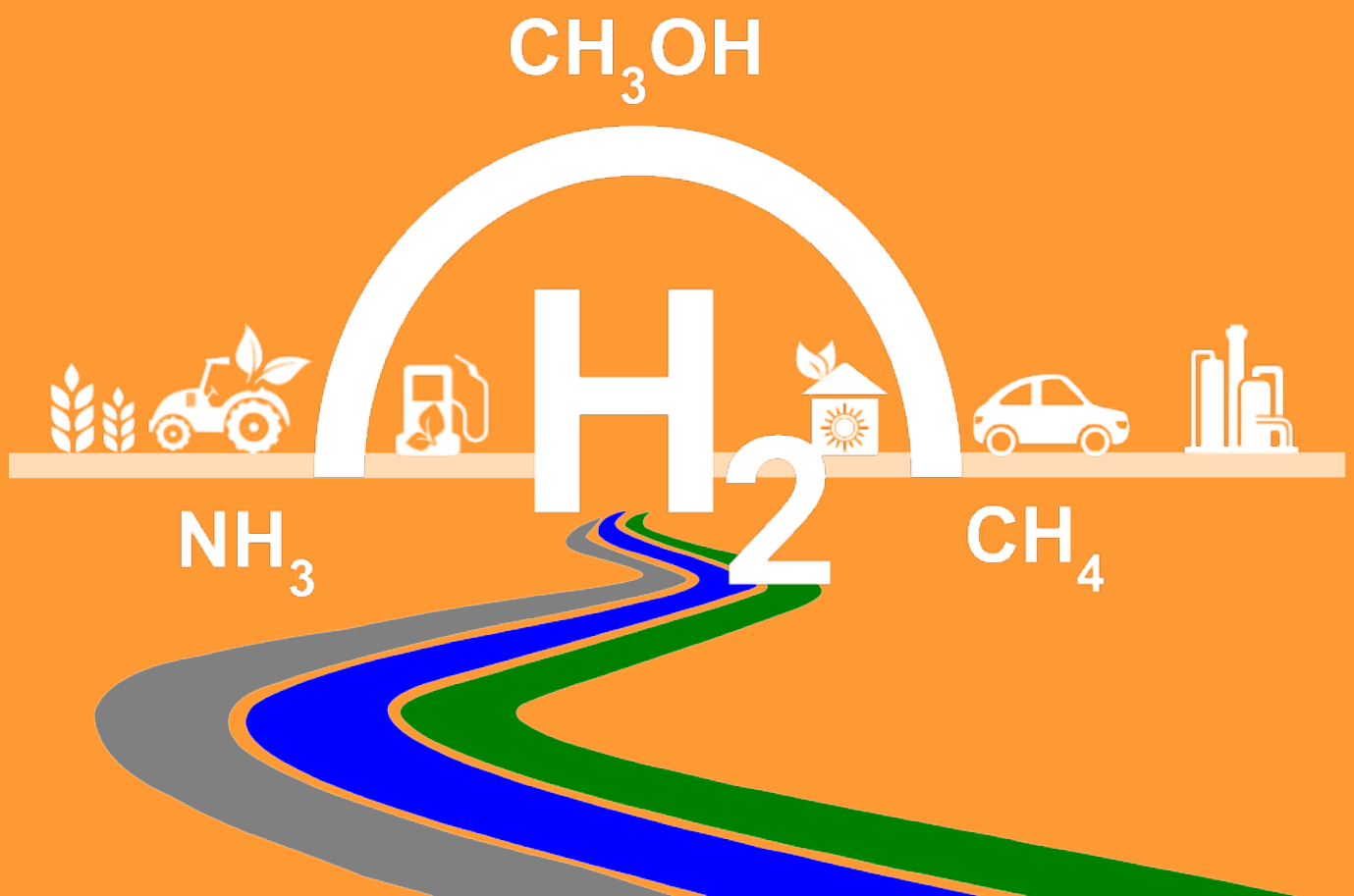


OUTCOMES SUMMARY

MID WALES HYDROGEN STUDY



Written and produced by



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for the **Growing Mid Wales Board**

Funded by:



Point of departure

We would like to provide the summary of outcomes derived from the work commissioned by the Growing Mid Wales (GMW) Board in partnership with Ceredigion and Powys County Councils and strategically carried out by Radical Innovations Group AB, Finland.

The importance, urgency, and timeliness of our efforts in the Mid Wales region are further emphasized by the ambitious targets set by the UK Government (UKG) to rapidly move towards low-carbon sources based on renewables and nuclear. Many activities are ongoing in different parts of the UK aiming to find the holy grail of low- or zero-carbon energy source. Though there are many fads that come and go, the obsession for the low- or zero-carbon holy grail remains obviously for the right reason – climate change. Today, the buzzword is “hydrogen.”

Politicians, policy makers, technocrats, project developers, and businesses across sectors have one thing or the other to say about hydrogen and its potential in decarbonizing various sectors of the UK economy. Like with all new technologies, there are groups within UK fully advocating for hydrogen and the others who are not convinced with the potential of hydrogen as a viable energy vector for the UK. While the former groups see huge potential in hydrogen in many applications, the latter group believe hydrogen is just another “hype” promoted by big corporate lobbies.

UK Hydrogen Strategy was recently released in August 2021 by Department for Business, Energy and Industrial Strategy (BEIS), UKG. Though Wales region is recognised to have significant opportunities for low-carbon hydrogen production and use, no specific mention is made about the possibilities in the Mid Wales region in UKG strategy document. While a clear timeline and what needs to be completed during this period are emphasized [there are no mentions about “how” we have to achieve “what” we need to achieve](#). Hence, it is left to our interpretation, and ability and willingness of the region to take risks and proactive steps to create actionable plans at the regional and county levels.

That being said, at the point of departure of our work in Mid Wales, we have taken a neutral stand and listened to relevant stakeholders to build a reasonably balanced picture about the true potential of hydrogen, hydrogen-carrier, and other low-carbon fuels in the Mid Wales region. In the opportunities assessment phase of our work, we summarized our initial findings addressing

- ◆ why Mid Wales region should pursue realistic low- and zero-carbon fuels market opportunities?
- ◆ what potential application areas and sectors should Mid Wales region target?
- ◆ how to prepare and pursue the identified market opportunities within and outside Mid Wales?

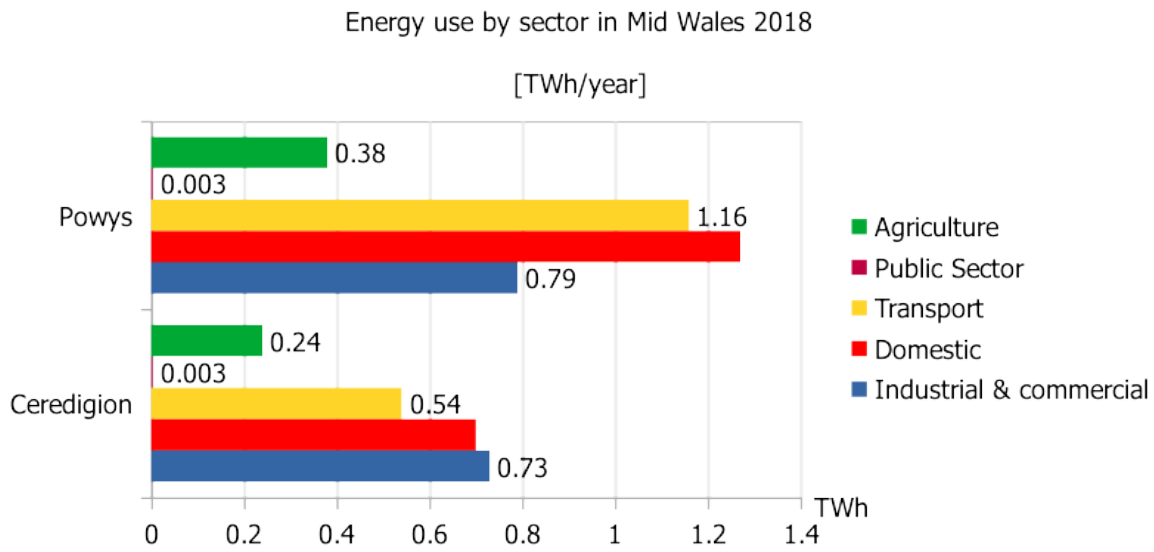
We have gathered solid evidence-based answers to above three questions and presented the initial learnings to the Growing Mid Wales (GMW) steering board, namely,

- ◆ the energy landscape of the region exploring the ideal (mix of) energy vector(s) that can be used to create value to the Mid Wales region,
- ◆ relevant applications areas and target sector where Mid Wales should focus
- ◆ ideal strategy for Mid Wales to pursue in short- and medium-term given the various developments in and around the region.

Mid Wales is considered for most part as “under-developed” due to poor, or lack of, infrastructure and mostly rural in the context of development opportunities. The lack of infrastructure, as we pointed out in the opportunities assessment report, has not only severely affected growth in the region, but also isolated the region from its regional siblings – North and South Wales. Efforts to improve the infrastructure in the region in the past were dealt with local oppositions for any such improvements were not seen to truly add value to the livelihoods of local population. For example, initiatives to improve grid infrastructure were seen as a way for big firms to make money for themselves milking the regional resources without giving back to the region. Number of companies, local job opportunities in sectors other than agriculture and forestry, quality of home and public infrastructure for heating, electricity, transport, etc. compared to regional neighbours – North and South Wales – and rest of the UK highlights the reasons for concerns regarding development in the region.

Any kind of value creation in the region requires reactivating the Mid Wales region’s energy landscape in terms of choice of low-carbon energy vectors, improving grid connectivity, ramping renewable energy assets, creating new job opportunities, improving quality of heating, electricity, and transport infrastructure, etc. Without creating local market opportunities that can benefit from these improvements and focusing only on export potentials of the region’s resources, we believe, there will hardly be any significant progress in the region. We have derived some important cues on where are the best bet for Mid Wales and what role Mid Wales could play in the larger scheme of things considering the developments in North and South Wales, and the rest of UK.

We would like to briefly highlight the energy landscape of Mid Wales. As of 2018, the overall energy (electricity and fuels) consumption in Mid Wales is split between the commercial and industrial (26%), the domestic (34%), the transport (29%), and the agricultural (11%) sectors. Annual energy consumption [TWh] across different sectors in Mid Wales is given in the figure below.



Based on the outcomes of the opportunities assessment phase, we carried out the feasibility study phase to evaluate different market opportunities for Mid Wales region to pursue involving hydrogen, hydrogen-carrier, and other relevant low-carbon fuels such as biogas and methane. Our insights are derived from qualitative and evidence-based assessments taking into account various ongoing developments in North, South, and Mid Wales aligning to the overall UK government priorities.

Stakeholder engagement

We have interviewed more than 50 key stakeholders in and outside Mid Wales region in the form of one-on-one meetings and focus-group discussions. We have highlighted only some of the organisations whom we have engaged in this process over the last 6 months below.



Apart from various one-on-one interviews and focus-group discussions, we have also interacted extensively with various members of the Growing Mid Wales (GMW) steering board, Powys County Council, Ceredigion County Council, and various departments of the Welsh Government. We have made sure that the activities of the project in the region are well aligned with the recent strategic developments and policy guidelines made by Welsh and UK governments.

Way forward

Having carefully reviewed potential strategies for Mid Wales, we have identified that **“first procure, later produce” strategy** will be the best option for the region in short- and medium-term going forward. We will discuss this strategy in more detail in the following.

Why first procure, later produce strategy?

First procure, later produce strategy can be win-win in the long-term with low risk exposure in the short-term as the real potential for green hydrogen and other hydrogen-based products to decarbonise various sectors inside and outside Mid Wales is still uncertain and evolving. Mid Wales can prepare the ground to decouple previous local opposition against wind farms and pylons by strategically introducing various developments by

creating local demand for different green fuels. If the market for green hydrogen is not picking up Mid Wales can play safe with minimum risks. In this strategy, if Mid Wales can position itself as a strategic partners, other regions will require Mid Wales in medium- and long-term.

The benefits of this strategy can be understood by splitting the strategy implementation process into two parts, namely, procurement part and production part. In terms of timescale, the procurement part will be addressed by short- and medium-term actions and goals. The production of green fuels will be addressed in the long-term goals. In the short-term, Mid Wales will be aiming to become strategic partner connecting North and South Wales and the rest of UK. As there are a lot of industrial developments happening in North (HyNet) and South Wales (SWIC). If we want to grow hydrogen economy in Mid Wales, we could find ways to expand HyNet to the south and SWIC to the north by using their infrastructure and creating market opportunities in Mid Wales. Given the huge potential for renewable energy in the region, Mid Wales can attract investments to produce locally various green fuels such as Hydrogen (H₂), Ammonia (NH₃), Methanol (CH₃OH), and Methane (CH₄) in the medium- and long-term. These investments can further be used to improve infrastructure and develop grid connectivity in the region, at the same time create new job opportunities.

Following our first procure, later produce strategy, the overall cost of the fuels can be reduced compared to as-it-is baseline scenario. The environmental cost of emissions have to be also considered as we are aiming for net zero emissions by 2030 along with all the public sector in Wales. If environmental emission costs are to be considered. then we have the option of fully using zero-carbon fuels such as ammonia or hydrogen.

Whatever the source of hydrogen, using hydrogen is not commercially feasible in the short-term as the cost of hydrogen is quite high. Using ammonia is always a good option as it is price-wise much cheaper than other alternatives. But we have to blend it with other fuels to use it in commercially available machineries. For a balanced overview, we have considered both fuel and environmental costs as overall fuel-related cost as shown in the table below.

[k£]	as-it-is	CH ₄	NH ₃ + CH ₄	CH ₃ OH	NH ₃ + H ₂	H ₂ + CH ₄
fuel costs	828	698	736	979	1417 to 1762	2383
emission costs (presently not accounted)	280	169	156	190	2 to 6	68
Overall fuel-related cost	1108	867	892	1169	1419 to 1768	2451

Strategy implementation challenges

In implementing this proposed first procure, later produce strategy, we anticipate some systemic challenges. First, based on the inputs received in our stakeholder engagements, we believe that the level of appetite for changes in the region is rather low compared to other regions in the UK. This could be one of the biggest challenge to overcome. Especially, for big changes in the region, for example, decarbonisation, require strong commitment and backing of the senior decision makers in the public offices at county level. Without such support, we can only talk about changes without changing anything on the ground. During our stakeholder engagement process, we found that there is a lack of real interest among stakeholders because of the systemic constraints, which we discussed in the opportunities assessment report. This could be one of the biggest challenges to overcome in the region. The mindset change and decision makers' commitment are fundamental to progress in the region.

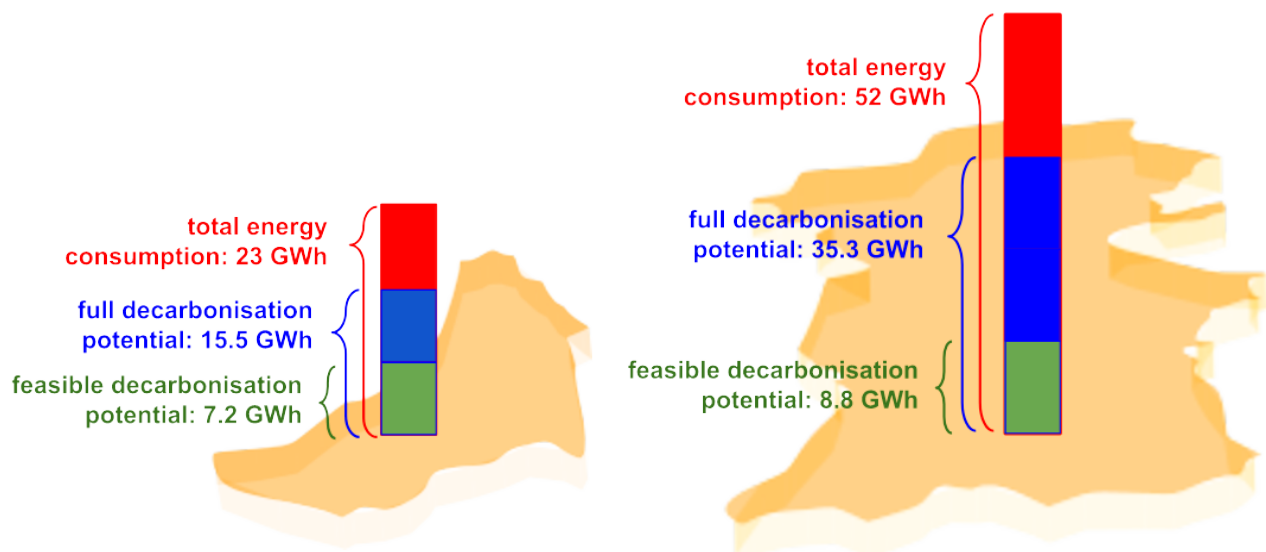
Last but not the least, we noticed that lack of relevant skills and expertise will be one of the challenges to overcome to make progress with the first procure, later produce strategy. Especially at county level, we need to train existing staffs and recruit potentially new staffs to deal with sustainability, energy, and decarbonisation related themes. Though this is not a huge risk or challenge, one has to address this completely before

venturing into strategy implementation process. Short-term and medium-term, we have expressed interest in support the region in addressing these challenges and risks.

We have explored ways to implement this strategy at business-, industrial-cluster-, industry-, and public-sector-level in detail in the feasibility report highlighting relevance, challenges, opportunities, and limitations at different levels one-by-one.

Broad-brush financial assessment

Based on the overall energy consumption data related to Powys County Council assets, we believe there is scope for decarbonising roughly 9 GWh of energy use annually using low- or zero-carbon fuels. For Ceredigion County Council assets the scope for decarbonisation is roughly 7 GWh annually. We have taken the net scope for decarbonisation for the entire Mid Wales using first procure, later produce strategy to be roughly 18 GWh annually. This is double of the Powys County Council assets consumption as a safe estimate. The **total environmental cost of emission presently is roughly 280 k£** which is due to combustion of LPG, domestic heating oil, and wood pellets as shown in the figure below. Please note that this is not "actual" but only a "proxy" cost, which is not currently paid for in the UK for emitting greenhouse gases (GHG). Though there is implicit carbon emission taxation, for instance, through duties on petrol and diesel, and some heavy industries pay an effective price on carbon, there are no taxes for consumers explicitly. Hence, we have estimated the environmental costs of emission based on the GHG emission costs set by the European Union Emissions Trading System (EU-ETS). When UK government implements mandatory emission trading system all emitters in public and private sectors will need to pay these emission costs. Depending on the choice of low- and zero-carbon fuels, we can reduce this environmental emission cost to **minimum 190 k£** and **maximum 2 k£ annually**. Using this as a starting point, we should identify and prioritize public-sector assets that we will step-by-step decarbonise in the region. This will feed into the next step related to procurement planning.



Presently there are 4 main fuels used for the public sector assets. We have not considered the emissions from the production of electricity, which is also used as an energy source for public sector assets in Powys. We have only considered fuels that are used in the region for energy production. For example, Powys public sector energy consumption is mainly based on natural gas (CH₄), liquefied petroleum gas (LPG), domestic oil, and wood pellets other than electricity. Of these 4 fuels, we have aimed to decarbonise only those applications currently run on LPG, domestic oil, and wood pellets. Those which are using natural gas are already at the best level of decarbonisation possible in the region given the constraints and limitations. In that sense, natural gas-based decarbonisation will be used as a benchmark for our calculation, where we will assess the pathway emission efficiencies in comparison to that of fully natural gas-fuelled system.

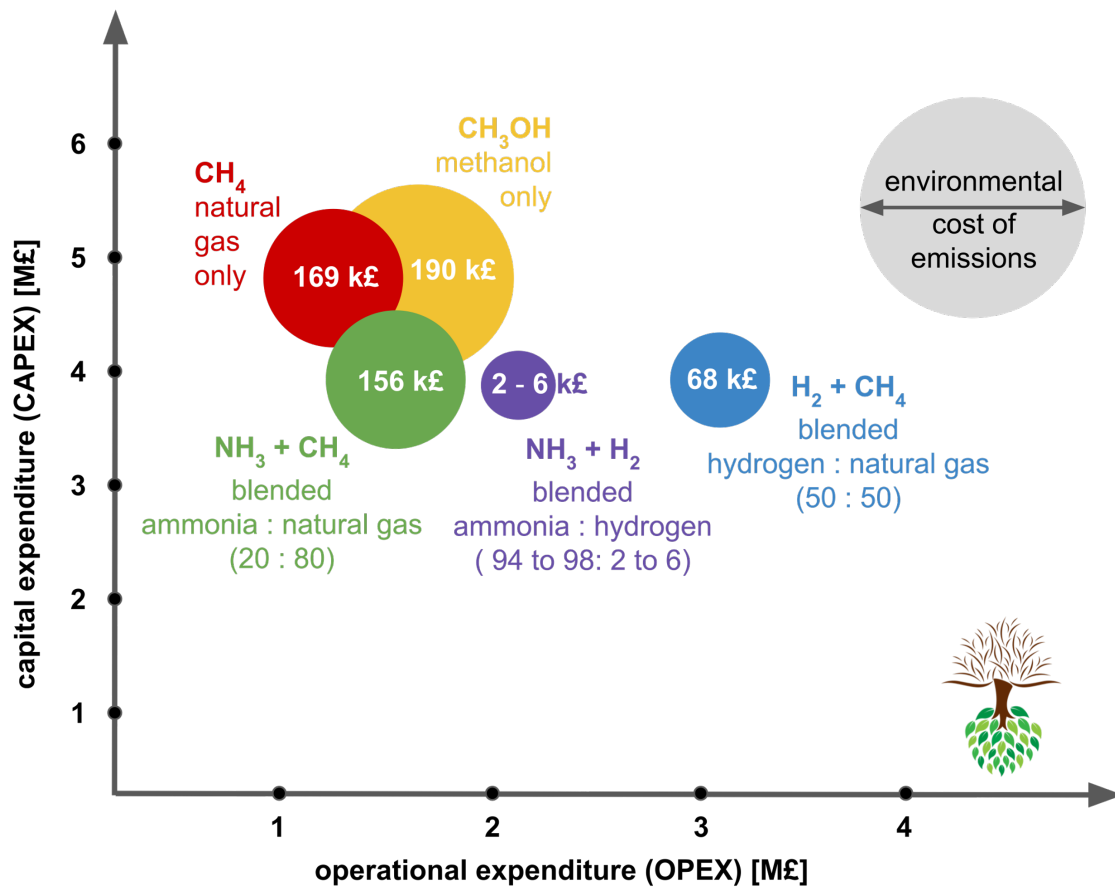
Based on these assumption, we have proposed **6 potential pathways** to reduce the current carbon emissions resulting from the use of LPG, domestic oil, and wood pellets. As mentioned above, we have not

considered natural gas-fuelled applications as it is already at the optimal level of emission for the region. The 6 potential low- or zero-carbon pathways are described below.

- ◆ **Pathway 1 (CH₄):** natural gas only
- ◆ **Pathway 2 (CH₃OH):** methanol only
- ◆ **Pathway 3 (H₂ + CH₄):** hydrogen blended with natural gas (50:50)
- ◆ **Pathway 4 (NH₃ + CH₄):** ammonia (20%) blended with natural gas (80%)
- ◆ **Pathway 5 (NH₃ + H₂):** ammonia (98%) blended with hydrogen (2%)
- ◆ **Pathway 6 (NH₃ + H₂):** ammonia (94%) blended with hydrogen (6%)

Each of these pathways will have different financial implication in terms of CAPEX, OPEX, and reduction in costs of emissions. Cost of emissions is also an important parameter, which is not considered normally in many calculations. Going forward, there will be implications for polluters who are using fuels that emit GHGs. We have considered this in our calculations to rightly price the overall cost of our pathways considering the environmental damages of such emissions. For this, we have used a basic tariff for CO₂ emissions used in European Union emission trading system (EU ETS). This is presently, 50-60 € per tonne, which corresponds 36 roughly 50 £ per tonne of CO₂ emitted. We have used the 200-to-300 year period NO_x global warming potential (GWP) value to calculate the environmental cost of NO_x emission. This is roughly 200 times that of CO₂ and taken as 10 k£ per tonne of NO_x emitted. CAPEX is calculated based on investment required for capital equipment, construction costs for buildings, piping, and related auxiliary facilities. OPEX is related to operation expenses required to run the new setup especially taking into account direct and indirect costs including the cost of alternative low-carbon fuels. [The cost of emission is to be considered because we have to account for the environmental damage resulting from the emission of GHGs.](#) We have to evaluate how our pathways' cost-efficiency (CAPEX & OPEX) and cost of emissions generated compared with the existing as-it-is scenario using 3 fuels LPG, domestic oil, wood pellets. If we assume the diameter of the bubbles in the chart as an indicator for the environmental cost of emissions, then we can compare these with 6 pathways suggested in this assessment.

Overall pathway impacts in terms of CAPEX, OPEX, level of emissions, and cost of emissions is given in the figure below. Please note that the baseline is the as-it-is scenario for entire Mid Wales region public sector energy consumption only using 4 fuels – natural gas, LPG, domestic heating oil, and wood pellets. As mentioned above, direct grid electricity and renewables generated electricity are not considered in this calculation as they remain the same in all the pathways.



Outcomes and next steps

Hydrogen and hydrogen-based fuels are increasing in popularity, thanks to the growing interest and increasing ambitious commitments from public and private sectors across the world. We have seen several ambitious targets set by UK government over these years in this direction. That being said, we have several reasons to believe that [there is still a huge gap between ambitious targets and ground reality](#). Welsh and UK governments must act decisively and provide clear political support to position itself at the forefront of a growing global industry. Though decisive policy and regulatory push is currently emerging, thanks to strategic developments at the local- and national-level in the UK, [detailed short-, medium-, and long-term action plans on "how" to go ahead are left to interpretations and capabilities available in the region](#). It is our humble and sincere opinion that [without such realistic action plans and support in the form of policy and regulation, we will still be only talking about hydrogen even in 2030](#). Hence, we aim that our present work will address this gap at the county-level providing actionable roadmap in short- and medium-terms by creating market opportunities and decarbonising the local public assets. Furthermore, strong and clear signals are also required from policy makers to encourage industries to confidently increase investments in this direction. Such private sector investments will form the evidence base that will set the long-term direction for growth in this sector.

Hence, we have strong reasons to believe that the [overall scale of hydrogen deployment in the energy system is largely uncertain and will heavily depend on the commercialisation of technologies](#) for electrification, hydrogen, and other hydrogen-based fuel options. There will be an increase in electrification across UK. Especially in the region of Mid Wales, where grid capacity is a huge bottleneck, we cannot talk about development of any sort without significant increase in grid capacity. For regions with limited grid capacity, it is likely that other energy carriers will be required to enable a more flexible, resilient and integrated system. Our opportunities assessment has revealed that [hydrogen and hydrogen-based low- and zero-carbon fuels such as methanol and ammonia can complement electricity](#).

Hydrogen (green or blue) as the way it is being positioned might very well be a wishful thinking or a miracle fuel of the future. Presently, direct hydrogen has only limited market opportunities within Mid Wales and developments outside Mid Wales are still evolving. Many of the applications are not yet ready for green fuels.

One has to think about a transitory period to create a pathway if green fuels have market opportunities. In this period, Mid Wales need to find realistic market opportunities as a way to support the organic growth within the region. There should be transition fuels specific to applications that can serve as a bridge between current fossil-fuels and the future green fuels. The transitory fuels should be easily usable with current infrastructure and machineries with minimum or no change. That being said, pure hydrogen has some niche market opportunities in the heavy goods vehicles and public transportation such as buses and trains. Synthetic methane, methanol, and ammonia could be seen as transition or ideal green fuels for many of the applications.

Given the lack of infrastructural support, supply chain challenges, and policy and regulatory gaps, the market developments can go either way as strategic goals are not linked to clear actionable plans in short-, medium- and long-term for hydrogen and hydrogen-based fuels. With these uncertainties, Mid Wales can best prepare by cleverly planning and positioning itself as a strategic partner to other regions that are acting as first movers. In doing so, Mid Wales region can also greatly benefit from the learnings derived from “others’ mistakes” before venturing into long-term large-scale investments. This way, Mid Wales can align itself as a strategic partner to North and South Wales and the rest of UK to create new market opportunities inside and outside Mid Wales.

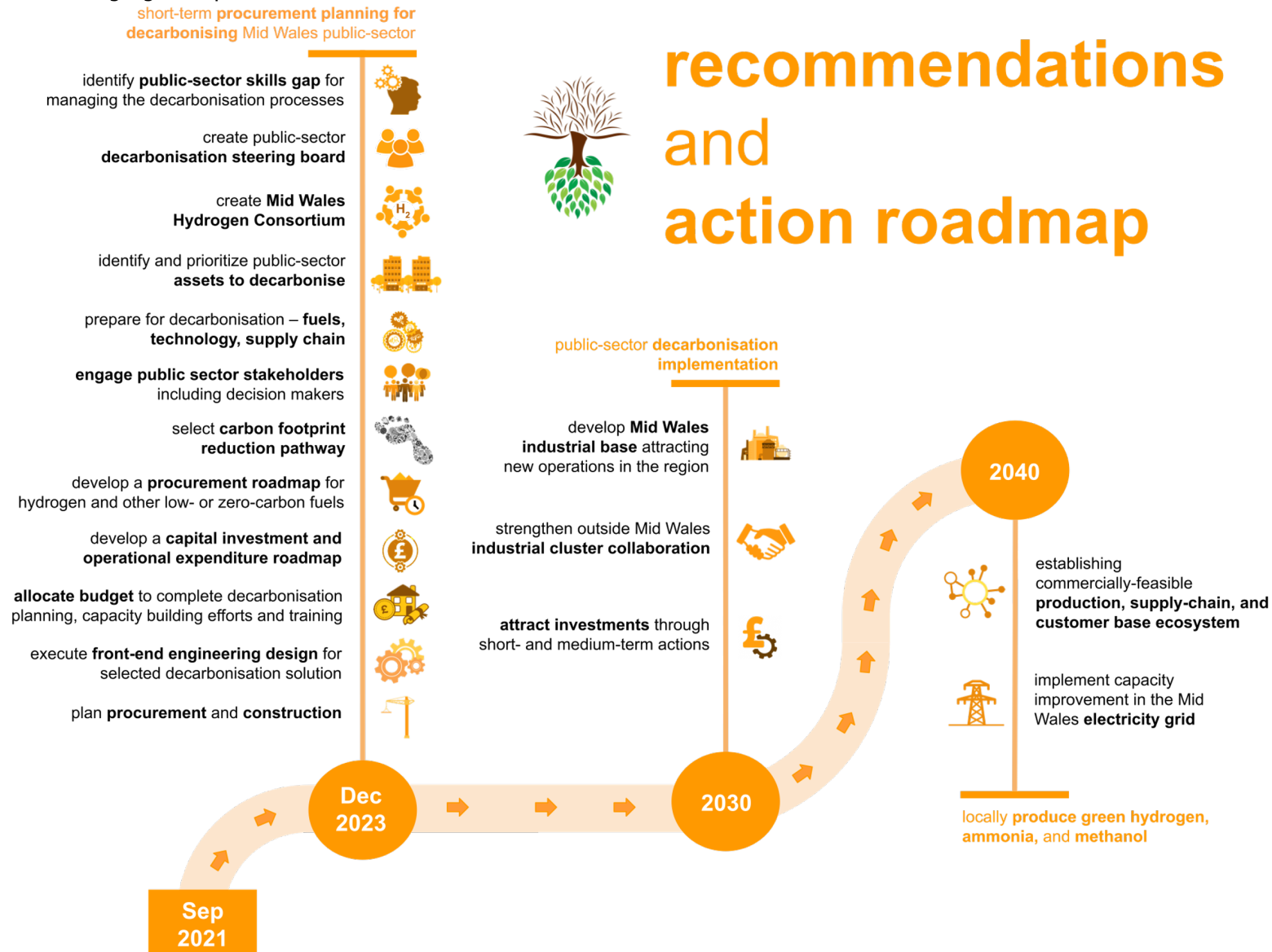
We have shown in our opportunities assessment report how the “first procure, later produce” strategy can be effectively implemented in the Mid Wales region. Our strategy is built on the basic premise that it would be a clever approach for the region to first create a market ecosystem for the low- and zero-carbon fuels identified in this study by first procuring these fuels in short- and medium-term (up to 2030) and in long-term partner with relevant stakeholders to locally produce these fuels in the region. To this end, we have explored ways to implement this strategy at business-, industrial-cluster-, industry-, and public-sector-level highlighting the **relevance, challenges, opportunities, and limitations** at different levels.

We have addressed the skills and capacity building challenge in the cleantech and renewable energy sectors, particularly in the hydrogen and hydrogen-based low- and zero-carbon fuel economy. In this feasibility study, we gathered insights that there is a significant skills gap in this sector in Wales, particularly in Mid Wales. This issue needs to be addressed strategically at the same time to ensure that the right talent is available at all levels, which includes an inclusive and diverse mix of people. We have already initiated dialogues with relevant government agencies and vocational and university educational institutions in Wales and Mid Wales during the course of this feasibility study to highlight and elevate this issue. More discussions should follow in this direction to initiate and develop relevant courses and training programmes at all levels from vocational training schools to research institutions to fill this gap in the coming years.

During the feasibility study, we found that many of the national and regional funds for developments related to hydrogen are mainly distributed in the North and South Wales region. That being said, contrary to the proverb, “hydrogen is not always greener on the other side!” This is probably the main “potential strength” of Mid Wales, which needs to be utilised to its fullest extent by attracting partnerships, developing value- and supply-chain mechanisms, and creating local demand in the short- to medium-term as part of the first-procure, later-produce strategy. The success of these short- and medium-term actions will prepare and strongly position Mid Wales to produce green hydrogen locally as part of the medium- to long-term development plan for the region. The decision makers in the region should prepare the region accordingly to attract investments through short- and medium-term actions.

We believe the outcomes of this feasibility report will strongly resonate with the stakeholders and decision makers in the region to drive change and progress in the Mid Wales. We take this opportunity to thank the Growing Mid Wales Board, Powys and Ceredigion Counties, and the funding agencies for giving us the opportunity to carry out this feasibility study.

We have provided an overview of targeted short- and medium-term actions that can form the basis for the long-term targeted goals for the Mid Wales region. The figure below highlights important milestones and actions.



Glossary

AD	Anaerobic Digester	H₂	Hydrogen
ADBA	Anaerobic Digestion & Bioresources Association	HVDC	High Voltage Direct Current
BEV	Battery Electric Vehicle	kWh	Kilowatt Hour
CAPEX	Capital Expenditure	LGV	Light Goods Vehicle
CCU	Carbon Capture and Utilization	LPG	Liquefied Petroleum Gas
CH₄	Methane (natural gas contains 70 – 90% methane)	MWh	Megawatt Hour
CH₃OH	Methanol	NH₃	Ammonia
CHP	Combined Heat and Power	NO_x	Nitrogen Oxides
CO	Carbon Monoxide	OPEX	Operational Expenditure
CODE	Cost Optimal Domestic Electrification	P2G	Power-to-gas
CO₂	Carbon dioxide	REPEX	Replacement Expenditure
COP	Coefficient of Performance	RHI	Renewable Heat Incentive
DEEP	Demonstration of Energy Efficiency Potential	ROI	Return On Investment
EU ETS	European Union Emission Trading System	SENS	Smart ENergy Savings Competition
EV	Electric Vehicle	SMR	Steam Methane Reforming
FEED	Front-End Engineering Design	SWIC	South Wales Industrial Cluster
GCRE	Global Centre of Rail Excellence	TEM	Techno-Economic Model
GMW	Growing Mid Wales	TWh	Terawatt Hour
GWh	Gigawatt Hour	UK	United Kingdom
GWP	Global Warming Potential	WMRIS	West Midlands Rail Investment Strategy
HGV	Heavy Goods Vehicle		

Orders of magnitude	Explanation
W	1 watt = 1 watt
kW	1,000 watts = 1 kilowatt
MW	1,000,000 watts = 1 megawatt
GW	1,000,000,000 watts = 1 gigawatt
TW	1,000,000,000,000 watts = 1 terawatt

Further reading

- [1] [UK Hydrogen strategy](#):
- [2] [Energy consumption at regional and local authority level](#), BEIS.
- [3] [Sub-national total final energy consumption in the United Kingdom \(2005 – 2018\)](#).
- [4] [Achieving Net-Zero Carbon by 2030](#).
- [5] [Powys Decarbonisation Strategy](#).
- [6] [Mid Wales Energy Strategy](#).
- [7] [Mid Wales Applied Research and Innovation Study](#).
- [8] [Social research with installers of heating systems in off gas grid areas of England and Wales](#).
- [9] [Midlands Regional Transport Hubs Midlands Energy Hub](#).
- [10] [Unicorn or Silver Bullet? Filling evidence gaps on decarbonising heat: Department of Business, Energy and Industrial Strategy \(BEIS\), UK Government](#)
- [11] [Hydrogen in a low-carbon economy](#)
- [12] [Energy Generation in Wales 2019](#)
- [13] [Path to hydrogen competitiveness: A cost perspective](#)
- [14] [A VISION FOR GROWING MID WALES: Strategic Economic Plan & Growth Deal Roadmap](#)
- [15] [Hydrogen in Wales](#)
- [16] [Batteries or Hydrogen? – RiverSimple](#)
- [17] [Green hydrogen is vital in decarbonising the hard-to-abate sectors](#)
- [18] <https://www.regen.co.uk/regen-responds-to-the-uk-hydrogen-strategy/>
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