydrogen village demonstrator by 2025.²⁰

Midlands Engine partners have phenomenal skills and products to exploit these opportunities through our Hydrogen Technologies Valley that will connect innovation, investment and infrastructure.

► Hydrogen for power generation

The Midlands has historically depended on large coal and gas fired power plants that have fed electricity directly into the high voltage distribution network. Midlands Engine partners are actively pursuing the repurposing of these sites to hydrogen power to provide low carbon electricity supply, alongside renewables, to remain in step with the government's net zero ambitions.

Power generators exploring the potential of hydrogen for gas turbine operation in our region include SSE, Uniper and Neptune Energy. The power plant at Keadby in North Lincolnshire, will be one of the UK's first to run on 100% blue hydrogen.

The conversion of power plants to low carbon hydrogen both safeguards jobs at power plants whilst creating jobs in the hydrogen technologies supply chain. As an example, Siemens Energy's Gas Turbine business, based in Lincolnshire, is leading development of gas turbines to run on blends of hydrogen and natural gas commencing at < 10% and moving to 10-30% and on to 100% hydrogen.

► Hydrogen for decarbonisation of heat

Baxi and Worcester Bosch are industrialising hydrogen technologies for home boilers, developing boilers based on either gas burning or fuel cell technologies for pure hydrogen and blends of hydrogen and natural gas. Over 24 million UK homes currently have a gas boiler which is typically replaced every ten years.²¹ Trials have shown that modest changes are needed to switch boilers to blends of natural gas and hydrogen and on to 100% hydrogen.²²

Both Baxi and Worcester Bosch have committed to make hydrogen-ready boiler technology available for commercial deployment from 2026, should the UK government give hydrogen boilers the green light. Cadent Gas's current upgrading of its Midlands gas network from iron to polyethylene pipes will be complete in 2032, removing a barrier to hydrogen use in the gas grid.

► Hydrogen for decarbonising industry

The government's net zero ambitions cannot be achieved without decarbonising energy-intensive industry, including the manufacturing sector. This is particularly important for the Midlands which is the UK's manufacturing heartland, accounting for 21% of UK manufacturers, 22% of UK exports and generating £36 billion in annual GVA.²⁴

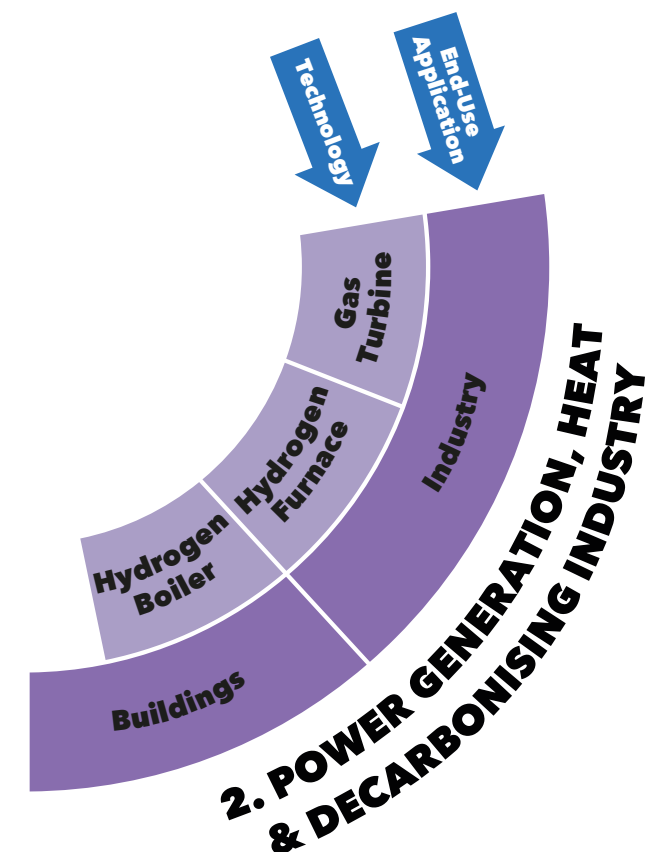
Midlands Engine partners are active in two key government-backed projects that are advancing the decarbonisation of industrial clusters. In the east of our region, the Humber Zero and Humber Industrial Decarbonisation Roadmap projects have brought together industry from the Humber and North Lincolnshire region to establish an energy estuary. In the West of the region, the Repowering the Black Country programme is seeking to directly address the challenge of establishing mini-clusters of zero carbon industry across the region in multiple industrial sectors.

► Portable and relocatable power

Both Adelan and Intelligent Energy have demonstrated small-scale (c1 kW to 15kW) portable and relocatable power generation using fuel cell systems with the capability to supply to global markets.

► Skills development to help support an expanded use of hydrogen

The transitioning of power generation, heat and industrial processes to hydrogen technologies will create a need for skilled engineers and technicians able to design, develop, build, operate, service and maintain hydrogen assets. The Midlands has academies, including the Uniper Academy at Ratcliffe-on-Soar and training colleges, as well as university-led initiatives, that can help train a skilled workforce needed to accelerate the transition to hydrogen technologies.



¹⁶ UK Hydrogen Strategy, pg. 51

¹⁷ UK Government, 'Industrial Decarbonisation Strategy', pg.19 [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf (Accessed: August 2021)

¹⁸ UK Government, 'Energy White Paper', [online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf (Accessed: August 2021)

¹⁹ National Statistics (2020), 'Households projections for England', Table 401 and Department for Business, Energy and Industrial Strategy (2020), 'Non-domestic National Energy Efficiency Data Framework' based on 2018 data (viewed October 2021)

²⁰ UK Hydrogen Strategy, pg. 7

²¹ Department for Business, Energy & Industrial Strategy, 'Sub-national estimates of properties not connected to the gas network 2015-2019', [online]. Available at: <https://www.gov.uk/government/statistics/sub-national-estimates-of-households-not-connected-to-the-gas-network> (Accessed August 2021)

²² The Worcester prototype H2 Ready boilers involve 3 inexpensive components and an hour of an engineer's time.

²³ Midlands Engine, 'Midlands Engine Makes: The Home of British Manufacturing', pg.2 [online]. Available at <https://www.midlandsengine.org/wp-content/uploads/Midlands-Engine-Makes-Brochure.pdf> [Accessed: September 2021]

SUCCESS FACTORS

TECHNOLOGY ENABLERS	REGIONAL PROGRESS	PARTNERSHIP PROSPECTS
Power generation		
Large-scale power plant conversion to hydrogen operation.	Uniper is working with gas turbine developers in our region to ensure warranted turbine conversions. Proposals for hydrogen power plants are progressing.	There is interest across the Midlands Engine partnership to transition legacy power station sites along the region's high voltage valley.
Hydrogen technologies for portable and relocatable power to help substitute for diesel generator sets.	Both Adelan and Intelligent Energy are pioneering the development of small-scale fuel cells for portable and back-up power systems.	The Midlands Engine has centre of excellence expertise in small-scale fuel cell systems that can be further developed through academic and industrial collaboration.
Heat		
Evidence of the safety of hydrogen boilers in the home, commercial building stock and factories.	Partners have played a key role in technology demonstration projects, including HyDeploy at Keele University. Baxi and Worcester Bosch report having the technical know-how to commercialise hydrogen-ready boilers and Cadent Gas the expertise and assets to transition gas networks to blends and set up dedicated hydrogen pipeline supply.	The proposed National Centre for the Decarbonisation of Heat in our region will pursue a wide-ranging research agenda to aid evidence-based policy for hydrogen for heat. Being among the market leaders in boiler supply in the UK, Baxi and Worcester Bosch can lead on the transition to hydrogen-ready boiler supply.
Industrial decarbonisation		
Integration of hydrogen heat and power assets into facilities within industrial clusters.	The Midlands Engine has a cohort of partners with an active interest in assessing the opportunities for decarbonising industrial processes. Current study work can lay the foundations for an ambitious scale up of industrial decarbonisation.	The Midlands is the heartland of UK manufacturing and hydrogen can play a critical role in helping manufacturers transition to net zero.

IMPACT POTENTIAL

Focus area	Jobs creation		Carbon impact	Economic impact (GVA)	
POWER GENERATION	>	1,588	>	[captured within distribution network emissions]	> £103 million
HYDROGEN DECARBONISATION OF HEAT	>	73,420	>	[captured within distribution network emissions]	> £5938 million
HYDROGEN DECARBONISING INDUSTRY	>	9,570	>	21% CO ₂ reduction against current emissions = 12.2m tonnes per year	> £615 million

WSP (2021), 'Impact Piece Calculations'

CASE STUDIES

WORCESTER BOSCH

Based in the Midlands, Worcester Bosch is the UK market leader in domestic boilers. Over the last few years, the organisation has been developing boilers able to run flexibly on natural gas, pure hydrogen, as well blends of natural gas and hydrogen. This means that in future, those that have 'hydrogen-ready' boilers can simply convert to hydrogen operation without the need for an entirely new heating system.



Image credit: Worcester Bosch

"The development of hydrogen-fired boilers will mean millions of existing heating systems in our homes can be saved, rather than the entire system needing to be replaced."

Martyn Bridges, Director of Technical Communication and Product Management, Worcester Bosch

SIEMENS ENERGY

Siemens Energy has leading expertise in a broad range of hydrogen production and distribution technologies. It makes large-scale electrolyzers for industrial complexes and is one of Europe's leading suppliers of gas turbines for power generation. Additionally, Siemens Energy is a major supplier of compressor technology for gas distribution pipelines. With operations in Lincolnshire, Siemens Energy has expert resource in the Midlands to aid the transition of assets to hydrogen operation.

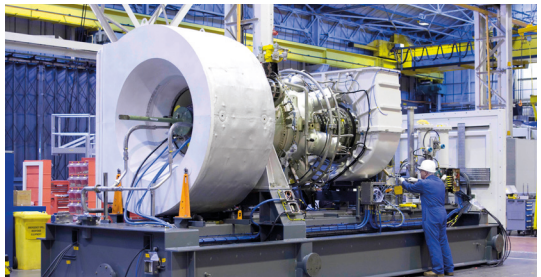


Image credit: Siemens Energy

"Low carbon hydrogen will be an essential part of delivering the UK's commitment to net zero. The potential for an integrated hydrogen economy that helps decarbonise energy, transport and industry sectors is enormous. Businesses across the Midlands are already working on a range of hydrogen topics but to reach ambitious net-zero targets we need more businesses to work together to innovate and disrupt. This strategy throws a spotlight on some of those companies paving the way and sets the direction for many more to get involved."

Steve Scrimshaw, Vice President, Siemens Energy

HYDEPLOY AT KEELE

The pioneering HyDeploy project, blending hydrogen into a natural gas network to heat homes and buildings in a bid to reduce carbon emissions, was successfully completed on the Keele University campus this year, proving that hydrogen can be blended at up to 20% volume with no adverse effects for users. Backed by Ofgem's Network Innovation Competition, the project was led by Cadent Gas, in partnership with Northern Gas Networks, Keele University and a consortium of technical experts.



Image credit: Keele University

"We're delighted to have been a partner in the landmark HyDeploy project and to have been able to use the Keele University campus for the first UK trial to blend hydrogen into the existing natural gas network. Blending hydrogen offers the potential of very significantly carbon emission associated with domestic and business gas use as part of the UK's ambitions to become Net Zero."

Professor Mark Ormerod, Deputy Vice Chancellor and Institutional Lead for Sustainability

3 HYDROGEN FOR TRANSPORT

The UK government's Transport Decarbonisation Plan identifies that whilst battery electric vehicles are well placed to decarbonise cars and light duty vehicles, hydrogen technologies offer better duty low carbon options for energy-intensive urban mobility applications including taxis, buses, trucks, construction equipment, trains, shipping and aviation.²⁵

The Midlands is the heart of the UK's transport equipment manufacturing sector, with regional capabilities extending from automotive to rail and aerospace. This sector is embracing decarbonisation through electrification and hydrogen technologies.



OPPORTUNITY & REGIONAL ASSETS

By 2050, hydrogen could fuel over 20% of road vehicles and, given its potential for use in heavier vehicles, cut over a third of road emissions. In non-road segments, 20% of passenger ships, 20% of non-electrified trains and significant numbers of aeroplanes could be powered by hydrogen or hydrogen-derived fuels²⁶. In road transport alone, vehicle and infrastructure manufacturing could create or protect almost 8,500 jobs, generating over £1.5 billion GVA by 2035.²⁷

► Decarbonising heavy goods vehicles

Our region hosts 35% of all warehouse space in the country - more than twice that of London, Scotland and Wales combined²⁸. The importance of the Midlands in UK logistics has encouraged Midlands Engine partners to come together to form the H2GVMids consortium, to study the feasibility and benefits offered by hydrogen truck logistics for the region.

Among the other truck applications, FAUN Zoeller is aiming to deploy its Bluepower hydrogen trucks into waste collection demonstration projects in our region, while Dennis Eagle has provided a donor vehicle

to Arcola Energy for a prototype hydrogen fuel cell Refuse Collection Vehicle.

► Refuelling infrastructure needs for logistics

Diesel-fuelled road freight vehicles account for 21% of all road vehicle emissions in the Midlands.²⁹ Providing an alternative fuelling network for logistics operators will be a key element of the transition to a net zero future. Partners including Midlands Connect and the H2GVMids consortia are studying the options for hydrogen refuelling to support a switch to hydrogen-fuelled trucks for logistics in region. Additional opportunities are expected for hydrogen-fuelled forklifts once logistics operations begin switching from diesel to hydrogen.

► Hydrogen and zero carbon construction

JCB is leading the application of hydrogen fuel cell technology to construction equipment, running internal testing on options including a 20 tonne digger. In addition, JCB is developing hydrogen internal combustion engine technology for its plant portfolio which, as well as producing no tailpipe CO₂ emissions, claims lower NOx emissions than diesel equivalents. A first prototype 3 tonne backhoe loader is now being tested.

► Supplying hydrogen technologies to the passenger vehicle sector

Jaguar Land Rover is developing a hydrogen-fuel-cell-powered Defender as part of its efforts to decarbonise the SUV market, with first prototypes to be road tested in 2022.

Intelligent Energy has worked with Suzuki to develop a fuel cell scooter which was trialled in London by the Metropolitan Police.

HORIBA MIRA has ambitions to be a sandbox location for the development and testing of hydrogen technologies, including working with Midlands universities to aid clients to improve fuel cell performance, durability, recyclability and help cut costs.

In collaboration with FEV, Coventry University runs a Centre for Advanced Low Carbon Propulsion Systems (C-ALPS) for zero-carbon propulsion system test and development. The university has secured funding for a hydrogen fuel cell test laboratory as well as an upgrade of its powertrain cells to add hydrogen fuelling.

► Hydrogen technologies for rail

The University of Birmingham has supported Porterbrook to develop the UK's first hydrogen-powered train, whilst the Black Country Innovative Manufacturing Organisation is currently setting up the UK's first Very Light Rail National Innovation Centre with hydrogen technologies being among its low-cost rail solutions.

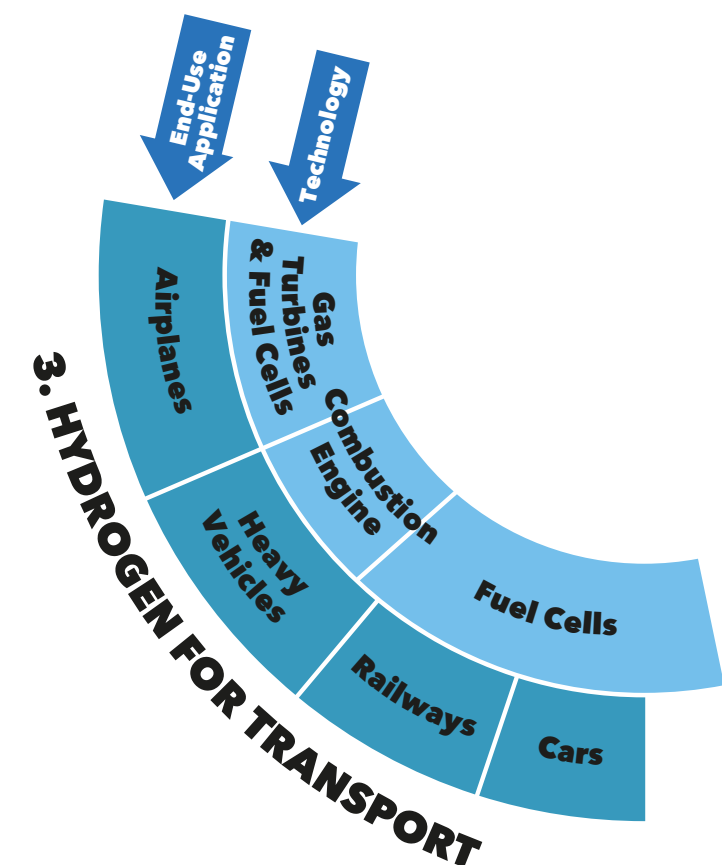
45% of UK rail freight and 33% of UK heavy road freight goes to, from or through the Midlands³⁰. Hydrogen technologies offer an alternative to overhead electrification for these operations with the University of Nottingham assessing options for hydrogen-fuelled rail freight operations within the East Midlands Hydrogen Innovation Zone.

► Hydrogen technologies for aviation

Hydrogen is expected to account for 40% of aviation fuels in future scenarios³¹. Intelligent Energy is developing fuel cell modules for use in drones and for light commercial aircraft, while the University of Nottingham is supporting research on hydrogen use in support of aerospace companies.

► Midlands Engine as an early market for hydrogen mobility solutions

The Birmingham Clean Air Hydrogen Bus Pilot provides an exemplar for hydrogen-fuelled city bus operation that can be replicated in other locations in the region. Similarly, the fuel-cell-powered Toyota Mirai has been deployed in taxi operations and as police vehicles in the UK and Europe, and Toyota is working with organisations in region to deploy these vehicles in fleets.



²⁵ 'Decarbonising Transport: A Better, Greener Britain'

²⁶ Hydrogen Council, 'Hydrogen - Scaling Up', 2017, pg.8 [online]. Available at: https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-Scaling-up_Hydrogen-Council_2017.compressed.pdf (Accessed: August 2021)

²⁷ Hydrogen Task Force, 'Economic Impact Assessment', [online]. Available at: <https://www.hydrogentaskforce.co.uk/wp-content/uploads/2020/08/6-EIA-report.pdf> (Accessed: August 2021)

²⁸ UKWA, 'The size and make up of the UK warehousing sector', 2021, pg. 5 [online]. Available at: <https://www.ukwa.org.uk/wp-content/uploads/2021/05/Savills-UKWA-A4-8pp-Report-Interactive3.pdf> (Accessed September 2021)

²⁹ Midlands Connect, 'Insights: What does the Transport Decarbonisation Plan mean for the future of freight?', 2021 [online]. Available at: <https://www.midlandsconnect.uk/news/insights-what-does-the-transport-decarbonisation-plan-mean-for-the-future-of-freight/> (Accessed September 2021)

³⁰ Department for International Trade, 'The Midlands Engine: A Financial Centre of Excellence', 2019. Available at: <https://www.midlandsengine.org/wp-content/uploads/Financial-Centre-of-Excellence.pdf> (Accessed: October 2021)

³¹ Clean Sky 2 JU & Fuel Cells and Hydrogen 2 JU, 'Hydrogen-powered aviation A fact-based study of hydrogen technology, economics, and climate impact by 2050', 2020, pg.37 [online]. Available at: https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf (Accessed August 2021)

SUCCESS FACTORS		
TECHNOLOGY ENABLERS	REGIONAL PROGRESS	PARTNERSHIP PROSPECTS
Passenger cars, HGVs and rail		
OEM integration of fuel cell and hydrogen internal combustion engines into vehicles for mass market supply, notably for 'difficult to electrify' applications.	Intelligent Energy is developing modular fuel cell systems for city bus, truck and other HGV applications. JCB and JLR are developing prototypes to ensure in-house expertise in hydrogen technologies as an alternative to battery electrification. Partners have highlighted a shared interest in fleet opportunities for taxis, buses and refuse collection vehicles as well as prototypes for rail and aerospace.	The Midlands transport equipment manufacturing sector needs to transition to ultra low and net zero solutions to ensure its long-term sustainability. Advanced engineering expertise in auto, aero and rail can be coupled with hydrogen technologies expertise to ensure development and mass manufacture of hydrogen powertrains.

Focus area	Jobs creation	Carbon impact	Economic impact (GVA)
DECARBONISATION HGVs AND REFUELLING INFRA-STRUCTURE - SUPPLYING H2 TECHNOLOGIES TO THE PASSENGER VEHICLE SECTOR	62,105	N/A	£1750 million
DECARBONISATION HGVs AND REFUELLING INFRASTRUCTURE - REFUELLING INFRASTRUCTURE NEED FOR LOGISTICS	1,036	3% CO ₂ reduction against current emissions = 1.6m tonnes per year	£68 million
OTHER TRANSPORT APPLICATIONS - AVIATION FUELLING	1,693	2% CO ₂ reduction against current emissions = 1.2m tonnes per year	£110 million
HYDROGEN TECHNOLOGIES FOR RAIL	2,500	0.3% CO ₂ reduction against current emissions = 173,593 tonnes per year	£207 million
HYDROGEN AND ZERO CARBON CONSTRUCTION	N/A	3% CO ₂ reduction against current emissions = 1.6m tonnes per year	N/A

WSP (2021), 'Impact Piece Calculations'

CASE STUDIES

H2-GEAR

Intelligent Energy, a Loughborough-based fuel cell engineering company, has been selected to develop its leading lightweight fuel cell modules for aerospace as part of the H2GEAR programme. As well as developing the next generation of fuel cell technology, this programme supports the growth of manufacturing in the East Midlands. Intelligent Energy is planning to increase its manufacturing capability with a new state-of-the-art Gigafactory facility in the region, positioning the East Midlands as a centre for hydrogen fuel cell manufacturing in the UK.



Image credit: Intelligent Energy

"Having worked with Boeing to successfully demonstrate the world's first manned flight under fuel cell power in 2008, we are now developing our next generation fuel cell technology through the H2Gear programme to meet the future commercial needs of the aviation industry. We are also making great progress with fuel cell technology for UAV applications, helping our partners and customers realise many operational and commercial benefits which battery-based technology can't achieve."

Chris Dudfield, Chief Technology Officer, Intelligent Energy

HYDROFLEX

The University of Birmingham's Birmingham Centre for Railway Research and Education (BCRRE) has collaborated with Porterbrook to develop the UK's first hydrogen-powered train. The HydroFLEX project has showcased the integration of hydrogen fuel cell into a Class 319 train. The technologies and supply chain developed by HydroFLEX can help decarbonise routes such as branch and rural lines where full electrification of isn't economically viable.



Images © University of Birmingham
Credit: 'HydroFLEX, University of Birmingham & Porterbrook

"HydroFLEX is a great example of how we are pushing forward the application if hydrogen technologies in rail. HydroFLEX is the UK's first hydrogen train to travel on the mainline network and we have set the ambition to have a fleet of these by 2023 as operating passenger trains."

Dr Stuart Hillmansen, Reader in Railway Traction Systems, BCRRE

H2GVMids

After successfully securing funding from DfT's Zero Emission Freight programme in July, the H2GVMids Project is well underway. Among other things, the consortium-led feasibility study, headed by EDF Energy, and supported by Cenex, the Energy Research Accelerator, and the Midlands Engine, together with numerous other private and public sector partners, will provide a design for a 44t HGV, a plan for H2 refuelling station distribution, an evaluation of skills required to underpin H2 freight programmes and a Green Book-ready business case for a demonstrator.



HGV 2 MIDS
Creating a hydrogen fuelled HGV network for the Midlands and beyond

Image credit: Energy Research Accelerator

"Hydrogen is a key technology for decarbonising heavy duty transport and EDF is delighted to have joined with partners from across the Midlands to deliver this exciting project. As EDF's coal generation stations in the region reach the ends of their lives, we are excited to work to develop the zero carbon technologies of the future in the region."

Rebecca Rosling, Head of Smart Customers, EDF Energy



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