Lowering your emissions through innovation in transport and energy infrastructure

WMCA Hydrogen Policy Position Paper

February 2023

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EXECUTIVE SUMMARY

Cenex, supported by WSP, were commissioned by the West Midlands Combined Authority (WMCA) in November 2022 to produce a hydrogen policy positioning paper. The paper seeks to provide an independent and objective view as to the relevance of hydrogen to the WMCA region to help inform policy. To develop the paper, Cenex and WSP carried out stakeholder engagement across the region's energy and transport landscape and would like to thank all those organisations (listed in the Acknowledgement section below) who freely committed time to share their knowledge and insight.

The paper is structured to give the introductory context, detail national policy drivers and then uses information gained from a range of stakeholder sources to forecast hydrogen demand in the region and clarify the expected roles for hydrogen, by sector. Due to the complex and emerging nature of hydrogen as an energy carrier, a sensitivity analysis was carried out on the key challenges and opportunities for the region. By combining the stakeholder input and analysis, a set of top-level policy positions were developed and are summarised below.

Within the national policy context:

- The future hydrogen economy opportunity is intrinsically linked to the energy transition needed to achieve Net Zero targets and therefore to both Net Zero and related energy policies.
- The context for investment in hydrogen is being driven by the policy driver of achieving Net Zero targets.
- The UK Government has set ambitious targets for hydrogen production and use, driven by demand forecast for industry, power generation and blending into the gas grid.
- Government policy aims to stimulate industry investment in hydrogen supply and demand.
- Local and regional strategies will be needed to help support the delivery of national strategy objectives.

Hydrogen offers a range of opportunities to WMCA:

- The WMCA region has a different starting point from other UK regions in that it has no established grey hydrogen economy supporting industry in region and is land locked away from coastal sites where blue and green hydrogen production is set to grow. This positions the WMCA region as a fast follower to other UK regions when it comes to hydrogen production and in application areas including for industry and buildings.
- As with the UK nationally, hydrogen can play a role in helping the WMCA achieve its Net Zero target by 2041 but a step behind those actions already planned and with hydrogen policy directed toward addressing "hard to electrify" applications.
- The Midlands is the UK heartland for advanced engineering and manufacturing. This position has been competitively maintained by the regions' strengths in innovation and the knowledge economy. These strengths position the region to benefit from opportunities to supply next generation hydrogen technologies to global markets.

Regarding potential hydrogen demand and timeline:

- The most significant demand for hydrogen in the region will be for long-range transport. There will be demand for hydrogen from industry and for potentially also for commercial and residential buildings. However, the decarbonisation of these sectors will be primarily via electrification, consistent with the WMCA Net Zero enhanced electrification scenario.
- The hydrogen economy in the region looks set to develop in earnest from 2030 onwards.

On the specific sectoral requirements:

- The timetable for decarbonisation of transport is being driven by national and international regulation specific to each sector.
- Battery electrification is considered the primary pathway for the decarbonisation of road vehicles to achieve Net Zero targets, with the focus of interest for hydrogen technologies being on transport applications that are considered “Hard to Electrify” using batteries.
- The largest demand for hydrogen is forecast for Heavy Goods Vehicles for long-haul trucks and this will need publicly accessible refuelling infrastructure to support development.
- Hydrogen is considered essential for the decarbonisation of certain hard to abate industrial processes which require high grade heat and cannot easily be electrified.
- Hydrogen has potential to provide heat for buildings. However, this would bring its own challenges and the hydrogen heating pathway needs national government approval.
- Due to current low gas demand for power generation in the region, hydrogen is not expected to play a significant role in future power generation.

Regarding hydrogen production, storage and distribution:

- Green hydrogen is the logical production choice for the West Midlands region.
- Even with in-region hydrogen production, a merchant market will be critical for a resilient hydrogen supply and a competitive market.
- Pipeline supply offers the most cost-effective means by which to distribute large quantities of hydrogen over long distances. Projects are under development for pipeline supply with the potential to connect to the West Midlands, in the 2030 to 2035 timeframe but this will depend on identifying appropriate demand to justify the investment costs involved.
- To ensure energy system resilience, consideration will need to given to hydrogen storage. The expectation is that the WMCA will be dependent on seasonal storage assets in other regions.
- Blending may help shorten the timescales for hydrogen introduction in region for use in industry and buildings with some short term decarbonisation benefits but cannot wholly decarbonise sectors and would need to be an interim step ahead of 100% green hydrogen use to meet Net Zero aims.
- There will be synergies and co-location benefits when it comes to hydrogen supply and demand. However differing hydrogen purity requirements may impact local distribution operations.

Following a sensitivity analysis, fourteen specific challenges and opportunities facing the region were identified:

Challenges	Opportunities
1. Complexity and safety 2. The skills challenge 3. Consenting for hydrogen investments 4. National government policy uncertainty 5. Market uncertainty at a regional level 6. Energy system constraints 7. Fitting new infrastructure investments into business service continuity 8. The need for a Just Transition to Net Zero 9. Disruption to the general public	10. Manufacturing capability 11. Skills and training capability 12. Inward investment 13. Regional coordination capability 14. Mayoral leadership and profile

Categorising the potential roles of WMCA as Delivery (D), Enabling (E) or Influencing (I), a set of recommended activities are proposed to tackle the previously discussed challenges while maximising identified opportunities.

WMCA activity	WMCA Role
Skills for market development Help set up familiarisation and training programmes for hydrogen production, distribution, storage and use; open to a broad range of stakeholders for differing learning objectives. This can include leveraging "show and tell" at facilities including the Tyseley Energy Park.	D, E, I
Skills for supply chain development Help set up SME training related to hydrogen technology opportunities working with organisations in region including WMG, MTC, the Black Country Innovative Manufacturing Organisation, Made in the Midlands, Make UK, HyDex and others	D, E, I
Awareness raising for market development Assist WMCA members and other stakeholders to better understand the business case for hydrogen vehicle operation, alongside battery electric operation, as an aid to technology agnostic transitioning to Net Zero. Hydrogen vehicles and HRS deployed in public service can provide exemplars for private sector fleets to follow. Explore the options for a network of HRS in prime locations (central Birmingham, Birmingham Airport, central Coventry, the new HS2 station, etc) to support hydrogen coaches and long-distance city bus operations. Establish a HGV Task Force, building on the work of the H2GVMids consortium, to help plan for the hydrogen HGV-related opportunities for decarbonisation and supply chain development.	E, I
Awareness raising for hydrogen matching hydrogen supply and demand Commission spatial analysis study work to identify candidate locations for hydrogen refuelling infrastructure and industrial supply including candidate Net Zero Hubs. This will draw on prior work conducted by Midlands Connect and by the H2GVMids consortium for transport demand and the Repowering the Black Country consortium for industry demand, as well as National Grid Energy Distribution's electrical capacity planning. Socialising this analysis can help encourage industry investment.	E, I
Addressing uncertainties and complexities around hydrogen for heat Following national government decisions on the role of hydrogen in heating, commission a study to better understand the housing types and economically viable locations for the use of hydrogen boilers for heating alongside insulation, heat pumps and solar PV across the regional housing stock.	D
Inward investment Work with West Midlands Growth Company and key stakeholders in region to develop an inward investment proposition focused around the strengths and opportunities in region.	D

The paper also completes economic modelling on the proposed policy interventions to estimate costs, jobs protected and created, and GVA.

ACKNOWLEDGEMENTS

The authors would like to thank the following organisations for their assistance and contributions.

BOC, Cadent Gas, Camirus, Energy Capital, the Energy Research Accelerator, Guidehouse, HORIBA, National Express, the Road Haulage Association and Transport for West Midlands.

INTRODUCTION AND POLICY CONTEXT

Hydrogen is a versatile energy vector, able to act as an energy store and a means to transfer energy (energy carrier = fuel) and harness that energy, using hydrogen technologies, to do useful work – providing power and heat to end users. Along with electricity, it is considered one of the main substitution options to replace fossil fuel use to help decarbonise energy.

An industrial hydrogen economy, involving onsite or local hydrogen production, already exists supporting specific industry sectors including petroleum refining, chemical manufacturing and steel making. However, the "future hydrogen economy" proposition is one where hydrogen enables a radical transitioning of current energy use in industry, buildings and transport away from oil and gas to hydrogen. This transition requires investment in new and repurposing of existing energy production, distribution and storage assets, alongside the deployment of hydrogen technologies in consumers' homes and workplaces.

This policy paper seeks to provide an independent and objective view as to relevance of hydrogen to the West Midlands Combined Authority region to help inform policy.

NATIONAL POLICY BACKGROUND AND APPROACH

The future hydrogen economy opportunity is intrinsically linked to the energy transition needed to achieve Net Zero targets and therefore to both Net Zero and related energy policies.

The context for investment in hydrogen is being driven by the policy driver of achieving Net Zero targets.

The work of the Climate Change Committee (CCC) positions hydrogen as an attractive option for the sectors considered "hard to abate" by other pathways. The CCC foresees hydrogen having a critical role to play in decarbonising industry, back-up power generation, Heavy Goods Vehicles and Rail. [1]

The UK Government has set ambitious targets for hydrogen production and use, driven by demand forecast for industry, power generation and blending into the gas grid.

The UK Government has set a target of 10GW for installed hydrogen production capacity by 2030, based on both blue and green hydrogen.

The 10 GW of supply draws on the UK Hydrogen Task Force Central scenario, which forecasts 76 TWh of hydrogen demand in the UK, with a split of 46% for industry, 29% for blending, 16% for power generation, 5% for transport and 4% for other applications.

Blending refers to the addition of hydrogen into natural gas supply for use in heat and power generation.

Hydrogen industry stakeholders are looking to policy makers for consensus on key elements of the roadmap to a hydrogen economy to help de-risk investments.

These include:

- Pricing support mechanisms for hydrogen production and other fiscal policies that can help ensure the decarbonisation benefits of hydrogen are valued.
- Timetables for regulatory changes that can open-up hydrogen markets as in the case of the approval of the blending of hydrogen into the gas distribution network; or give increased

certainty as to the market requirements, as with the phase out of internal combustion engine vehicles.

Government policy aims to stimulate industry investment in hydrogen supply and demand.

The UK Government's Hydrogen Strategy is supported by strategies designed to address the policy barriers to hydrogen on a sector-by-sector basis, thereby helping de-risk industry investment in the building blocks needed for a hydrogen economy. In return for policy support the Government is looking to industry to invest in the critical enabling building blocks required for a hydrogen economy, which include:

- deployment of the industrial equipment needed to produce green and blue hydrogen, along with the storage and pipeline distribution of this hydrogen to businesses and consumers across the UK.
- development and manufacture of hydrogen technologies for transport, heat and power applications and the marketing of these products to end users.

Local and regional strategies will be needed to help support the delivery of national strategy objectives.

The emerging policy framework for hydrogen in the UK has been developed through consultation between Government and industry and has, and will, remain subject to expert scrutiny. The policy framework combines an aspirational and target-based approach with measures that can help address barriers and make informed policy choices within sectors.

The national policy framework, as it currently stands, does not set regional targets. Nor does it devolve delivery responsibilities to local Government. However, industry is looking to regional bodies for support with their localised investments, recognising that some regions are better placed to contribute than others. Options for policy support by the WMCA and its stakeholders will be explored in this policy paper.

WHAT DOES HYDROGEN OFFER THE WMCA REGION?

Hydrogen is a "new fuel - new opportunity" for the WMCA region.

A review of national, regional and devolved administrations' hydrogen policies and initiatives show 3 key overarching themes driving interest in the transition to a hydrogen economy. These are:

- decarbonisation
- industrial transformation
- environmental protection

For the West Midlands, all three of these drivers are in play.

This hydrogen policy position for the WMCA region seeks to recognise those opportunity areas of greatest relevance to the region but also recognises the role the region can play in supporting other regional and national objectives and that gaps can best be addressed by a collaborative approach.

As with the UK nationally, hydrogen can play a role in helping the WMCA achieve its Net Zero target by 2041 but a step behind those actions already planned and with hydrogen policy directed toward addressing "hard to electrify" applications within a WMCA regional context.

The WMCA has prioritised decarbonisation through its 2041 Net Zero Strategy and the opportunities offered by hydrogen will be explored with this strategy as the driver.

As a landlocked region, the WMCA does not currently benefit from easy access to blue hydrogen, or to green energy from curtailed offshore wind electricity. Therefore, WMCA strategy is to prioritise use of electrical energy, as opposed to converting electrical energy to hydrogen energy, prior to end use. This document refers to this as the enhanced electrification scenario.

To achieve Net Zero targets the WMCA needs to decarbonise energy use. A breakdown of current energy usage in WMCA is detailed in Figure 1 [2], with a breakdown of CO_2 emissions estimates shown in Figure 2 [3].

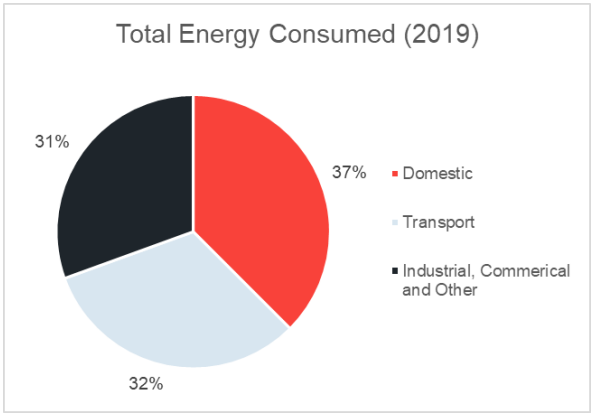

Figure 1: Total energy consumed in WMCA 7 LAs [2]

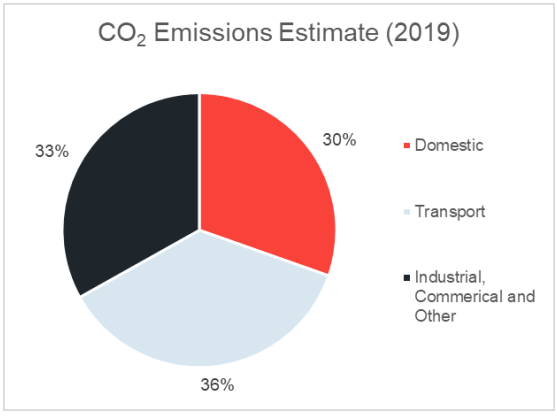

Figure 2: CO_2 emissions estimate in WMCA 7 LAs [3]

Under the enhanced electrification scenario within the Net Zero Strategy, progress toward Net Zero can be achieved by leveraging green electricity supply from renewables and distributing this for use in the electrification of transport, buildings and industry in region.

The key policies by sector include:

Transport	Supporting the uptake of battery electric vehicles to replace fossil-fuel burning Internal Combustion Engine vehicles on West Midlands roads
Industry	Creation of Zero Carbon Hubs to increase resource and energy efficiency, followed by electrification where possible.
Buildings	Improving the insultation of housing and commercial buildings in region, adding rooftop solar PV and switching from gas boiler use to heat pumps powered by green electricity

The role of hydrogen in the first 5-year plan (2021 – 2026) [4] is limited to a supporting role for bus decarbonisation. However, consistent with the emerging themes within national policy, the expectation is that hydrogen will play an increasing role in each of the subsequent three 5-year plans through to 2041. Importantly, WMCA hydrogen policy can, and should, complement and build on the policy pathways that have been identified as key success factors for the Net Zero strategy.

This phasing will be illustrated in this policy paper.

Figure 3 demonstrates how much energy demand could move to either hydrogen or electricity in a highly electrified scenario, across the WMCA seven Local Authorities (LAs). Figure 3 is based on 2019 total final energy consumption data [2], and its purpose is to highlight the estimated, relatively small hydrogen demand compared to total energy consumption across the seven LAs. It does not account for any efficiency improvements (e.g. from improved building insulation) and is a snapshot based on scaling of 2019 data. This chart draws on data from the Leading the Way Scenario from Western Power Distribution Future Energy Scenarios (WPD FES) [5]. Figure 3 shows energy format at point of use (i.e. does not account for electrical energy which is required to generate hydrogen from electrolysis).

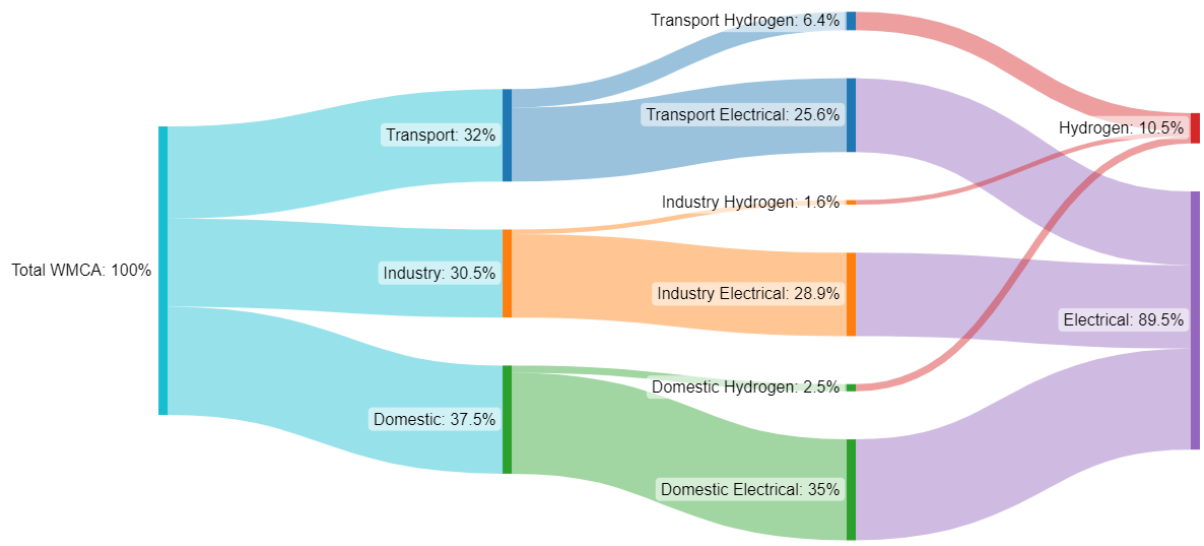

Figure 3: WMCA Energy Transition

The Midlands is the UK heartland for advanced engineering and manufacturing. This position has been competitively maintained by the regions' strengths in innovation and the knowledge economy. These strengths position the region to benefit from opportunities to supply next generation hydrogen technologies to global markets.

Across the UK, within the context of Net Zero, a key industrial transformation priority is to support energy intensive businesses to transition their operations away from their current reliance on fossil fuels to low carbon pathways including electrification and hydrogen. This is to safeguard economic activity and employment in these sectors.

An additional economic priority is to support businesses that will design, build, service and maintain the equipment and processes required for the transition to Net Zero.

As a follow on to the Midlands Engine Ten Point Plan for Green Growth [6], the Midlands Engine Hydrogen Technologies Strategy [7] highlighted the opportunity for the Midlands to leverage the region's advanced engineering and manufacturing expertise, directing this toward the development and manufacture of hydrogen technologies, amongst other net zero industries, as a means of delivering business and employment growth.

As an early mover to a hydrogen economy the UK can be a leader in the knowledge economy for hydrogen. Building on the track record of research expertise in Midlands' Universities and through

ongoing leadership by the Energy Research Accelerator, the Midlands can play an important supporting role in research and teaching related to the development and application of hydrogen technologies.

The environmental protection opportunities offered by hydrogen technologies are broader than just Net Zero.

Environmental protection aims include protecting against the adverse impacts of climate change, as well as improving air quality cutting other emissions and reducing waste by moving to a more circular economy. Hydrogen technologies can deliver either zero or ultra-low emissions when compared with the current burning of fossil fuels. Zero emission at the tailpipe has driven interest in fuel cell electric vehicles for transport applications given the need to cut oxides of nitrogen, particulate matter and other air pollutants, alongside greenhouse gases. By cutting pollutant emissions, the transition to hydrogen technologies can help improve air quality, thereby reducing adverse health effects for the general population, as well as reducing damage to biodiversity.

HYDROGEN DEMAND POTENTIAL IN REGION, BY APPLICATION AREA

The most significant demand for hydrogen in the region will be for transport. There will be demand for hydrogen from industry and for commercial and residential buildings, but the decarbonisation of these sectors will be primarily via electrification, consistent with the WMCA Net Zero enhanced electrification scenario.

To assist the estimation of hydrogen demand in the WMCA region, several stakeholders were engaged. The first key stakeholder was Cadent and the Hydrogen Valley project. A meeting with Cadent and their consultants Guidehouse was held to understand their methods to estimate demand. The methods used were logical and not unduly favourable to hydrogen. However, as this work is for a larger region, of which the WMCA 7 LAs form a small proportion, the model had not accounted for the planned high electrification route and improvements to insulation in homes which are detailed in the WMCA five-year plan.

To validate the initial estimates, WSP also took data from the Western Power Distribution (now National Grid Electricity Distribution) Future Energy Scenarios (NGED FES) [5]. In this report, the "Leading the Way" scenario appeared the most applicable to the WMCA region, as it focused on high electrification and insulation. Using this document to estimate proportions of homes which would move to electrified heating, a lower estimate of hydrogen demand for buildings was produced. It is notable that the NGED FES scenario is heavily dependent on abundant availability of renewables and sufficient electrical infrastructure, to deliver a highly electrified heating scenario.

The WMCA five-year plan is for 292,000 homes to be heat pump ready by 2026, and both the Hydrogen Valley and NGED FES modelling is in line with this. We have built in the expected insulation rates to the Hydrogen Valley modelling to estimate a rational future hydrogen demand, between the upper (Hydrogen Valley) and lower (NGED FES) estimates (these limits are shown in Figure 4).

Another key stakeholder was the Repowering the Black Country project. Repowering the Black Country is a programme of initiatives supporting Black Country businesses to take advantage of global clean growth opportunities and to make the transition to a net-zero industrial future. The project has engaged business leaders, government departments, MPs and Local Authorities across the Black

Country. The project has also completed modelling to estimate future hydrogen demand in both the Black Country and the WMCA 7 LAs, some of the outputs from that modelling have been shared with this project. The industrial demand for hydrogen is expected to be low due to the enhanced electrification scenario, but also due to the highly distributed nature of industry in the region.

Make UK completed a decarbonising manufacturing survey in July 2022. In this survey, 7% of respondents were considering the use of hydrogen for a decarbonisation pathway, compared to 42% who were looking towards electrification [8]. The Hydrogen Valley project also identifies a relatively low demand for hydrogen within the WMCA 7 LAs but does note the potential significant demand from the nearby Cemex plant at Rugby. Whilst this plant is out the WMCA 7 LAs, it represents a pull factor for hydrogen local to the region.

The demand assessment has been limited to within the WMCA 7 LAs and has been assessed with two approaches. The first approach has estimated how much natural gas can be moved to hydrogen by assessing proportions of high temperature process heating, low temperature process heating, space heating and others which could move to hydrogen in a highly electrified scenario. In the second approach, the focus was on the hard to abate sectors - here a factor was applied for the proportions which could move to hydrogen. This has provided an upper and lower limit for demand estimation for Industry, which can be found in Figure 4.

Transport demand has also been estimated. It is notable that due to the WMCAs geographic location, and its positioning as a national transport hub, the demand for hydrogen from transport is higher than that of industry and buildings. It is noted that fuel cell powered transport applications require a higher purity of hydrogen than for applications where hydrogen in burned and this is expected to result in a two-tier (by purity) distribution system developing.

The demand profile estimation from an enhanced electrification scenario within the WMCA 7 LAs is shown in Figure 4.

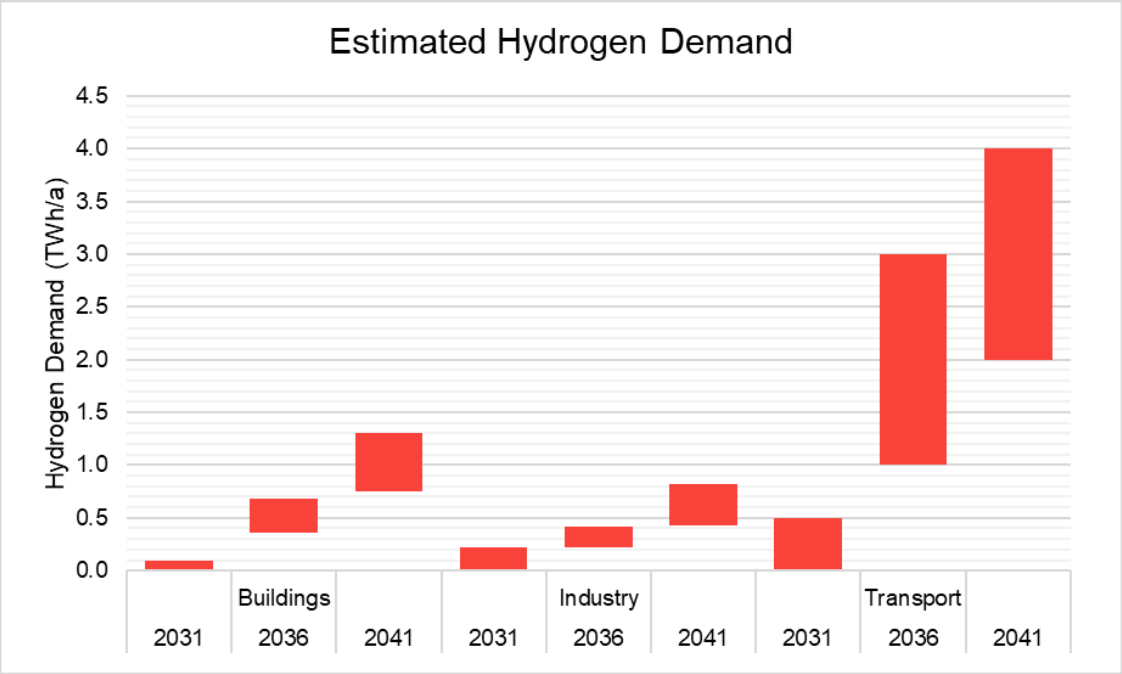

Figure 4: WMCA estimated future hydrogen demand across the 7 LAs with variation.

The estimated hydrogen demand without variation is shown in Figure 5.

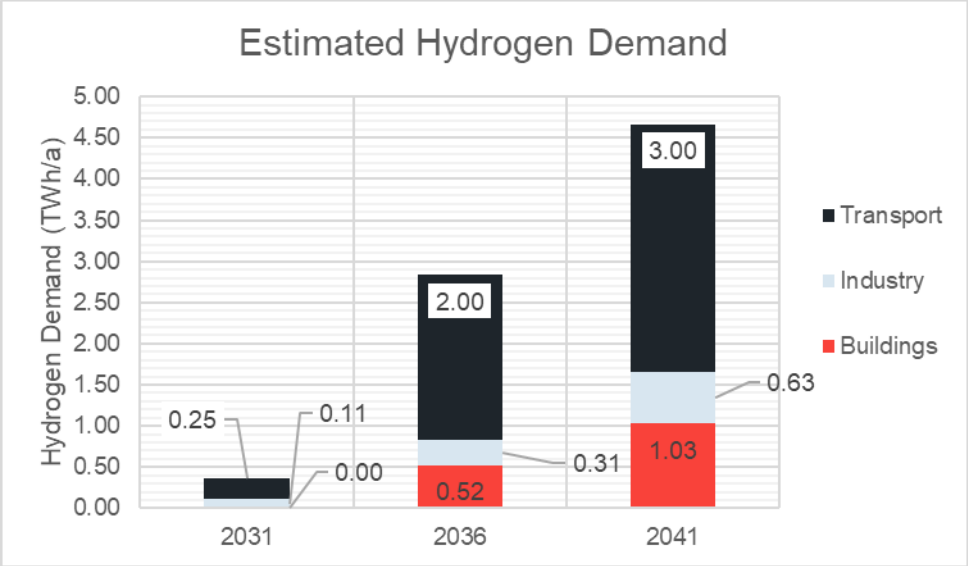

Figure 5: WMCA estimated future hydrogen demand across the 7 LAs.

HYDROGEN TIMELINE

The hydrogen economy in the region looks set to develop in earnest from 2030 onwards.

Figure 6 depicts a timeline for hydrogen with key timescales both in and out of region, with their applicability to each of the WMCA 5-year blocks leading up to 2041.

In terms of production, blue hydrogen is expected to be produced at scale, starting from the 2026 – 2031 block. This hydrogen will be produced out of region but will be available to WMCA, initially through the merchant market (via road tanker distribution) but by pipeline once a suitable distribution network is in place. For green hydrogen, initial commissioning of small-scale electrolysis plants is expected to meet demand during the 2026 – 2031 block. From 2031 onwards, it is expected that medium and large-scale green hydrogen production will take place either in region, or close to the boundary of the WMCA, to meet in-region demand.

Anticipated hydrogen demand across the Transport, Industry and Buildings sectors has been assessed in this report. It is expected that transport demand will begin towards the end of the 2021 – 2026 period. This will gradually increase through the following 5-year intervals. For buildings, there may be some small-scale early adoption up to 2031, but it only after this point that demand begins to increase. Industry behaves similarly, with small scale demand possible for early adopters prior to 2031. From 2031 onwards, demand is expected to increase, as hydrogen becomes more widely available as a fuel (government target of 10 GW production by 2030). Maturity of technology could also lead to less risk being associated with conversion to hydrogen once early adopters have provided confidence.

For transport of hydrogen, it is anticipated from discussions with the Hydrogen Valley project that there could be a piped hydrogen supply through the National Transmission System up to Rugby in 2032. This pipe would be dependent on a secure high demand from industrial users in that area, such as Cemex. The demand from Cemex could be in the order of 0.73 TWh/a, compared to the estimated 0.63 TWh/a for all industry in the WMCA 7 LAs . Whilst this pipe does not currently extend into the WMCA region, it provides a piped supply in close proximity to the region. Existing natural gas distribution networks could be repurposed from 2026 onwards, to support local hydrogen distribution

in the region. This also includes the possibility of new local distribution networks for hydrogen where specifically required.

Whilst there are no plans for in region storage of hydrogen at present, assessment of any requirements would likely take place from 2026 onwards, following output from national storage requirements assessments.

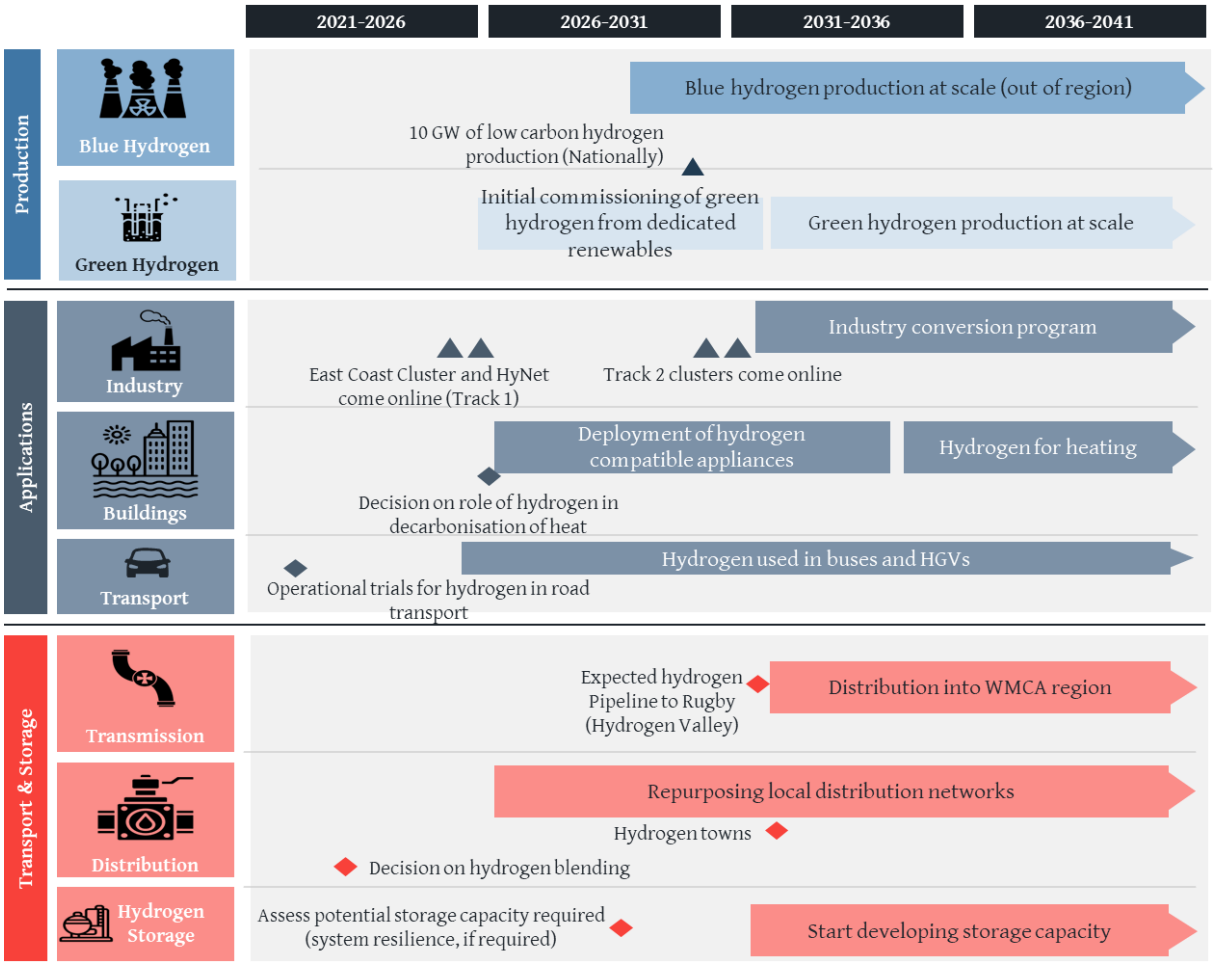

Figure 6: Hydrogen Timeline

SECTORAL DECARBONISATION APPLICABILITY

TRANSPORT

The timetable for decarbonisation of transport is being driven by national and international regulation specific to each sector.

The transport sector is broad in scope, covering a wide range of vehicle types, leading to sector-by-sector variation in the regulatory and market drivers. Road vehicles have had air pollutant emissions regulated in the UK from the late 1980s, with the emphasis on progressively tighter Euro standards for new vehicle models sold across Europe, with a time-table industry can work to. Interest to regulate to cut CO_2 emissions commenced in the late 2000s with the emphasis on transitioning to Net Zero in

this decade. For passenger cars and vans, as well as for trucks and buses, UK policy includes timetables for the phase out of fossil-fuel burning Internal Combustion Engines for new vehicle sales (from 2030 for cars through to 2040 for the heaviest categories of truck). For rail, UK policy is targeting the phase out of all diesel trains on UK passenger and freight routes by 2040. Other sectors are choosing to self-regulate, as in the case of Aviation. Construction equipment and other Non-Road Mobile Machinery (NRMM) including tractors are not yet regulated for CO_2 emissions.

Organisations targeting Net Zero need to address scope 1 emissions (from vehicles in their fleet), scope 2 (from energy used to refuel\recharge those vehicles) and scope 3 (the emissions from the services they procure, whether bus services, refuse collection or the logistics linked to material supply). Driving down scope 3 emissions will require a transition to Net Zero across transport as a whole.

Battery electrification is considered the primary pathway for the decarbonisation of road vehicles to achieve Net Zero targets, with the focus of interest for hydrogen technologies being on transport applications that are considered "hard to electrify" using batteries.

Figure 7 shows an anticipated market development roadmap for hydrogen in transport applications within the WMCA region. The roadmap takes into account stakeholder feedback by sector to capture how the dynamics and timescales for the transport applications differ. It also identifies the main pathway Net Zero where there is consensus, and the favoured option is to be confirmed (TBC). The key illustrates the anticipated market share of new vehicle sales (as opposed to the total vehicle parc) in the 5-year timescales of the WMCA Net Zero Strategy.

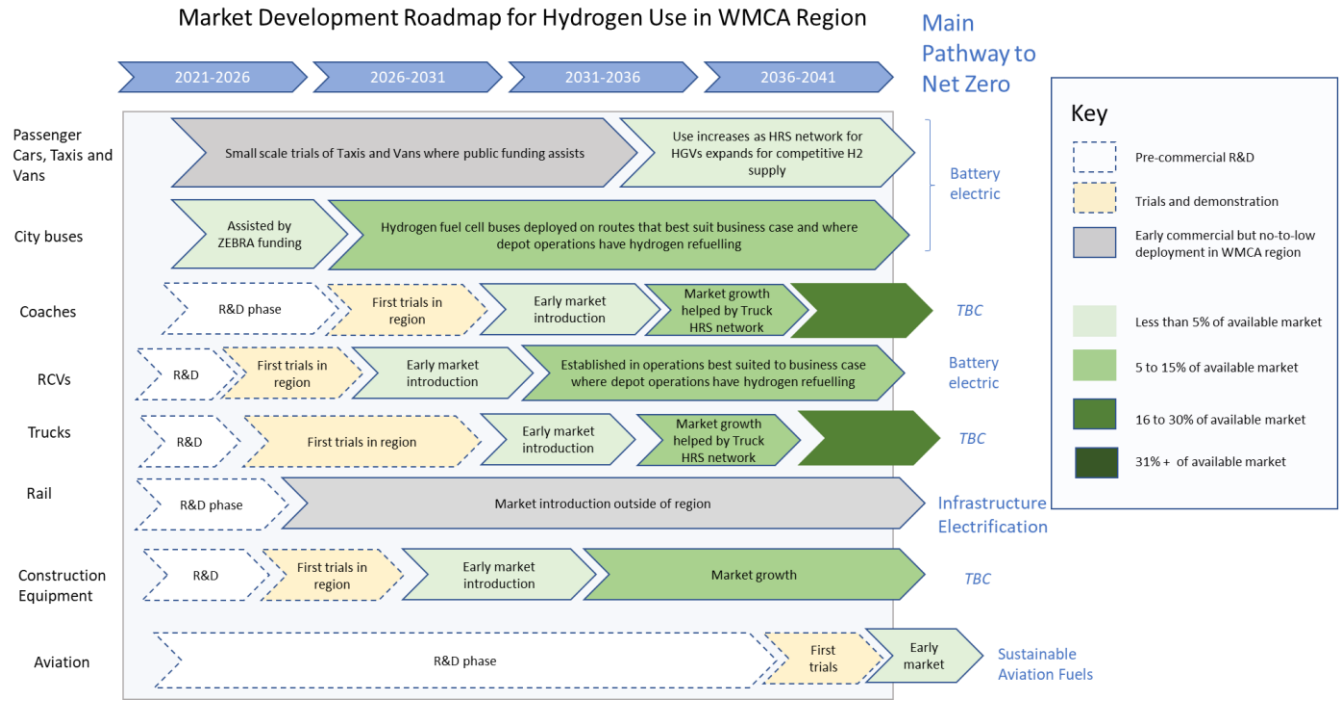

Figure 7: Market Development Roadmap for hydrogen in transport in the WMCA region.

Hydrogen demand for transport is expected to rise from 0.25 TWh/a of demand in 2031 to 2 TWh/a demand by 2036, with the main contributor to growth in this period being for trucks above 26 T. Of the 3 TWh/a demand by 2041, 2.5 TWh/a will be from trucks with the balance split between the other application areas with aviation having begun to contribute. These numbers are based on a mid-case

scenario with the anticipated upper and lower levels of demand shown in Figure 4, reflecting that there remains a good deal of uncertainty as to if and how the different markets will develop, reflecting key sensitivities including HRS roll out, hydrogen pricing, technical maturity and the performance and TCO of hydrogen technologies versus their competition.

The largest demand for hydrogen is forecast for Heavy Goods Vehicles for long-haul trucks and this will need publicly accessible refuelling infrastructure to support development

The WMCA is an important region for logistics in the UK and if hydrogen trucks can be commercialised for application in the UK market, hydrogen demand in region could quickly scale to over 2.5 TWh/a by 2041. The HRS network needed to support trucks for logistics has been forecast to be 6 stations in the WMCA region by 2030, rising to 55 by 2040.

Transport applications only expected to contribute a low level of hydrogen demand (when compared with trucks and aviation) in region include:

- Passenger Cars including Private Hire Taxi operations
- Vans and light trucks
- City buses and Refuse Collection Vehicles (RCVs)
- Coaches
- Construction equipment

In the case of cars, vans and trucks, the numbers of vehicles on the road are high but the market penetration of hydrogen is expected to be low. For those vehicles that do run on hydrogen, the consumption typically be a few kg of hydrogen per day. In the case of city buses, RCVs and construction equipment, the numbers of vehicles in region will be low (< 1000) but the hours of operation will be high. Given the weight of the vehicles and the work being done (RCVs including compaction of waste and construction equipment earth moving) the daily hydrogen consumption rates could be several tens of kg or higher, depending on the duty cycle.

The successful launch of hydrogen trucks in region will require supporting refuelling infrastructure leading to hydrogen supply. This is expected to see the hydrogen suppliers working with vehicle manufacturers on joint vehicle and refuelling propositions for fleet operations, particularly where depot sites aren't easily able to electrify, or HRS locations can be conveniently located to support fleets of more than one vehicle type.

The early deployment of fuel cell city buses in Birmingham will help build confidence for fleet in adopting hydrogen for RCV and truck operations but particularly also for coaches, where hydrogen operation can help achieve the high daily ranges and coaches will be able to utilise truck HRS dispenses at motorway locations.

Transport applications not expected to contribute to hydrogen demand in region include rail, as overhead electrification is the favoured primary pathway with battery electric solutions assisted by partial electrification applied on remaining track. This would be to support both passenger and freight services. This positions hydrogen as a back-up option if an electrification programme for the region doesn’t progress or is more limited in scope than currently expected.

INDUSTRY

Hydrogen is considered essential for the decarbonisation of certain hard to abate industrial processes which require high grade heat and cannot easily be electrified.

There will be a demand for hydrogen within the WMCA region, albeit a relatively low one.

The WMCA is an inland region, with a limited number of energy intensive industrial users, particularly within the Black Country area of the region. A large amount of research has been undertaken through the Repowering the Black Country project, which has created and assessed industrial decarbonisation scenarios for the Black Country.

Following feedback from regional businesses, Repowering the Black Country has focused on an enhanced electrification scenario, alongside the creation of Zero Carbon Hubs. Enhanced electrification will prioritise the electrification of energy over other vectors wherever possible. Given the inland location of the region, there is currently limited access to blue hydrogen or green hydrogen from curtailed offshore electricity. Therefore, priority has been given to electrical energy. This strategy is supported by the anticipated lower cost of electrical energy when compared to hydrogen. It is noted that it is not possible to electrify all energy vectors, particularly within certain sub-sectors.

Zero Carbon Hubs aim to take advantage of energy intensive businesses, by understanding how its decarbonisation strategy can impact adjacent operations. The focus is then on local renewable energy generation with consideration of scope to export excess energy to the surrounding industry within the hub.

Despite the energy demand reduction created through zero carbon hubs, and the enhanced electrification scenario, there is expected to be demand for hydrogen as industry within the WMCA decarbonises. Some sub-sectors within the region (Iron and Steel, Metals, Chemical and Cement) are expected to require hydrogen for high temperature processes, which cannot be electrified. There will therefore be a demand for hydrogen from industry.

COMMERCIAL AND DOMESTIC BUILDINGS

Hydrogen has potential to provide heat for buildings where electrification is challenging. The specific housing applications and timing for hydrogen heating remains dependant on national government decisions and economic viability.

The WMCA strategy for decarbonisation of buildings is detailed within the five-year plan [4] and focuses on improved energy efficiency to cut energy consumption, combined with electrification of power supply through roof-top solar and heat supply by heat pumps. This will be the primary pathway for achieving Net Zero targets. The use of hydrogen for heating could potentially provide an alternative option for buildings that are not suitable for electrification, or as an alternative decarbonised solution, should the policy or market conditions limit the ability of the enhanced electrification strategy to deliver a “just transition” for the housing and building stock in region.

Figure 7 and 8 Figure 7 7Figure 88 show the housing stock within the WMCA 7 LAs in terms of both age and type. With older homes typically being more challenging to insulate efficiently, and homes such as terraced being currently less suited to heat pumps, other means of heating (other than electrification) could be vital to the decarbonisation of the region. These means could be district heating, where appropriate, or hydrogen.

Despite electrification being the preferred route for decarbonisation of buildings, not all buildings may be suitable for this mechanism or the alternatives, and there could potentially be a demand for hydrogen for heating within the WMCA.

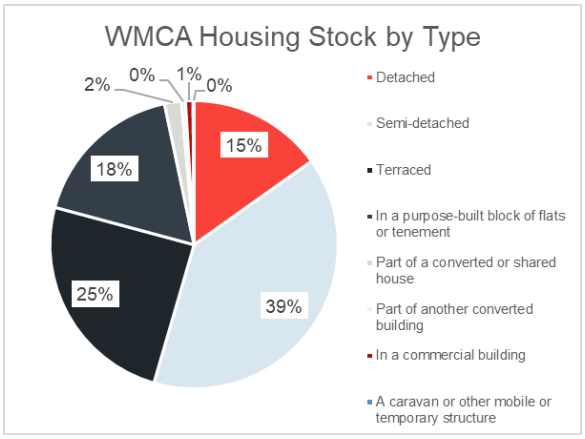

Figure 7 7: WMCA Housing Stock by Type [9]

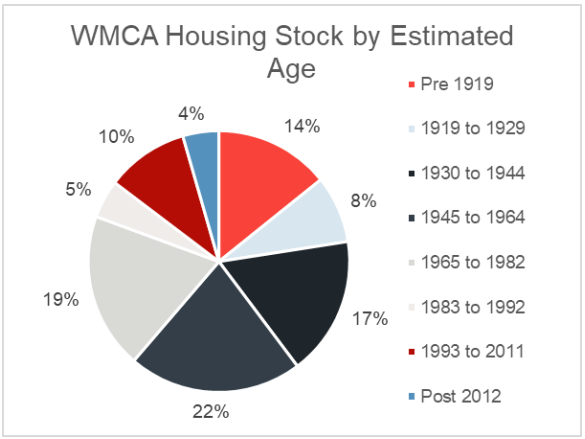

Figure 88: WMCA Housing Stock by Estimated Age [10]

POWER GENERATION

Due to current low gas demand for power generation in the region, hydrogen is not expected to play a significant role in future power generation.

The WMCA region currently features a very limited amount of gas turbine power generation, and no major power stations [11]. The only notable power generator is the 100 MW gas fired Heartlands power station (otherwise known as the Fort Dunlop power station). It is not considered to be a major power station [12]. There are no plans currently for significant gas fired power stations within the region and as such, hydrogen for power generation is not anticipated to play a significant role within the WMCA. This may change once a reliable piped hydrogen supply becomes available in region and can be used to enable turbine operation to help meet peaks in electricity demand.

HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

Green hydrogen is the logical production choice for the West Midlands region.

UK National Policy for hydrogen proposes a twin-track approach based on blue hydrogen and green hydrogen. Blue hydrogen represents a transitional pathway that is attractive for UK regions able to leverage Carbon Capture and Storage (CCS). This is the approach being favoured for the industrial clusters in the North West, Teesside, Humberside and the East Coast of Scotland, where captured CO_2 can be redirected to depleted oil and gas wells.

As a land locked region, the West Midlands does not have this opportunity to produce blue hydrogen. There will be opportunities to produce green hydrogen through water electrolysis using renewable electricity located either in region or from the grid, although consideration will need to be given to how to best use limited renewable electrical resource, given the likely conflicting sources of demand.

Electrolyser-based hydrogen production options include:

- Small units installed at customer sites for industrial and transport use, or at publicly accessible sites for vehicle refuelling.

- Medium sized decentralised production plants, from 10 MW+ in size, installed in or near region, from which hydrogen is transported by merchant market suppliers, either as a gas or liquid, to end user customers within a 50 to 100-mile radius.
- Large, centralised electrolyser plant from 100 MW+ in size, installed to feed hydrogen to large industrial customers, to supply to the merchant market and to feed into pipeline distribution.

The hydrogen production plant at the Tyseley Energy Park represents a first regional exemplar for the smaller scale onsite set up, being able to provide hydrogen for University of Birmingham's hydrogen laboratories, as well as for vehicle refuelling for buses, vans (350 bar) and passenger cars (700 bar). The smaller sized units can be deployed in depot operations or at factories where available space allows. Otherwise, those sites will have storage, gas compression and dispensers but no onsite production.

The medium sized production plants will support merchant market supply, with the hydrogen from these units will be transported by road. However, connecting these stations to a local pipeline network is also an option. At present, the merchant hydrogen supply model is based around generating green hydrogen out of region. However, suitable sites will be available in region either with the electrical capacity and water supplies needed or with investments needing to be made. A key site feature will be the ability to expand production as local market demand increases. This will be able to be achieved by adding electrolyser, compressor and dispensing modules, along with additional onsite storage. Sites of this size could be well suited to Zero Carbon Hubs servicing sector-coupling of demand.

No large Multi-MW scale hydrogen production assets are expected to be deployed in the WMCA region until such time as end user markets are developing. This contrasts with other UK regions which are positioned to be producers and distributors (exporters) of hydrogen at scale.

Were a single Multi-MW electrolyser plant to be planned for the region, it would require an exclusion zone to keep it distant from residential properties. If a suitable site could be found within the WMCA region, it is estimated that an electrolysis plant which could meet the regions demand in totality would cost in the order of £1,5 billion [13] [14].

Figure 9 shows hydrogen supply when compared with total forecast demand in the region. It is highlighted that whilst local merchant supply (from a medium-to-larger scale localised production plant) may be a good solution during initial growth phase for hydrogen demand, it cannot fulfil the regions demand by 2041, thereby requiring either a ramp up in distribution or a 100+ MW scale electrolysis plant.

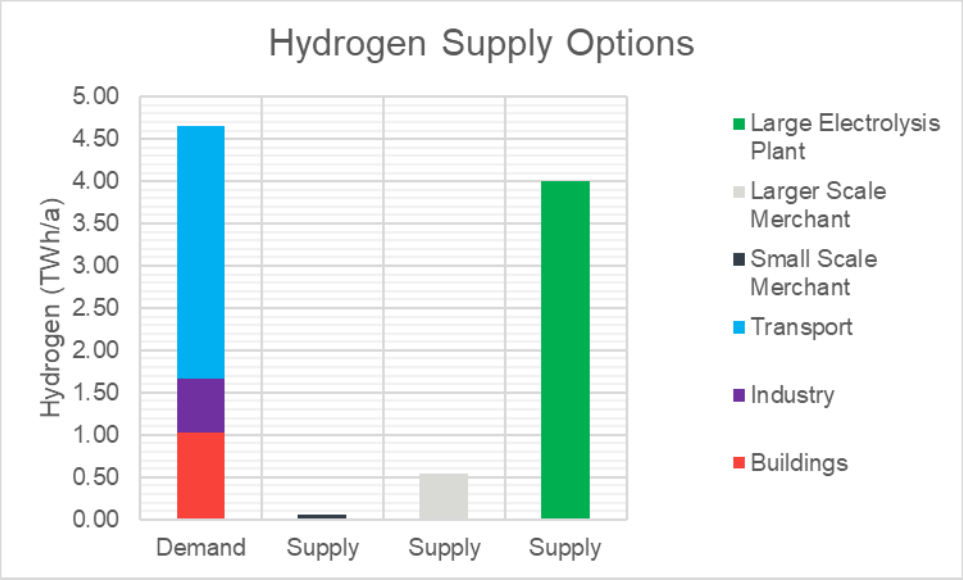

Figure 9: Hydrogen supply options

Even with in-region hydrogen production, a merchant market will be critical for a resilient hydrogen supply and a competitive market.

Customers are looking for both delivery to-site and onsite production options to ensure operational continuity. The merchant market can help provide hydrogen as a back-up for when local production assets need downtime for service and maintenance but can also support direct delivery to factories, to Zero Carbon Hubs and to support fleet operations, at depots and on-highway locations, where space constraints prevent the sites from having onsite generation.

The expectation is that merchant markets will transition from current grey hydrogen supply to blue and green supply, with future green hydrogen supply being from both UK and international production. The competitiveness of the green hydrogen supply is expected to be boosted by green hydrogen produced and shipped (as ammonia) from the Middle East and Africa and converted from ammonia back to hydrogen at UK refineries and port operations.

Fleet operators will want to minimise stem (or dead) mileage (to and from refuellers) and their operational reliance on hydrogen will mean they will have to weigh up the case for dedicated depot refuelling versus using publicly accessible stations and face the risk of queuing delays. Within municipal operations it will be possible to have different vehicle types (e.g. Buses, Refuse Collection Vehicles, vans) refuelled based on separate dispensers and differing shift patterns. However, the largest commercial fleets will favour dedicating the refuelling to their own operations and not allowing public access or restricting it to time windows when their own fleets will not be coming in to refuel. The case for public ownership of refuelling infrastructure should therefore be considered, particularly where it is supporting the decarbonisation of critical municipal operations and public transport services.

The expectation is that a depot refuelling will be problematic for a proportion of fleets where depot space is limited and it is therefore expected that a network of publicly accessible HRS will be needed on the strategic road network, to support fleets of all sizes but particularly smaller fleets and owner operators, as well as international hauliers.

Pipeline supply offers the most cost-effective means by which to distribute large quantities of hydrogen over long distances. Projects are under development for pipeline supply with the potential

to connect to the West Midlands in the 2030 to 2035 timeframe but the business case depends on the identification of appropriate levels of demand.

Plans are in place for pipeline supply of hydrogen across the UK and the WMCA would benefit from pipeline hydrogen supply.

Plans are being developed for the distribution of hydrogen in the UK via gas pipeline. These plans include:

- National Grid's Project Union [15], which aims to establish a hydrogen backbone in the UK linked to a pipeline network across Europe and the UKHyNet Project [16], in the North West; both of which are not expected to reach through the WMCA region.
- The East Coast Hydrogen project (Teesside, Humberside, Lincolnshire and East Midlands) which could connect to the West Midlands in its later phases (2040+ timeframe)
- The Hydrogen Valley Project (connecting hydrogen distribution in the East of England with the West Midlands) .

Of these projects the Hydrogen Valley is the most important but will not reach the region until 2032 and is currently expected to come into the south-east of the WMCA region first due to the presence of Cemex – the large industrial cement manufacturer – in Rugby. To extend this into the heart of the WMCA region, and towards industrial demand in the Black Country, is estimated at £96 million (this is based on a new 80 km pipeline and using Energy Networks Association Hydrogen costings report [13]).

For earlier pipeline supply, there would be the option to develop short distribution pipelines fed by production assets in or just outside the region, with the aim of linking these to form local area networks that eventually connect to networks in other regions.

To ensure energy system resilience, consideration will need to be given to hydrogen storage. The expectation is that the WMCA will be dependent on large-scale seasonal storage assets in other regions.

The UK has the potential to store more than 2000 TWh of hydrogen in naturally occurring salt deposits [17]. Among the UK salt deposits, based on the geology, the most attractive locations are in Teesside, Lancashire and Wessex (Dorset). There are salt deposits in the West Midlands, in both Staffordshire and Worcestershire. However, these deposits are in smaller and shallower salt basins that have previously been used for salt recovery. The prior working makes these basins less uniform when compared with virgin salt in other regions. This, and no local business lead, has led to them not being developed for gas storage and are not considered attractive for hydrogen storage.

Blending may provide some short term decarbonisation benefits but cannot wholly decarbonise sectors.

Blending of hydrogen into the existing natural gas supplies could provide a short-term emissions reduction. All gas network operators in the UK will be capable of blending by 2023, but a final policy decision is required by BEIS, which is expected later in 2023 [18]. By integrating a proportion of hydrogen into existing natural gas pipelines, carbon emissions would be reduced at the point of use with estimates that up to a 6% reduction will be possible from a 20% blend. This option would be attractive to end users as it generally requires limited modification and can therefore be implemented as an emissions reduction with relative ease. It allows for cohesive working between key industrial stakeholder and the local distribution network operator. Industrial stakeholders benefit from an immediate impact on reduction of their emissions and can also time their lifecycle replacements to cope with 100% hydrogen in the future.

This option is a short-term solution as it does not wholly displace natural gas. It is also noted that displacing a proportion of current natural gas supplies with hydrogen would require a significant supply of hydrogen into the region. 20% blending supplied to all industrial users would require an estimated 0.72 TWh/a of hydrogen supply, compared to an estimated 0.63 TWh/a for industry in the highly electrified scenario. A reliable source would need to be found at pace to supply blended hydrogen demand in the near term. This demand would further increase as the proportion of hydrogen in the natural gas blend increased.

Blending scenarios, as shown in Figure 10, could form part of the transition to hydrogen but will not be a final solution to meet the critical Net Zero year for the WMCA which is 2041.

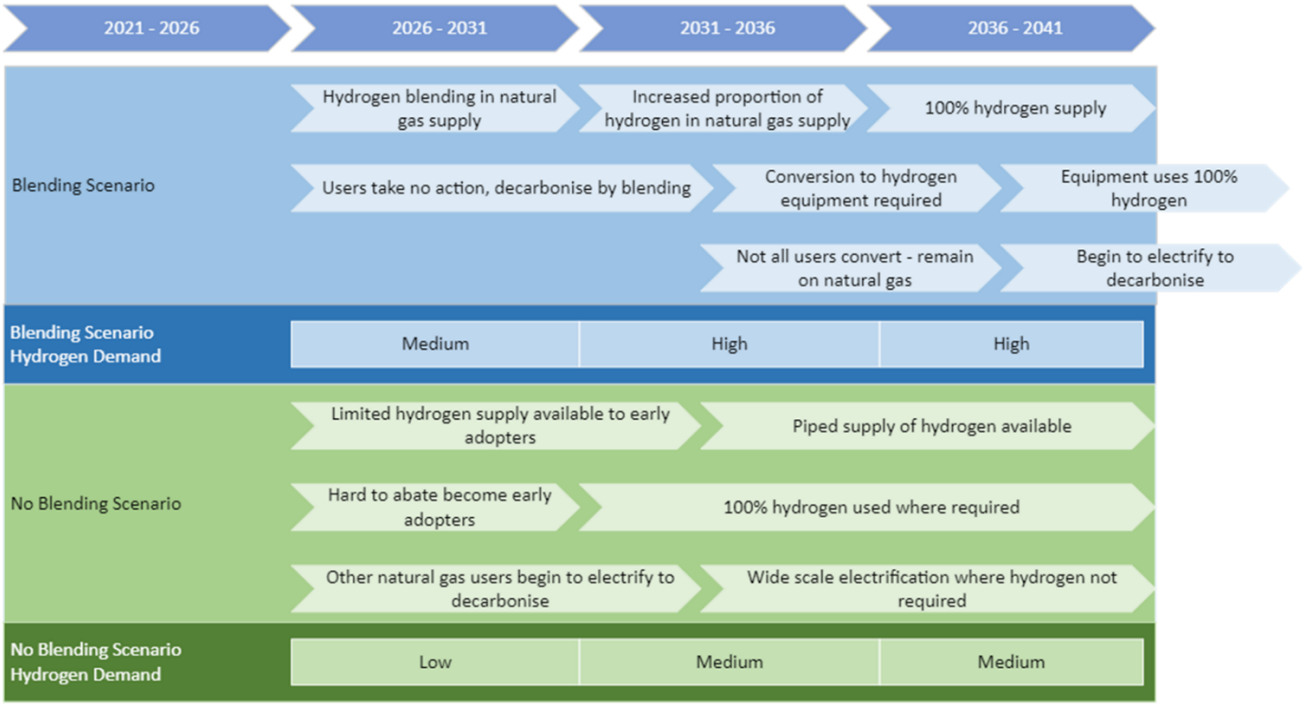

Figure 10: Hydrogen blending scenarios

SYNERGIES BETWEEN SUPPLY AND DEMAND

There will be synergies and co-location benefits when it comes to hydrogen supply and demand, however differing hydrogen purity requirements may impact local distribution operations.

The Repowering the Black Country consortium have identified candidate Zero Carbon Hubs that link adjacent organisations to share zero carbon energy supplies, whether green electricity or green hydrogen.

For hydrogen production and/or storage, these Hub-related sector coupling opportunities include:

- Industrial hydrogen use and nearby demand for decarbonised residential heat (either via heat networks or hydrogen into the gas grid).
- HGV refuelling and the industrial and commercial premises these logistics operations support
- RCV or bus refuelling and nearby heat demand for public buildings.
- Airport aviation and nearby industrial, commercial building and transport operations at the Birmingham Business Park.

The equipment assets required for sector coupling will add to investment costs and require dedicated staff to operate. Equipment operation may extend to include onsite electrolyser operation, or where sites are linked to gas distribution networks, piping hydrogen and hydrogen blends over short distances to different end users and having onsite purification operations where needed to ensure high purity hydrogen for the automotive fuel cell vehicle applications that require it.

Sector coupling will be more straightforward where the hydrogen is burned in furnaces and boilers for industrial, commercial and residential heat, in gas turbines for power generation or where trucks operate with hydrogen ICE.

POLICY CONSIDERATIONS

The hydrogen opportunity is characterised by being multifaceted but also in its infancy, so the WMCA policy approach needs to be one of assessing where best to focus to help unlock those opportunities of greatest utility for the region.

Policy considerations related to hydrogen can be split into three aspects, as follows:

- Policy positions that recognise challenges, barriers, and risks and seek to address these where appropriate.
- Policy positions that target opportunity areas.
- Policy positions that maintain continuity of purpose and delivery over time, consistent with WMCA's wider policy priorities.

The transition to a hydrogen economy is not without its challenges. These challenges can be broadly classified into three main areas, as follows:

- Complexity challenges related to the characteristics of hydrogen as an energy carrier.
- Uncertainties related to how supply and demand for hydrogen will develop over time, including policy uncertainties and market uncertainties related to which technologies will win out in competitive markets.
- Local and regional factors.

A sensitivity analysis was completed to assess the challenges and the regional strengths and opportunities listed below, proposing corresponding policy position implications. In turn these are used to inform the recommended next steps activities for the WMCA.

Hydrogen challenges and opportunities:

Challenges	Opportunities
1. Complexity and Safety 2. The Skills challenge 3. Consenting for hydrogen investments 4. National Government policy uncertainty 5. Market uncertainty at a regional level 6. Energy system constraints 7. Fitting new infrastructure investments into business service continuity 8. The need for a Just Transition to Net Zero 9. Disruption to the general public	10. Manufacturing capability 11. Skills and training capability 12. Inward investment 13. Regional coordination capability 14. Mayoral leadership and profile

RECOMMENDATIONS FOR SUBSEQUENT WMCA ACTIVITY

The policy roles available to WMCA have been broadly categorised into three types as follows:

Deliver (D)	Enable (E)	Influence (I)
Lead on, and work with members and public bodies, to deliver hydrogen investments.	Support others to make progress through regulatory powers e.g. planning consents	Influence action through stakeholder engagement, collaboration, knowledge-sharing and advocacy.

The recommended activities attempt to tackle the previously discussed challenges while maximising identified opportunities, utilising the specific WMCA policy roles as indicated.

WMCA activity	**WMCA Role**
Skills for market development Help set up familiarisation and training programmes for hydrogen production, distribution, storage and use; open to a broad range of stakeholders for differing learning objectives. This can include leveraging "show and tell" at facilities including the Tyseley Energy Park.	D, E, I
Skills for supply chain development Help set up SME training related to hydrogen technology opportunities working with organisations in region including WMG, MTC, the Black Country Innovative Manufacturing Organisation, Made in the Midlands, Make UK, HyDex and others	D, E, I
Awareness raising for market development Assist WMCA members and other stakeholders to better understand the business case for hydrogen vehicle operation, alongside battery electric operation, as an aid to technology agnostic transitioning to Net Zero. Hydrogen vehicles and HRS deployed in public service can provide exemplars for private sector fleets to follow. Explore the options for a network of HRS in prime locations (central Birmingham, Birmingham Airport, central Coventry, the new HS2 station, etc) to support hydrogen coaches and long-distant bus operations. Establish a HGV Task Force, building on the work of the H2GVMids consortium, to help plan for the hydrogen HGV-related opportunities for decarbonisation and supply chain development.	E, I
Awareness raising for hydrogen matching hydrogen supply and demand Commission spatial analysis study work to identify candidate locations for hydrogen refuelling infrastructure and industrial supply including candidate Zero Carbon Hubs. This will draw on prior work conducted by Midlands Connect and by the H2GVMids consortium for transport demand and the Repowering the Black Country consortium for industry demand. Socialise this work to encourage industry investment.	E, I
Addressing uncertainties and complexities around hydrogen for heat Following national government decisions on the role of hydrogen in heating, commission a study to better understand the housing types and economically viable locations for the use of hydrogen boilers for heating	D

alongside insulation, heat pumps and solar PV across the regional housing stock.	
Inward investment Work with West Midlands Growth Company and key stakeholders in region (Midlands Engine and Department for International Trade) to develop an inward investment proposition focused on the strengths and opportunities in region.	D

ECONOMIC MODELLING OF INTERVENTIONS

Financial benefits analysis

Sector	**Intervention**	**Potential financial benefits (by 2041)**
Transport	Support installation of hydrogen refuelling stations (HRS)	Capital cost: £110 m Jobs created: 858 GVA created: £56 m/a
Industry	Support transition of hard to abate sectors to hydrogen	Capital cost: £6.8 m Jobs created: 53 Jobs safeguarded: 12,250 GVA created: £3.5 m/a GVA safeguarded: £1,065 m/a
Buildings	Conversion and maintenance of equipment converted to hydrogen to heat homes and commercial buildings in applications not suitable for electrification	Capital cost: £481 m Jobs created: 3,441 GVA created: £223 m/a
Production	Highlight the WMCA market demand for green hydrogen to encourage in region green hydrogen production	Capital cost: £1,553 m Jobs created: 8246 GVA created: £873 m/a
Local Distribution	Support new/repurposed distribution networks for hydrogen in region	Capital cost: £50 m Jobs created: 373 GVA created: £26.5 m/a
Transmission	Support extension of hydrogen supply from Rugby into region	Capital cost: £96 m Jobs created: 119 GVA created: £7.7 m/a

Scenario analysis

There are two scenarios detailed in this section, the 'do nothing' scenario where no action on hydrogen is taken by the WMCA and its partners, and the 'intervention' scenario, where the interventions of this document are followed. The impact on jobs and GVA per annum in each scenario can be found in Figure 11 and Figure 12.

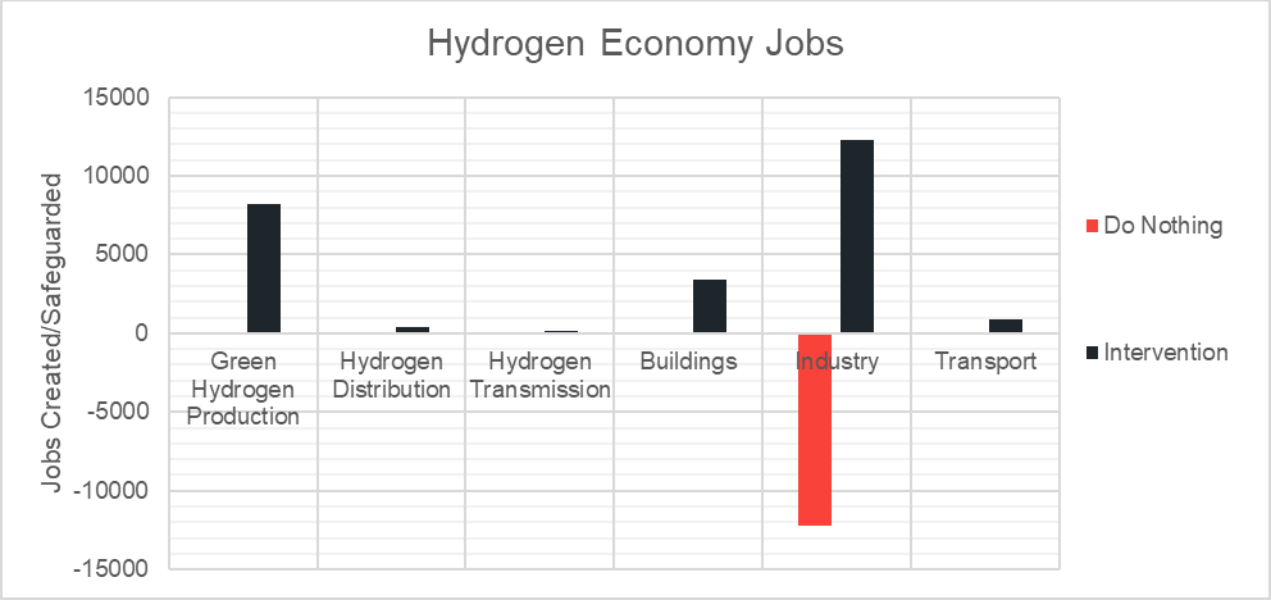

Figure 11: Hydrogen economy jobs

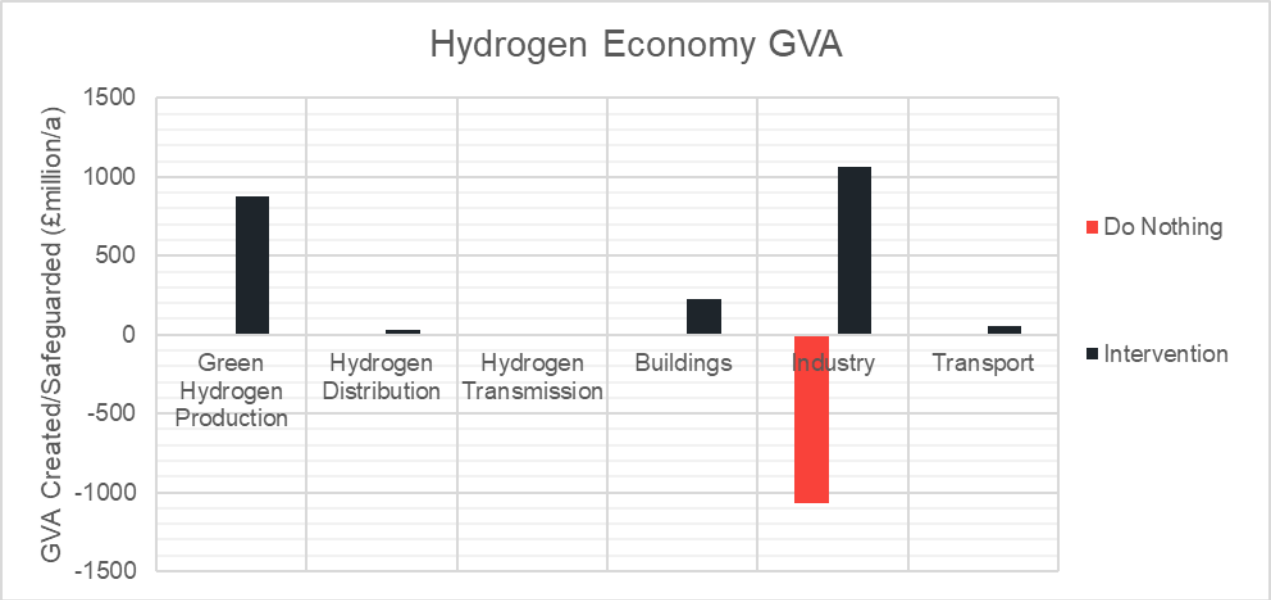

Figure 12: Hydrogen economy GVA.

In addition to the economic scenarios shown above, there are also opportunities for the region with the export of Hydrogen products. Boiler manufacturers Baxi and Worcester Bosch are both based within the West Midlands, and account for 45% of the UK boiler market at present. Both companies are planning to offer hydrogen-ready boilers and heat pumps to the UK market. There is an opportunity to benefit the WMCA region by export of these products to the wider UK, subject to the national direction on hydrogen for building heating.

Do nothing scenario

In the do nothing scenario, the region will not benefit from the additional jobs and GVA associated with the hydrogen economy. There is also a risk that industrial parties, particularly in the hard to abate sectors would leave the region. The hard to abate sectors account for 12,250 jobs and contribute a

GVA of £1,065 million per annum [19]. Without supporting these industries to move towards hydrogen there is potential they could leave the region. If the actions identified on hydrogen transmission and distribution are not enacted, the region will not benefit from the jobs associated with this.

Intervention implementation scenario

The potential jobs and GVA from a WMCA hydrogen economy are shown in Figure 10 and Figure 11.

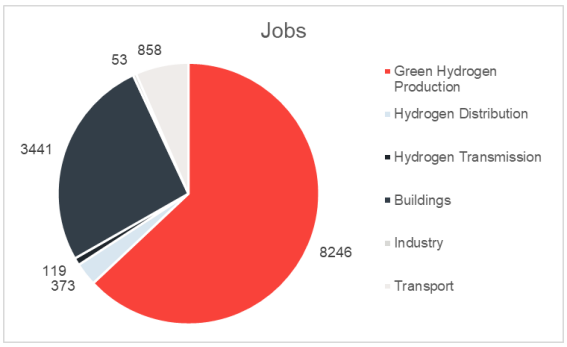

Figure 10: Potential jobs created in WMCA hydrogen economy

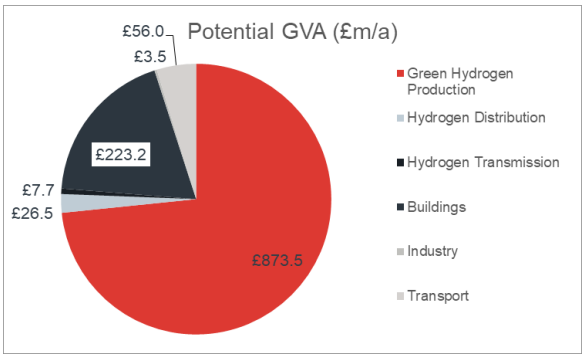

Figure 11: Potential GVA created in WMCA hydrogen economy

Despite the significant challenges associated with in region green hydrogen production, it is highlighted that there is significant potential to contribute to GVA and jobs by generating all required hydrogen from an in-region source. An estimated 8,250 job could be created alongside a GVA contribution of £873.5 million per annum.

Developing an appropriate in region transmission and distribution systems for hydrogen could create 492 job and contribute £34.2 million per annum GVA. This assessment is based on the addition of a new transmission pipeline from Rugby into the heart of the region. It is also based on the repurposing of local distribution networks, in line with the proportion of buildings which have the potential to move to hydrogen, if other measures have been exhausted.

Conversion of appropriate buildings, industry and supporting the transport sector could support 4352 jobs and contribute £282.7 million per annum GVA. For buildings, this has been assessed on the basis of installing, maintaining and operating hydrogen ready boilers. In industry this has been based on conversion and maintenance of equipment which is converted to hydrogen. Ensuring a supply of cheap hydrogen for industry will be vital to support these jobs and GVA. For transport, the figures have been assessed on the basis of the number of hydrogen refuelling stations which would be required within the region to support demand.

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