HyLine Cymru – Phase 2

Net Zero pre-construction Work and Small Net Zero Projects Re-opener submission

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2 "Project on a Page"

Adeiladu'r biblinell i sero net yn Ne Cymru

Building the pipeline to Net Zero in South Wales

HyLine Cymru's vision is to deliver the low carbon hydrogen needed to support the decarbonisation of industry in South West Wales, one of the biggest clusters in the UK, which is currently responsible for a substantial proportion of Wales' carbon emissions. This groundbreaking project will enable the development of hydrogen production and industrial fuel switching by doing what Wales & West Utilities (WWU) do best – expertly connecting customers to the energy they need, whilst investing wisely to create a sustainable, greener future.

Growing from the collaboration of South Wales Industrial Cluster (SWIC) partners, HyLine Cymru is a proposal to build a new 130km hydrogen pipeline across South Wales from Pembroke to Port Talbot. This pipeline will help unlock up to 3GW of offshore wind in the Celtic Sea by providing a route to market for clean energy producers, whilst transporting a homegrown low-carbon energy source to WWU's hard-to-decarbonise customers and contributing to long term energy security in the region. As well as offering value to current industry, HyLine Cymru will also attract new industry, and directly support local authorities to deliver their Local Area Energy Plans (LAEP), helping Wales achieve its vision for the future.

With support from Welsh Government and local industry, the project aims to support national commitments to deliver a cleaner, greener and fairer Wales. This means changing the way energy is produced and used at home, in industry and for travel. One of the largest and most challenging sectors to decarbonise is heavy industry. South Wales has a rich industrial heritage; it is home to industries such as cement, paper, steel, nickel, mineral wool, and chemicals. It also has a diverse energy supply sector, including power stations, onshore wind sites and Liquified Natural Gas (LNG) terminals capable of supplying over 20% of the UK's natural gas demand. The project supports this heritage by progressing the critical transport infrastructure required to move low-carbon hydrogen from points of production, to points of end use, where customers can benefit the most and where decarbonisation can be maximised at least-cost.

The project recognises the need to invest for the future to decarbonise industry whilst protecting communities, jobs and the economy in Wales and beyond. Whilst current infrastructure, such as that used for LNG imports, is needed to maintain existing supplies of energy and support our national energy security strategy, new infrastructure is needed to transition towards the ability to deliver low-carbon hydrogen at scale.

This phase of the project is eligible for funding under the Ofgem Net Zero Preconstruction Work and Small Net Zero Projects Re-opener (NZASP) mechanism, which will enable progression to a Final Investment Decision (FID) in 2028. Following this, it is intended that the project progresses into Round 2 of the DESNZ Hydrogen Transport Business Model (HTBM) to enable construction and project completion by 2033.

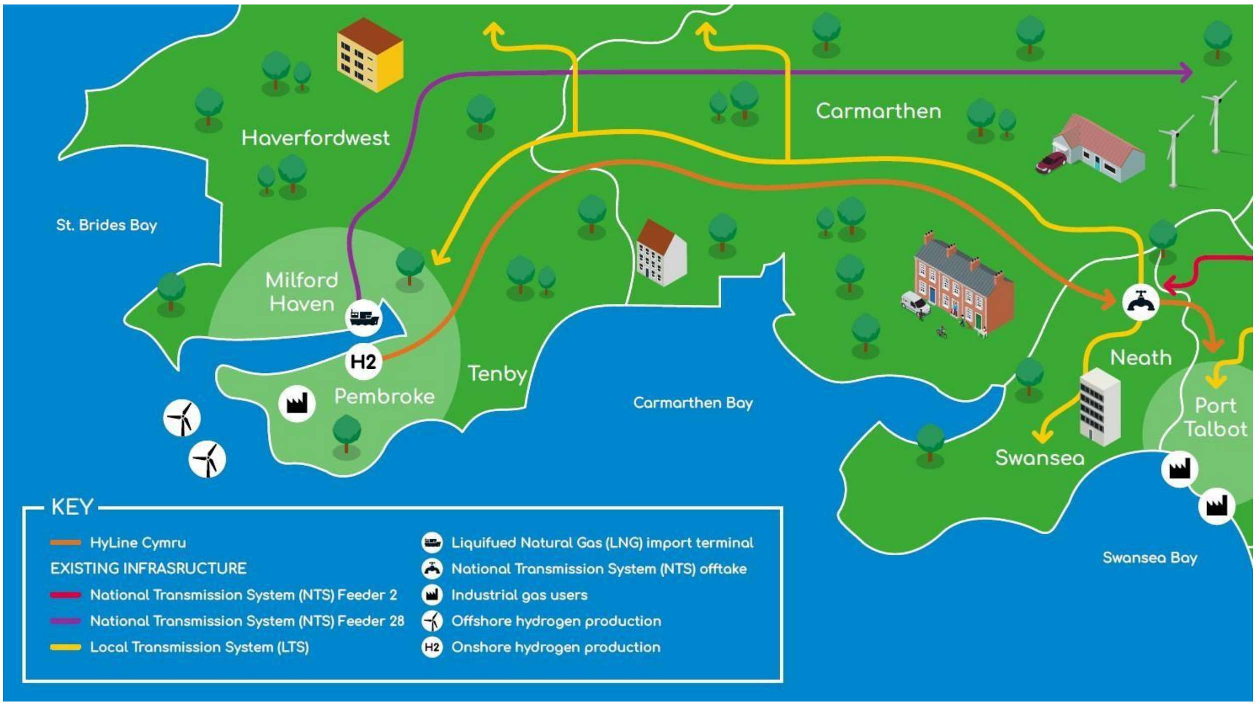


Figure 1 Proposed HyLine route

3 Re-opener Map

Table 1 outlines where each section of this application relates to Special Condition 3.9 of our Gas Transporter licence, as well as Ofgem's requirements as set out in Special Condition 9.4.

Ofgem Requirement	Application Chapter/Section
Special Condition 3.9 Net Zero Pre-Construction Work and Small Projects Re-opener (NZPt)	
Support the achievement of Net Zero (3.9.1)	Section 5
Application Requirements (3.9.4 a-d)	Throughout
Re-opener Guidance and Application Requirements document (Feb 2023)	
Introduction	
Para 3.1 – Why adjustment / What is adjustment	Section 5
Para 3.2	N/A – generic guidance note
Para 3.3 – Non-conformance justification	N/A
Para 3.4 – Re-opener map	This Section
Para 3.5	N/A – generic guidance note
Gas Distribution Sectors	
Para 3.6	N/A – generic guidance note
Para 3.7 – Materiality threshold	Section 5.6.3 & 5.6.4
Needs case and preferred option	
Para 3.8 – Needs case	Section 5
Para 3.9	N/A – generic guidance note
Para 3.10 – Alignment with strategy & RIIO-GD2	Section 6.1
Para 3.11 – The problem and background	Section 5.2 & 6.2
Para 3.12 – Rationale for expenditure	Section 5.6.4, 12 & 14
Para 3.13 – Options and method of selection	Section 8
Para 3.14 – The preferred option	Section 10
Para 3.15 – Phase 2 scope & project delivery plan	Section 11 & 12 (FEED Lite Appendix I)
Para 3.16 – Stakeholder engagement (supply/demand)	Section 7
Para 3.17	N/A
Para 3.18	N/A
Cost information	
Para 3.19 – Cost justification	Section 5.6.3, 12, 13 & 14 (FEED Lite Appendix I)
Para 3.20 – Cost evidence	Section 12, 13 & 14 (FEED Lite Appendix I)
Para 3.21 – Cost estimating guidance compliance	Section 12
Cost benefit analysis and engineering justifications	
Para 3.22 – CBA & EJP	Section 9 & 14
Para 3.23	N/A – generic guidance note.
Net Zero Pre-Construction Work and Small Projects Re-opener Governance Document (March 2023)	
Scope and Eligible Projects (para 2.1 to 2.3)	Section 5.6.3
Materiality Threshold (para 2.4 to 2.6)	Section 5.6.3 & 5.6.4
Process (para 2.7 to 2.9)	N/A – generic guidance note
NZASP Contribution (para 2.10 to 2.13)	Section 5.6.5

Table 1 Re-opener map

4 Executive Summary

HyLine Cymru is a proposal for a new build 130km hydrogen pipeline running from Pembroke to Port Talbot which will connect our hard-to-decarbonise industrial customers with low-carbon hydrogen. Wales & West Utilities has been working to develop HyLine Cymru as part of the South Wales Industrial Cluster (SWIC) since 2021.

Working in close partnership with organisations within SWIC, we have identified the need for new hydrogen pipeline infrastructure in South Wales to help deliver net zero emissions while retaining industrial businesses and developing new economic and employment opportunities. This is endorsed by industry within the SWIC Cluster Plan[1], and most recently by UK Research and Innovation (UKRI) reporting[2] on the progress of the Industrial Decarbonisation Challenge, where both publications demonstrate how HyLine Cymru is critical to the decarbonisation of South Wales industry. It is also recognised in regional Local Area Energy Plans.

We are applying for funding for £23m (2018/2019 prices) to undertake a "Base Case" option, **or** a "FEED Lite" option for Phase 2 (FEED, Planning and Land Rights) of the HyLine Cymru project, with WWU contributing 10% in both cases. The "Base Case" option is the preferred pathway forward and presents best overall value to customers, covering Front-End Engineering Design (FEED), obtaining planning consent and acquiring the necessary land rights to reach a Final Investment Decision (FID). The FEED Lite option is a cut-back version of the Base Case, documented in Appendix I with a funding requirement of £6m (2018/2019 prices). Section 7 explains the structure of each Phase 2 delivery option.

Following Phase 2, it is intended that the project progresses into Phase 3 which is the detailed design and construction phase. It is expected that Phase 3 of the project shall be eligible for Round 2 of the DESNZ Hydrogen Transport Business Model (HTBM) to enable construction and project completion by 2033.

The pipeline directly supports Welsh Government's ambition to create a cleaner, greener and fairer Wales by delivering energy security and resilience to industry and beyond. Low-carbon hydrogen will offer a cost-effective solution for the five cornerstone offtaker sites which form the basis of demand in Llanelli and Port Talbot, whilst three hydrogen producers will produce hydrogen in and around Pembroke where it will enter the pipeline. This proposal is supported by both the private and public sector, including unanimous support across all four Local Authorities, where HyLine Cymru has formed a fundamental part of each developing Local Area Energy Plan (LAEP).

The project also aligns with the ambitions of UK Government's recent Invest 2035: The UK's Modern Industrial Strategy[3] which outlines likely targets in growth-driving sectors such as advanced manufacturing and clean energy industries. The strategy recognises the need for energy and infrastructure, stating that 'infrastructure underpins all economic activity by connecting people, goods, services, energy, and ideas.' This is the first crucial step in regional hydrogen pipeline infrastructure, and can also support national initiatives such as Project Union.

Upon delivery, HyLine Cymru will form part of SWIC's plans to achieve net zero industries in South Wales by 2040: equating to 40% reduction of current Welsh CO2 emissions. SWIC also aims to retain 113,000 jobs in industry, unlock £30bn in investment opportunities and grow the £6bn Gross Value Added from South Wales industry.

By enabling the decarbonisation of multiple hard-to-decarbonise industrial sectors in the UK's largest industrial cluster, HyLine Cymru has the potential to unlock wider system benefits for the South Wales region and beyond, positioning Wales as a pioneer in hydrogen production, transportation, and use.

WWU's board of directors have approved this application for funding under both cost options.

Phase 2 Scope option	Delivery cost (£m) 2018/19 prices	Delivery cost (£m) 2024/25 prices
Base Case	23.02	29.32
FEED Lite	6.21	7.92

Table 2 Summary of cost options

A summary of the funding request for both options can be found in Section 6.6.4.

A detailed breakdown of the Base Case option can be found in Section 13.7, and a detailed breakdown of the FEED Lite option can be found in Appendix I. See Appendix A for a full breakdown of activities and costs for each option.

[1] SWIC Cluster Plan: A Plan for Clean Growth (swic.cymru)

[2] Enabling net zero: progress on decarbonising UK industrial clusters (ukri.org)

[3] Invest 2035: The UK's Modern Industrial Strategy (publishing.service.gov.uk)

5 Needs Case – Why HyLine Cymru?

5.1 Net Zero Commitment

HyLine Cymru and the commitments of South Wales Industrial Cluster partners have been developed in response to environmental and legislative imperatives to decarbonise. The UK Climate Change Act 2008[4] commits the United Kingdom to a legally binding target of reducing greenhouse gas emissions to Net Zero by 2050. Initially, the Act mandated an 80% reduction in emissions from 1990 levels by 2050, but this was amended in 2019 to the more ambitious net zero goal. The Act establishes a system of five-yearly carbon budgets to set interim targets and ensure steady progress. It also created the Committee on Climate Change, an independent body tasked with advising the government and reporting on progress towards meeting the targets, thus ensuring accountability and informed decision-making in the UK's climate policy.

The UK's Sixth Carbon Budget[5], published in December 2020, sets the emissions reduction target for the period 2033-2037, aiming for a 78% reduction in greenhouse gas emissions by 2035 compared to 1990 levels. This ambitious target aligns with the UK's overarching goal of achieving Net Zero emissions by 2050. The Sixth Carbon Budget includes comprehensive measures across various sectors, including energy, mobility, buildings, industry, agriculture, and land use. It emphasises the need for rapid deployment of low-carbon technologies, increased energy efficiency, and significant changes in consumer behaviour. The budget also highlights the importance of innovation and green investment to drive the transition to a sustainable, low-carbon economy, ensuring that the UK remains on track to meet its long-term climate commitments.

Figure 2 HM Government strategy and planning papers

[4] Climate Change Act 2008 (legislation.gov.uk)
[5] Sixth Carbon Budget - Climate Change Committee (theccc.org.uk)

The UK's policy for achieving Net Zero by 2050 heavily emphasises the role of hydrogen as a key component in its decarbonisation strategy. The UK Hydrogen Strategy, published in 2021[6], sets an ambitious target of 5GW of low-carbon hydrogen production capacity by 2030 which was later revised to 10GW. The policy supports both green hydrogen, produced using renewable energy, and blue hydrogen, derived from natural gas with carbon capture and storage. To drive this transition, the government has introduced funding mechanisms such as the Net Zero Hydrogen Fund and the Hydrogen Business Model, to incentivise production and reduce costs. Hydrogen is seen as crucial for decarbonising hard-to-abate sectors like industry, mobility, and heating, with investments in infrastructure, such as hydrogen hubs, transportation and storage.

Since the election of a new government in July 2024, political commitments to decarbonisation have been reemphasised by the introduction of Great British Energy which will invest in new renewable energy projects, and targets for net zero power brought forward from 2035 to 2030. This movement emphasises the need for investment in all areas of our energy system. HyLine Cymru will support the delivery of net zero in sectors which would otherwise be difficult to decarbonise.

5.2 Problem Statement

South Wales is home to major industries including steel, cement and chemical production, among others. These include hard to decarbonise industries where the role of hydrogen is recognised by the Heat Strategy for Wales as industries which will be dependent on hydrogen for high-temperature processes, and where electrification is not feasible or is too costly. At present there is no significant infrastructure for the cost-effective transportation of hydrogen in South Wales. This stifles the development of demand opportunities in locations where the necessary resources and infrastructure aren't available to produce hydrogen locally, and production opportunities where resources are available and abundant but where production outstrips demand. With nothing in place to provide this service, both sides of the hydrogen market will struggle to develop further, and South Wales grid operators may be at risk of costly curtailment payouts for new renewable projects which aren't able to produce and export energy as seen in other areas of the UK[7].

Therefore, investment in this area is of utmost importance to kick-start the South Wales hydrogen economy. Through our participation in the South Wales Industrial Cluster (see 8.2.3), ongoing engagement with local industry has identified five offtakers with the combined requirement for up to 178 tonnes per day of hydrogen. This demand, through the HyLine Cymru pipeline, is linked to three hydrogen producers who will provide the hydrogen needed.

The requirement for hydrogen in South Wales is therefore clear and expansive, but now requires the development of enabling transport infrastructure as recognised and endorsed by the SWIC Cluster Plan, and as strengthened by the 29 public and private organisations who have demonstrated their direct support in Appendix F.

Decarbonising existing industries, which are significant to the region's economy and employment, and attracting new development with low carbon energy sources, are central to the vision of the Welsh Government and regional and local authorities.

The UK Government's Hydrogen Allocation Round 1 (HAR1) provides funding and support to hydrogen producers as part of the broader strategy to promote low-carbon hydrogen production. A key component of the eligibility criteria for HAR1 funding is the Commercial Readiness – Market Demand criteria, which requires producers to demonstrate market demand though letters of intent or agreements from potential customers. HAR2 is currently in development but will likely have similar constraints. The lack of a transportation network acts as an impediment to the pairing of producers with offtakers, in effect blocking a significant funding mechanism for hydrogen producers. The original Needs Case was presented to Ofgem in April 2024 and was accepted in May 2024. This reopener builds on the Needs Case which can be found in Appendix B.

[6] UK Hydrogen Strategy (publishing.service.gov.uk)
[7] UK spent just under £1bn in curtailment costs last year (utilityweek.co.uk)

5.3 Why a Pipeline?

5.3.1 Overview

HyLine Cymru is a proposal to build a new 130km hydrogen pipeline across South Wales which could be delivered by 2033, in response to the need for low-carbon hydrogen as an option for industry to decarbonise their processes and the UK Hydrogen Strategy to have measures in place for regional hydrogen networks in place by the mid-2030's. The regional pipeline will transport hydrogen from Pembroke to Port Talbot where it will connect with a range of consumers across the South Wales Industrial Cluster (SWIC). This pipeline will help unlock up to 3GW of offshore wind in the Celtic Sea by providing a route to market for clean energy producers, whilst transporting a homegrown low-carbon energy source to hard-to-decarbonise WWU customers. As well as offering value to industry, HyLine Cymru will also help local authorities deliver their Local Area Energy Plans, helping Wales achieve its vision for the future.

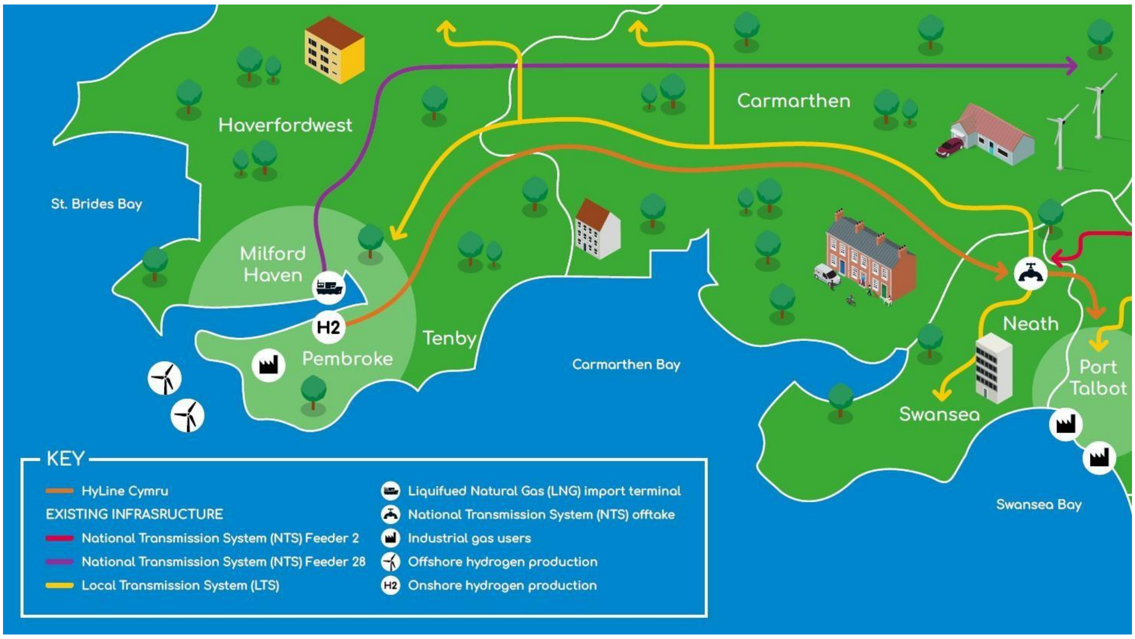


Figure 3 HyLine Cymru

The proposed development of the Celtic Sea for wind power and location of the two LNG terminals in Pembroke, which supply over 20% of the UK's natural gas demand, make Pembroke a very attractive location for the production/supply of both green and blue hydrogen. The cornerstone industrial offtakers are located in the Llanelli, [redacted] region of Port Talbot ~100-125km from Pembroke. Along this route i[redacted], one of three WWU sites which provide natural gas to existing customers in South Wales. Whilst the direct link to an existing natural gas offtake is not a core component of HyLine Cymru, within its initial period of operati[redacted] through which future blending and hydrogen conversion opportunities could be unlocked for the South Wales Network or nationally via Project Union, depending on the future direction of policy.

Various hydrogen transportation options were considered, which are discussed further in Section 8. Given the quantity of gaseous hydrogen that is required to be transported from the point of production to the offtakers, a pipeline is the only practical method for transportation. At present, transport by road or rail requires the use of tube trailers whose storage capacity would be insufficient for this application, nor resilient and reliable enough given road types and conditions in the region. An over-land pipeline was chosen over a subsea pipeline due to the licensing considerations, lower cost and opportunities presented for future additional offtakers, which would not be viable with a subsea pipeline. There are no existing pipelines which are suitable for conversion to hydrogen service, thus a new pipeline will be required. The only existing natural gas pipeline with the flow of gas running east from Pembroke, National Gas Feeder 28, is a critical component of the existing natural gas transmission system, which is likely to make it unavailable for conversion to hydrogen in the required timeframe given its criticality to national and European security of supply.

The project will support 2050 Net Zero targets by developing a core hydrogen pipeline as outlined by the National Infrastructure Commission. It also aligns with the UK Government's Ten-Point Plan for a green industrial revolution by driving the growth of low-carbon hydrogen and helping to bring down emissions in vital UK industrial sectors by providing flexible energy for power, heat and mobility as outlined in the UK Government Hydrogen Strategy.

Research on regional decarbonisation pathways across Wales and the South West of England, outlined three scenarios which consider high electrification, high hydrogen and balanced scenarios to meet the current UK Carbon Budgets. For the UK to meet this national goal, it needs to reduce industrial emissions by at least 90% by 2050, half of which are industrial cluster emissions (32 MtCO2e) from industrial sites.

South Wales represents the largest UK industrial cluster which has led to the formation of SWIC. WWU is one of 47 collaborators and a funding partner across both “Cluster Plan” and “Deployment” projects. The Cluster Plan project identified the technologies and infrastructure required to achieve net zero industry in South Wales, including new hydrogen pipeline infrastructure. The follow-on Deployment project allowed partners to progress projects through Feasibility and FEED studies, where WWU progressed HyLine Cymru through the initial Phase 1A Feasibility.

As well as offering collaborative value at established industrial sites, HyLine Cymru will also help local authorities deliver and strengthen their Local Area Energy Plans (LAEP) mentioned specifically as a key action in plans produced by Swansea City Council[8], Carmarthenshire County Council[9] and Neath Port Talbot County Borough Council[10] as a key pathway to help them realise their net zero ambitions.

The LAEPs developed in all Welsh local authorities provide a strategic roadmap to enable regions to decarbonise their energy systems by 2050, HyLine will support this strategy by providing a large scale source of hydrogen to each authority area. This in turn will provide an additional decarbonisation solution for existing industry but also new industry, helping Wales achieve its vision for the future and a just transition. The presence of the pipeline within these local authorities will also offer future opportunity for hydrogen usage in other settings such as commercial, domestic and possibly mobility.

5.3.2 Customer Requirements and Decarbonisation Plans

HyLine Cymru is supported by a strong group of regional private sector hydrogen offtake and production projects.

Collaboration with SWIC partners, as well as with organisations who are external to the cluster but have interests in hydrogen, has enabled us to build a project consortium with public and private sector organisations. The commitment of these organisations in developing the project through Phase 1A Feasibility demonstrates the technical deliverability of HyLine Cymru, but also the importance of the project in ensuring that WWU’s existing and new customers can meet their decarbonisation goals.

Stakeholder milestones:

- November 2022: Project publicly launched with partners and Feasibility work started.
- March 2023: HyLine recognised as critical to the success of the SWIC Cluster Plan.
- October 2023: Project presented to Welsh Government and at key industry events.
- November 2023: 12 months of Feasibility, environmental and planning work completed (Phase 1A).
- January 2024: Launch of public feasibility report in Senedd with support from Plaid Cymru.
- February 2024: Briefings held with and support from all four Local Authorities.
- March 2024: Start of transportation agreements and pre-consenting work (Phase 1B).

The key hydrogen producers and offtakers are listed below:

Hydrogen producers		Hydrogen offtakers	Offtaker industry
RWE		Heidelberg Materials	Concrete
Dolphyn Hydrogen		Tata Steel	Steel
H2 Energy Europe	**HyLine Cymru**	LanzaTech	Sustainable Aviation Fuel
		Sofidel	Paper
		Vale	Nickel

Table 3 Hydrogen producers and offtakers

[8] Swansea Local Area Energy Plan 2024 (swansea.gov.uk)
[9] Carmarthenshire Local Area Energy Plan 2024 (gov.wales)

[10] Neath Port Talbot Local Area Energy Plan 2024 (npt.gov.uk)

> **What is the HUG?**
>
> "HyLine User Group", was established as a working group to develop the connections of hydrogen producers and offtakers and to coordinate their respective development projects. For more information see Section 7.1.2.

Each of the potential offtakers currently use natural gas for their energy intensive production processes and are looking to decarbonise this function as part of their net zero plans. The project has engaged directly with these parties to establish use cases, demand profiles, and to aid in the process of pairing producers and offtakers as currently required by the HAR subsidy mechanism. This work was initially carried out through SWIC and then through the HyLine User Group (HUG). Further detail can be found in section 7.1.2. During the project, Tata Steel has announced plans to adopt Electric Arc Furnaces for the replacement of the existing blast furnaces, which has influenced the hydrogen demand profiles adopted. This is discussed in more detail in the following sections of this re-opener application. Further producers and offtakers are considered likely to emerge throughout the course of the project, however the core proposal is based on the firm information available at this stage. Work to onboard additional hydrogen offtakers will continue through the HyLine User Group (HUG) initiative.

The three hydrogen producers that have been engaged with all favour green hydrogen production from renewable power sources. This will act as a significant driver in the unlocking of offshore wind generation in the Celtic Sea.

Further discussion on the major supply/demand stakeholders and the demand envisaged is presented in Section 6.2 and Section 7 respectively.

5.4 Project Impact

HyLine Cymru will unlock opportunities for hydrogen production and demand in South Wales. It will be an enabler for thousands of jobs indirectly through new energy production facilities and new industrial plants. HyLine serves as a driving force behind Welsh and UK decarbonisation goals. Aligned with the UK government's strategic directives, including target for 10GW of hydrogen production by 2030, HyLine stands at the forefront of infrastructure delivery. By enabling seamless, large-scale, and low carbon hydrogen transportation, it propels Wales and the UK toward a greener, net zero future.

The following presents the key expected benefits of the HyLine Cymru hydrogen pipeline project:

- Remove up to 10% of Great Britain's industrial emissions (3.2MtCO2/y)
- Protect or create thousands of high skilled jobs in South Wales
- Provide UK industry with a cost effective path to decarbonisation
- Put Wales at the forefront of the emerging hydrocarbon economy
- Contribute £billions GVA over its operational lifetime
- Unlock up to 3GW of offshore wind generation
- Supports Pembroke Dock Marine[11] project by boosting the potential development opportunities of the Celtic Sea floating offshore wind and marine energy

For a list of linked and supporting projects see Appendix G.

The results of the Cost Benefit Analysis (CBA) can be found in Section 15.

5.5 Wider Benefits

5.5.1 HyLine Benefits Wales

Hydrogen is being considered for hard-to-decarbonise industry in Wales. Specifically, where electrification is not feasible or is too costly, which includes the generation of high temperature heat required in industrial furnaces. It also has a diverse energy supply sector including power stations, onshore wind sites and two LNG terminals supplying over 20% of the UK's natural gas demand.

HyLine Cymru will support the commitment to delivering a cleaner, greener, and fairer Wales alongside UK Government commitments in net zero, energy security, and direct action in delivering against the national Hydrogen

[11] Pembroke Dock Marine (mhpa.co.uk)

Strategy. To achieve this, we need to change the way we produce and use energy for industry, mobility, power generation and in homes.

Figure 4 Benefits for People and Planet

The HyLine project will facilitate access to affordable hydrogen in South Wales, helping to support economic growth and tackling industrial decarbonisation head-on, whilst safeguarding and creating both local and national jobs, and innovation in industries who are reliant on secure and sustainable energy sources to meet their net zero commitments. This is particularly true for the heavy industries of steel, concrete and paper production which are major employers in the region.

By providing an alternative green energy source it also fosters competition among energy providers, ultimately lowering costs for consumers and improving service quality. Support for the HyLine project will demonstrate a commitment to the inclusivity of Wales in the net zero journey and avoid the potential for negative market signals which could push delays in regional decarbonisation plans.

We recognise the need to invest for the future to decarbonise industry whilst protecting communities, jobs and the economy in Wales and the UK.

5.5.2 HyLine supports a Net Zero energy system

The UK government has adopted a legally binding commitment to achieve "Net Zero" greenhouse gasses by 2050. Significant changes to the UK energy sector need to happen to facilitate this. Wales as a region contributes close to 19% of the UK industrial emissions, while South Wales is the second largest UK industrial cluster, contributing around 12% of all UK industrial emissions. With 93% of these emissions coming from 25 sites, investing early in Welsh hydrogen transport infrastructure has a significant role to play in achieving the UK's Net Zero commitment. As noted above, following the general election in July 2024 political commitments to decarbonisation have been reemphasised by the new UK government.

Given the project benefits are at a national level, it is fair that the project Phase 2: FEED, Planning and Land Rights study is funded at a national level.

5.5.3 HyLine Supports Energy Security

HyLine helps facilitate the British Energy Security Strategy which promises to bring clean, affordable, secure power to people for years to come. Transitioning to a hydrogen inclusive energy system protects consumers from future global price spikes associated with more traditional imported energy sources, by enabling “local” energy production. Consumers benefit from greater financial security and confidence for clean energy availability. Access to affordable, low-carbon hydrogen enables the industrial & commercial (I&C) and power sectors to invest and expand, which reduces demand for imported energy and could help stimulate export opportunities for UK-produced low-carbon hydrogen and low-carbon industrial products in international markets.

The project aligns with the UK Government’s strategy to support deployment and use of low carbon hydrogen infrastructure for future demand, including the increased 10GWs of hydrogen production targeted by 2030. By doing what Wales & West Utilities (WWU) do best, we can expertly connect our consumers with energy whilst investing wisely to create a sustainable, greener future.

5.5.4 UK Wide Context: natural gas, hydrogen and Project Union

The UK has an extensive network for the transmission and distribution of natural gas, delivering around 600TWh of gaseous fuel to domestic, commercial and industrial consumers, and almost 300TWh to generate electricity during period of peak demand. In energy terms, the UK uses around three times more gas than electricity, with around 85% of households using gas as their primary source of heating. In South Wales, 71% of households use gas as their primary source of heating, putting a clear emphasis on the need for alternative sources of heat in the future and the critical infrastructure to support this. We, as Wales & West Utilities, are undertaking a major programme of change to support decarbonisation and deliver a net zero gas network.

A clear and coordinated pan-UK strategy for hydrogen and carbon capture and storage (CCS) is yet to be established, to facilitate large-scale hydrogen transportation and storage for industry. This should build on the Future Energy Networks Hydrogen Vision for the UK, along with nationally significant projects such as HyLine Cymru and Project Union.

Project Union[12] is a separate project being led by National Gas (as the gas transmission network), which plans to build a hydrogen transmission backbone in the UK to connect hydrogen production and storage to industrial demand centres by the 2030s, with the option to expand to other consumers in the future. Currently, the hydrogen backbone is planned to connect to South Wales and extend to Milford Haven in the west of the region. Whilst Project Union remains in its early stages, we have worked closely with National Gas to de-risk a future interconnection through the proposed HyLine Cymru link to WWU’s existing [redacted] and the National Gas Feeder 2 pipeline. This anticipatory design feature will benefit both projects once the South Wales transmission system moves to 100% hydrogen. Our evidence suggests that there is a need for local hydrogen transmission infrastructure, driven by industrial decarbonisation, designed alongside national hydrogen transmission infrastructure. We will continue to work closely with the National Gas team as HyLine Cymru progresses into Phase 2: FEED, Planning and Land Rights.

5.6 Funding & Policy Justification

5.6.1 Background

Whilst WWU’s RIIO-GD2 business plan allowed for the funding of supportive innovation projects associated with the development of local hydrogen transmission infrastructure, as described in Section 5.6.2, the plan doesn’t include any allowance or funding at the required level to progress the HyLine Cymru project through the associated FEED, planning and land option agreement activities which form this Phase 2: FEED, Planning and Land Rights proposal.

Early estimation identified that progressing the project to Phase 2: FEED, Planning and Land Rights (Section 6.4) will require a budget in excess of the £1M materiality threshold to trigger this reopener and the £2m materiality cap of the Net Zero and Re-Opener Development Fund (NZARD) Use It Or Lose It (UIOLI) mechanism as detailed in Section 5.6.3. Thus, the NZASP mechanism remains the only option to progress the project.

[12] Project Union (nationalgas.com)

5.6.2 Costs to Date

We have used multiple funding approaches to progress the projects that have influenced the development HyLine Cymru.

- Network Innovation Allowance (NIA): this funding mechanism facilitates the energy system transition and has allowed us to develop new learning and model the different regional pathways and assess infrastructure planning in untested areas.
- Net Zero and Re-opener Development use-it-or-lose-it allowance (NZARD UIOLI): this funding facilitates net zero early development work and has allowed us to explore feasibility and pre-consenting before developing into a re-opener.
- UK Research and Innovation (UKRI): this funding was secured through various funding sources including the Industrial Decarbonisation Challenge and Launchpad: net zero industry, South West Wales, amongst others.

The project costs to date for each funding mechanism are presented in both tables 4 and 5 below.

- Table 4 details the core projects that have directly contributed to the development of the HyLine Cymru proposal to date. These projects have provided the research and development needed to support strategic direction, engineering design and cost estimation. They have also supported the build-up of key evidence to support the necessary expenditure through Phase 1 Feasibility and Planning Options, up to the point of submitting this reopener.
- Table 5 details additional projects which complement HyLine Cymru and supplement WWU's understanding of the hydrogen market and technical implications of a network transition to hydrogen. The evidence provided through this work has supported the development of HyLine Cymru in a number of key areas, including non-pipeline transportation, above ground storage and storage vessel repurposing, and historical lessons regarding the transition of industrial and commercial customers to alternative fuels.

Project title	Delivery partner	NIA Cost**	NZARD UIOLI cost	UKRI cost	Year of spend
SWIC Hydrogen Supply Pipeline Infrastructure	Costain	[redacted]	[redacted]	[redacted]	2021
SWIC Assessment of potential hydrogen demand in 2030-2050	Progressive Energy	[redacted]	[redacted]	[redacted]	2021
Regional Decarbonisation Pathways	Energy Systems Catapult, Costain	[redacted]	[redacted]	[redacted]	2021-22
Potential for Salt cavern storage of hydrogen in and near South Wales	Progressive Energy	[redacted]	[redacted]	[redacted]	2022
HyLine Feasibility 1B study	Apollo, ERM, Mabbett, FGP	[redacted]	[redacted]		2022-23
HyLine Planning and Legal Delivery Strategy	Turley	[redacted]	[redacted]		2023
*HyLine Phase 1B Offtaker agreements and pre-consenting	Apollo, ERM, Burges Salmon, Gardiner & Theobald	[redacted]	[redacted]		2024
*OptiFLOW	Arup	[redacted]	[redacted]	[redacted]	2024-25
	Totals	**£1,339,951**	**£937,240**	**£249,527**	

Table 4 Core project costs to date and inflight projects
(indicates work is ongoing or planned – quoted costs are forecast only)*
*(** indicates figures taken from the NIA project registration & PEA document)*

Project title	Delivery partner	NIA cost**	NZARD UIOLI cost	UKRI cost	Year of spend
SWIC Market-Accelerating Hydrogen Distribution and Storage	Costain	[redacted]	[redacted]	[redacted]	2021
Storage vessels	National Composites Centre	[redacted]	[redacted]	[redacted]	2023
Lessons Learnt: Past Energy Transitions in the Gas Industry	WSP	[redacted]	[redacted]	[redacted]	2023
*Gas Separation within UK Gas Networks	ERM	[redacted]	[redacted]	[redacted]	2024
*Sensitive I&C Users	Costain	[redacted]	[redacted]	[redacted]	2024-25
*Application of Function Blending Specification	TBC	[redacted]	[redacted]	[redacted]	2024-25
	Totals	**£599,013**		**£49,727**	

Table 5 Complimentary project costs to date
(indicates work is ongoing or planned – quoted costs are forecast only)*
*(** indicates figures taken from the NIA project registration & PEA document)*

5.6.3 Eligibility

The NZASP Governance Document section 2.2 sets out project eligibility criteria which includes:

- Early development, design and general pre-construction work that will enable the achievement of Net Zero Carbon Targets;
- Front-End Engineering Design (FEED) studies, conceptual design Feasibility and general feasibility work required for large capital projects;
- Net Zero projects that exceed the £2m materiality cap of the Net Zero and Re-opener Development use-it-or-lose-it allowance (NZARD UIOLI) or are otherwise not suitable for the NZARD UIOLI; and
- Net Zero facilitation (green gas and hydrogen) projects and hydrogen projects that are required as part of the Department for Business, Energy & Industrial Strategy Hydrogen Grid Research and Development Programme, including projects that may be interpreted as innovative – where there is a clear need, and it is appropriate for network consumers to fund.

The re-opener has been triggered by the authority under Special Condition 3.9, and HyLine Cymru meets the criteria for applying for this reopener under Special Condition 3.9.4 items a) and c):

a) It is a Net Zero Pre-construction Work or Small Net Zero Project that will support the achievement of Net Zero Carbon Targets;

c) The effect, or estimated effect, of the Net Zero Pre-construction Work or Small Net Zero Project on the cost of Licensed Activity exceeds the materiality threshold of £1m but does not exceed £100m.

The funding should be treated according to the rules of the NZASP - Pre-Construction & Small Projects re-opener, noting that timelines will require the project to cross regulatory price control periods from RIIO-GD2 into RIIO-GD3 requiring consideration of the whole project cost over the price controls and any bridging allowances via true-up at closeout of RIIO-GD2 or setting of RIIO-GD3.

5.6.4 Funding Request

The Net Zero and Small Projects re-opener mechanism has a broad scope, however, through discussions with Ofgem throughout the course of the needs case submission and clarifications, Ofgem have highlighted to WWU that there could be potential limits to the funding available through the NZASP re-opener mechanism, particularly with costs that fall into the RIIO-GD3 price control timeline. Ofgem have advised they are in discussion with DESNZ on how future funding may be allocated under the HTBM mechanism, which is still in development at this time. As such, we are submitting two potential options for consideration as part of this NZASP reopener, a Base Case option which is detailed in full throughout this document, and a FEED Lite option which is referenced within this document but detailed in full within Appendix I.

The first option is our base case for the full scope of works, which is our recommended option as we believe this is the most cost-effective approach for the consumer, as it includes everything required to enable a final investment decision at the end of the project. Further funding support would then be sought through the DESNZ HTBM mechanism to undertake detailed design, remaining planning activities and pipeline construction. The base case option would minimise any rework requirements which would be required if planning and land rights were secured at a later stage. Most funding for the base case option sits within the RIIO-GD3 price control period, so we have also included a second option.

The second option is a FEED Lite approach, which would be a minimised scope to cover delivery essentials for a FEED study only alongside some supportive planning and survey work where necessary to inform the FEED study.

Our recommended option is the base case on the basis of cost effectiveness over the lifetime of the project, primarily due to the increased likelihood for rework as planning and land rights would be secured at a later stage. FEED Lite would however enable the project to complete the feasibility and strategy stages. This option would leave a funding gap between the FEED Lite option work packages which would otherwise be undertaken as part of the Base Case option. At the time of writing, it is anticipated that this gap would ultimately be supported by the HTBM funding mechanism in addition to the funding required for the pipeline detailed design, procurement, remaining planning activities and construction, with the option for a stage gate between final investment decision and construction.

Details of both options are outlined in Table 6 below:

Approach	Description
Base Case – Recommended option (Figure 5)	This option takes the project from its current status all the way through to the point of Final Investment Decision (FID). It represents the most cost-efficient option due to the continuous pathway to FID. Furthermore, it also provides the quickest path to the execution of HyLine Cymru and the realisation of benefits. The full scope would be covered under the NZASP funding mechanism. Note: This scope is an expansion of what was submitted under the initial needs case and is proposed as the option with best overall value and least cost to the consumer.
FEED Lite – Alternative option (Figure 6)	This option takes the project from its current status to the completion of the FEED scope as far as is practicable. In parallel, the Planning and Land Rights scope shall be taken to completion of their feasibility and strategy stages only. These scopes are envisaged to be covered under NZASP. The “delivery” stages of the Land and Planning scopes, along with the Transportation Agreements (TAs) and HTBM application for Phase 3 (Detailed Design and Construction), shall be broken out as a separate scope covered under the HTBM mechanism.

Table 6 Description of Base Case and FEED Lite approach

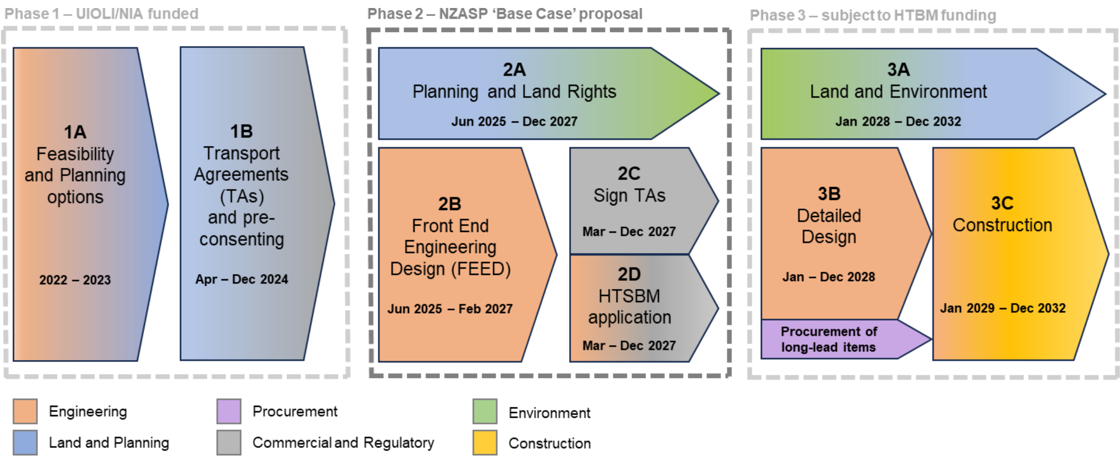


Figure 5 Base Case (recommended) approach to phasing

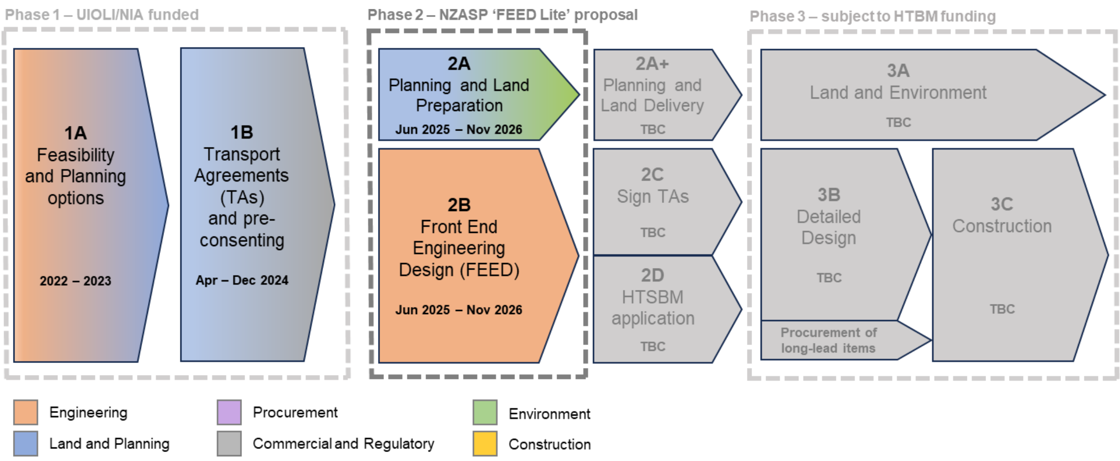


Figure 6 FEED Lite (alternative) approach to phasing

This NZASP re-opener application is structured around the Base Case option as this is the recommended and best value solution which presents the least risk.

We recommend that this option is taken forward on the basis of ensuring that:

- The project is delivered within the expected timeframes, providing hydrogen to customers when they need it and when it is available. The project is therefore relevant and timely.
- The project is delivered at the least overall cost by ensuring a timely Final Investment Decision through continuity of funding.
- The project doesn't incur unnecessary risk, impacting the overall deliverability and credibility of the project.

The relating scope, plan, cost estimate, installed cost estimate, Cost Benefit Analysis (CBA) and Engineering Justification paper (EJP) are addressed in Sections 9 (EJPs) and 14 (CBAs).

The FEED Lite option, which is a cut back version of the Base Case option, is documented in Appendix I. This section of the application will highlight the differences, including risks and opportunities, should this option be preferred by Ofgem.

This NZASP re-opener application is being submitted in October 2024, ready for a planned project initiation early in 2025. The project will ultimately help enable the achievement of the UK government's Net Zero Carbon Targets by servicing the industrial clusters in this area, retaining / creating 100s of jobs during the construction and operational phases and enabling 1000s of jobs indirectly through new energy production facilities and industrial plants.

The following sections explain the high-level scope of each option, with the detailed project scope of work presented in Appendix H. Details of the delivery plan, costings and cost benefit analysis are presented in Sections 1111, 1212 and 1414 respectively.

5.6.4.1 Base Case

The projected cost of the Base Case scope option proposed for this NZASP re-opener, is **£23.02m**. This cost is expressed in 2018/19 prices for consistency with RIIO-GD2 and to comply with the cost guidance in section 3.19, 3.20 etc. of the re-opener guidance document. The cost spreadsheet is given as an embedded document in Appendix A.

- Firm costs for the funding request have been obtained during a procurement exercise and benchmarked independently to an Association for the Advancement of Cost Engineers (AACE) Class 4 estimate as presented in Section 12.
- Spend will take the project to a Final Investment Decision in January 2028.
- Majority spend in GD2 for completed FEED study and partial Planning and Land Rights feasibility and strategy work with remaining spend occurring in RIIO-GD3 under re-opener programme conditions.

As a high level summary the funding request covers:

- Engineering FEED
- Stakeholder engagement
- Securing planning permission
- Acquiring land rights along the full route
- Producing the Transportation Agreement to bind WWU with producers and offtakers
- Producing a HTBM application for Phase 3 (Detailed Design and Construction) funding

5.6.4.2 FEED Lite

The projected cost of the "FEED Lite" option scope proposed for this NZASP re-opener, is **£6.21m**. This cost is expressed in 2018/19 prices for consistency with RIIO-GD2 and to comply with the cost guidance in section 3.19, 3.20 etc. of the re-opener guidance document.

- Firm costs for the funding request have been obtained during a procurement exercise and benchmarked independently to a AACE Class 4 estimate as presented in Section 12.
- Spend will take the project to the completion of the engineering FEED study, and the feasibility and planning stage of the Planning and Land Rights scopes.
- As a high level summary, the funding request covers:
    - Engineering FEED study
    - Stakeholder engagement
    - Planning and land rights feasibility and strategy

5.6.5 Company Contribution

WWU is committed to providing a shareholder contribution of 10% as there may potentially be ongoing benefit for WWU, but only if this new pipeline opens additional business opportunities.

The project is innovative in attempting to connect hydrogen production, transportation and consumption, in a way which enables future development of hydrogen infrastructure. The project is inherently different to other similar proposals in other clusters, with simplicity at its core, it demonstrates how hydrogen network infrastructure can enable significant decarbonisation without involving large numbers of offtakers and the associated interdependencies and complexity. If successful it could potentially give rise to additional network charging revenue for WWU and provide insight and experience for WWU in progressing these kinds of projects. However, it is not expected to bring material non-network benefits for WWU or its existing network offtakers.

As a network licensee, at this stage, there are significant risks and there is limited benefit outside of the knowledge to be gained from the creation of hydrogen pipelines. The project is inherently driven by the HM Government's commitment to Net Zero and the need to decarbonise energy. As a result of all of these factors, a contribution of 10% is considered appropriate by WWU; the risks to future revenue are too great to justify a higher level.

5.7 Timelines

HyLine Cymru target timelines are summarised below:

- NZASP re-opener needs case submission, anticipated trigger and application submission dates.
    - Target submission date for the detailed assessment phase – by Oct 2024.
- 6-month Ofgem review period.
- Anticipated approval from Ofgem – May 2025
- NZASP re-opener initiation and Phase 2: FEED, Planning and Land Rights - completion dates.
    - Project initiation in June 2025
    - FEED phase ends by February 2027 (November 2026 for FEED Lite option)
    - Planning and Land Rights end by Q4 2027
- Phase 3: Detailed Design and Construction - Project execution
    - Final Investment Decision (FID) is anticipated to be January 2028
    - Detailed Design and the procurement of long lead items throughout 2028
    - Construction phase from 2029 through to 2032
    - Commissioning in Q1 2033

6 Project Description

The following section provides a description of the project background, and a summary of the work carried out to date.

6.1 Wales & West Utilities

We, as WWU, own 35,000km of pipelines across Wales and south west England, maintaining delivery of energy to 2.5 million households and businesses. WWU plays a crucial role in ensuring safe and reliable transmission and distribution of gas, maintaining infrastructure and responding to emergencies within the community. WWU holds legal responsibilities as a statutory undertaker in its service area, guaranteeing the public's access to essential gas supplies while adhering to regulatory standards. HyLine Cymru will enable WWU to continue serving the public and industry on the path to net zero, promoting the diversification of green energy sources in the regions it serves.

6.1.1 Ambition

Our ambition is to be trusted to expertly serve customers and communities with safe, reliable and affordable energy services today, while investing wisely to create a sustainable, greener future.

The services we provide are essential in everyday life for all our customers. We invest £2 million every week in improving our gas network so it is safe, and so that gas is available when people need it, whether that's for heating their home or running their business. We have a strong track record of delivering high standards of safety, reliability and customer service, for which we have received multiple accreditations and awards.

We recognise most of the gas transported to our customers today is a fossil fuel and that our operations have a direct and indirect impact on the environment. We support the commitment of the UK and Welsh governments to reaching net zero carbon emissions and believe the investments we are making in reducing emissions and decarbonising heat, power and mobility can help deliver a net zero energy system.

Through HyLine Cymru, we continue to enhance our gas network, ensuring safety and availability while minimising environmental impact.

Figure 7 WWU's service area (Wales and south west England)

6.1.2 Priorities

Our business priorities play a central role in helping us achieve our mission. They guide our key business decisions and are reflected in our day-to-day work, set out the things that are most important to our customers and colleagues alike, and create a roadmap to keep us focused on what we are going to do. HyLine Cymru is a testament to our commitment to providing sustainable energy, spearheading efforts to meet net zero targets with greener energy solutions. It helps shape a resilient future for our stakeholders and delivers value for money through cost-effective and sustainable energy services.

Figure 8 WWU priorities

6.1.3 Values

Our values continue to be as important to us today as they ever have been. They are what drive us to create a better world for this generation and the next. HyLine Cymru fits with our core values by prioritising customer needs through reliable and sustainable energy solutions, whilst demonstrating pride in our commitment to innovative green energy advancements. By fostering teamwork with industry partners and stakeholders and applying our energetic and enthusiastic approach drives us to continually improve and embrace cutting-edge technologies, ultimately enhancing service delivery and contributing to a sustainable future for the regions we serve.

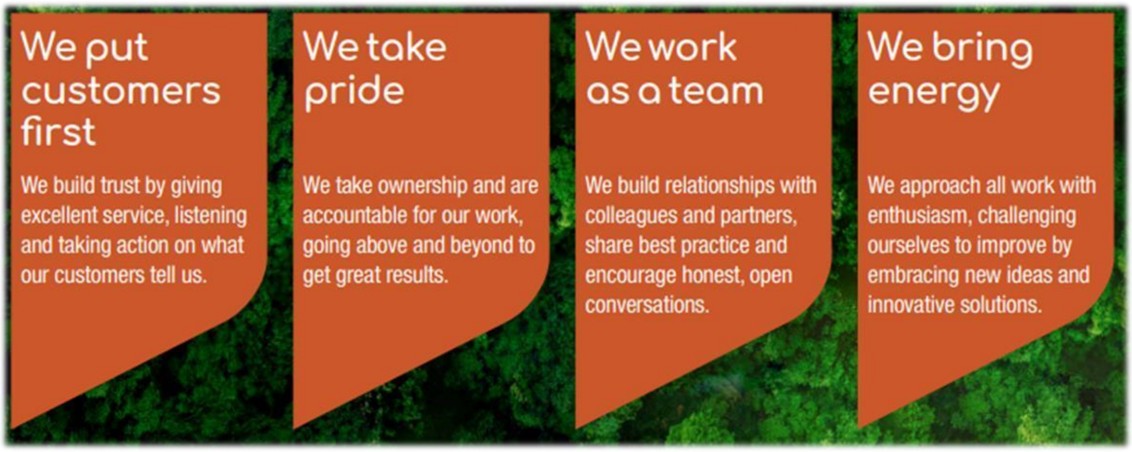


Figure 9 WWU values

6.1.4 Vision for a Net Zero Energy System

For the UK to reach net zero carbon emissions, we need to change virtually everything about the way we generate and use energy across our society. Today, most energy used in the UK is from fossil sources.

Delivering net zero means a combination of one or more of the following:

- energy will need to come from alternative cleaner sources such as wind, solar, biomethane and low carbon hydrogen;
- carbon emissions will need to be mitigated;
- customers will need to change the technologies they use.

Ultimately, the transition is likely to include all three of these elements and we believe the scale of the role gas plays in our system, the need to meet seasonal demands and the need to minimise disruption and cost means that gas distribution networks will play an important role through the transition and for the long term.

We can accelerate the transition by maintaining a reliable and efficient network, continuing to invest in emission-reducing activities and ensuring our assets are ready to carry low-carbon gases such as hydrogen and support a fully renewable energy system. WWU has a key target to invest in at least three industrial clusters to support industry transitioning to net zero and develop broader rollout plans for hydrogen.

As a gas distribution network, it is through working with our customers and partners on the use, generation and storage of cleaner energy that we can take our business on the journey to becoming net zero, while continuing to deliver the standards of safety, reliability and positive social impact they value and expect. We cannot deliver this vision alone: we need to work with communities in the areas we serve and with partners across the country. By collaborating with customers, partners, and communities, HyLine Cymru is dedicated to delivering a safe, reliable, and socially impactful energy solution while supporting the UK's goal of achieving net zero carbon emissions.

More can be found at: https://www.wwutilities.co.uk/media/4824/sustainability-strategy-2023.pdf

6.1.5 Net Zero Delivery Plan[13]

We are developing a Net Zero Delivery Plan which demonstrates how HyLine Cymru is a core infrastructure project in our journey to net zero. The plan will supplement our Sustainability Strategy by directing activity to deliver our vision for a net zero energy system.

It aims to identify specific projects and delivery periods required to achieve our targets, ensuring we align with current and future reporting standards. This includes a transition plan, to support future annual reporting on decarbonisation progress within our sustainability reports and Environmental Action Plans, alongside the delivery of key enabling projects such as HyLine Cymru.

6.2 Background

6.2.1 UK Policy

In June 2019, the UK became the world's first major economy to legally commit to a net zero greenhouse gas emissions (GHG) target by 2050. Since this time, the UK government has issued various policy and strategy documents in relation to hydrogen. These are listed in Table 7. The relevant Welsh Government strategy and guidance documents, in relation to hydrogen, are listed in Table 8. The tables also highlight the alignment between the proposed HyLine project and commitments and objectives of these policies and strategies.

UK Government Policies	Policy Summary	HyLine Alignment
The ten point plan for a green industrial revolution [14] (Nov 2020)	It describes an approach to 'build back better, support green jobs, and accelerate our path to net zero. Objectives included driving the growth of low carbon hydrogen, a production target of 5GW of low carbon hydrogen by 2030 and completing testing to allow up to 20% blending of hydrogen into the methane network by 2023.	Point 2 of the plan is driving the growth of low carbon hydrogen. HyLine Cymru is a key enabler for connecting hydrogen producers and offtakers, facilitating the growth of hydrogen use in South Wales in alignment with the 10 point plan.
Energy white paper [15] (Dec 2020)	Sets out how the UK will decarbonise its energy system and reach Net Zero by 2050 through a strategy to transform energy, support green recovery and create a fair deal for energy consumers. The paper commits to	HyLine Cymru will provide prospective hydrogen market participants with investment confidence to promote private sector investment by ensuring there will be access to a hydrogen market.

[13] Future of Energy | Renewable Gas | WWU (wwutilities.co.uk)
[14] HM Government: The Ten Point Plan for a Green Industrial Revolution (Nov 2020)
[15] HM Government: Energy White Paper (Dec 2020)

	setting out the revenue mechanism to bring through early-stage private investment in industrial carbon capture and hydrogen projects.	
Industrial decarbonisation strategy [16] (April 2021)	Sets out how industry can decarbonise in line with net zero. Fuel switching to hydrogen has been identified as an option for UK industries to decarbonise.	The HyLine pipeline will connect the key heavy industrial energy users of South Wales, predominantly located in the Port Talbot area, with prospective hydrogen producers in the Pembroke region, providing a viable alternative to hydrocarbon fuels which are currently used by these industries.
Hydrogen strategy [17] (Aug 2021)	Sets out Government's plan for scaling up the investment, testing and adoption of hydrogen technologies across the UK. The strategy sets out the approach for developing a thriving low carbon hydrogen sector in the UK to meet our ambition for 5GW of low carbon hydrogen production capacity by 2030 (now doubled to 10GW by (BESS).	The hydrogen strategy identifies the challenge of a "need for hydrogen infrastructure". HyLine Cymru is a key piece of infrastructure which will help facilitate the growth of hydrogen producers in the South Wales region, helping to contribute to the 10GW hydrogen production ambition – and beyond.
Net Zero strategy (Oct 2021) [18]	Sets out a delivery pathway showing indicative emission reductions across sectors to meet targets up to the sixth carbon budget (2033-2037). The strategy cites Hydrogen as supporting up to 10,000 jobs in 2030 and starts to mobilise additional public and private investment in line with the strategy's proposed delivery plan.	The HyLine pipeline will support the UK government in realising the Net Zero commitments made to; 5GW UK low carbon hydrogen (3ii), support the increased requirement for fuel switching to low carbon alternatives for industrial hydrocarbon fuel users (3iii), making the transition to low carbon buildings affordable and achievable (3iv), support the development of skilled, competitive supply chain for key green energy industries in the UK (4iii), empower businesses and the public to make green choices (4vi), and deliver against net zero on a trajectory in line with the Paris Agreement (4vii).
Heat and buildings strategy [19] (Oct 2021)	Sets out the immediate actions the UK Government will take for reducing emissions from buildings, including deploying energy-efficient measures, and transitioning to low-carbon heating. In 2026 a critical decision is due from Government on the whether the future of domestic heating includes the use of hydrogen.	Enabling blending of hydrogen in the gas grid is one key commitments of this strategy. The HyLine pipeline could help to facilitate this in the South Wales region.
British Energy Security Strategy (BESS) [20]	Billed as the plan to ensure we have, "a power supply that's made in Britain, for Britain", this signals the Government	HyLine Cymru will provide the infrastructure to enable the growth of a low carbon hydrogen market in South

[16] HM Government: Industrial Decarbonisation Strategy (Mar 2021)
[17] HM Government: Hydrogen Strategy (Aug 2021)
[18] HM Government: Net Zero Strategy Build Back Greener (Oct 2021)
[19] HM Government: Heat and Building Strategy (Oct 2021)
[20] HM Government: British energy security strategy (April 2022)

(Apr 2022)	commitment to double hydrogen production ambition to 10GW by 2030, with at least half of this from electrolytic hydrogen.	Wales by connecting hydrogen supply and demand. This is significant in facilitating the growth of hydrogen use in South Wales and pushing towards to the UK ambition of 10GW of hydrogen production capacity by 2030.
Hydrogen sector development action plan [21] (2022)	Sector Development Action Plan is to highlight the nature and scale of opportunities across the hydrogen economy in the UK. It focuses on four key areas: investment; supply chains; jobs and skills; and exports. It sets out actions in those areas being taken by government and industry to maximise the benefits from scaling up the UK hydrogen economy.	Through the ability to begin pairing producers and offtakers, reducing the barriers to investment, the HyLine pipeline would be a significant step for South Wales in addressing the UK governments priority for de-risking capital investment in low carbon hydrogen production. It also aligns with the government priorities to unlock significant investment in infrastructure, opening the door to the repurposing of existing natural gas infrastructure, as well as enabling infrastructure for industry to fuel switch to low carbon hydrogen.
Hydrogen transport and storage networks pathway [22] (Dec 2023)	The Hydrogen Transport and Storage Networks Pathway sets out government's approach to the development of UK hydrogen T&S infrastructure. This approach should help ensure the right T&S network is available to support the evolving hydrogen economy and contribute whole energy system benefits.	Transport infrastructure is recognised as being critical in enabling hydrogen to play its full role in decarbonising the UK economy. The HyLine Cymru pipeline will directly support the goal of connecting hydrogen production to demand centres to enable decarbonisation at pace. The pipeline project will facilitate the growth of the hydrogen market by expanding access to hydrogen for new users and ensuring a secure demand for producers. This supports the goal of developing an efficient and competitive hydrogen market, which in turn promotes economic growth, job creation, and investment in the South Wales region. Given the South Wales Industrial Cluster is the second largest emitter of CO_2, of all UK industrial clusters, HyLine also supports the near term needs case to build emerging regional networks in the areas of highest potential.
Hydrogen production delivery roadmap [23] (Dec 2023)	This roadmap sets out how we expect the hydrogen production landscape to evolve towards 2035, and the key opportunities and challenges that we face.	The hydrogen production delivery roadmap acknowledges the need to build investor confidence and the key enabling role that hydrogen transport can play in growing the hydrogen economy. HyLine has a strong role to play in promoting early-stage investment and market development for hydrogen production.

[21] BEIS: Hydrogen Sector Development Action Plan (2022)
[22] DESNZ: Hydrogen Transport and Storage Network Pathways (Dec 2023)
[23] Hydrogen Production Delivery Roadmap (Dec 2023)

Hydrogen blending into GB gas distribution networks [24] (Dec 2023)	Government has taken a strategic policy decision to support blending of up to 20% hydrogen by volume into GB gas distribution networks, in certain circumstances that align with blending's strategic role.	HyLine Cymru could facilitate the utilisation of the existing gas distribution infrastructure in the [redacted] Local Distribution Zone (LDZ) for hydrogen blending.
The Second National Infrastructure Assessment [25] (Oct 2023)	The Second National Infrastructure Assessment outlines that over the next 30 years, the UK will need industry running on electricity where possible, but, where it is not, new infrastructure to supply clean hydrogen, or capture and transport the carbon emitted from burning fossil fuels to underground stores.	Recommendation 16 of the Assessment relates to developing a core hydrogen pipeline network connecting key regions in the UK by 2035. The report notes that connecting south Wales depends on the role hydrogen plays in decarbonising the steel industry, making up over 90 per cent of emissions in the area.
Hydrogen Net Zero investment roadmap [26] (Feb 2024)	The hydrogen investment roadmap showcases the UK's hydrogen offer and the scale of our ambition for the role of the hydrogen economy in meeting net zero.	The roadmap brings together previous policy and summarises investment mechanisms for hydrogen projects. It recognises that as demand grows, hydrogen infrastructure will be vital to connecting and balancing supply and demand.

Table 7 UK government policy and strategy

Welsh Government Policies	**Policy Summary**	**HyLine Alignment**
Prosperity for all: A low carbon Wales [27] (Mar 2019)	This Plan sets the foundations for Wales to transition to a low carbon nation. The Plan pulls together 76 existing pieces of policy from across the Welsh Government, UK Government and the European Union (EU) where decarbonisation is integrated either as a direct outcome or a wider benefit.	If Wales is to meet its climate targets, buildings will need to operate at close to zero emissions by 2050. Around 40% of Wales' emissions come from industry and heating buildings, primarily residential buildings. Much of this is located in South Wales. HyLine Cymru can directly contribute to reducing carbon emissions from heating and industry, by linking hydrogen supply with offtakers in this region, aligning with the Welsh Government's goal to achieve a low carbon economy.
Net Zero carbon budget 2 [28] (Oct 2021)	This Net Zero Wales Plan represents a new phase in the decarbonisation journey with a new net zero target. This Plan sets out 123 policies and proposals, alongside commitments and action from every corner of Wales.	HyLine aligns with the Welsh government policy on fuel switching, to change to low carbon fuels including hydrogen, and the phasing out of fossil fuel heat sources. It's aligned with the proposal for a decade of action.
Hydrogen in Wales	The Welsh Government published the Hydrogen in Wales; A pathway and next steps for developing the hydrogen	HyLine is aligned with the pathway objective to plan for large scale hydrogen

[24] DESNZ: Hydrogen Blending into GB Gas Distribution Networks (Dec 2023)
[25] NIC: The Second National Infrastructure Assessment (Oct 2023)
[26] HM Government: Hydrogen Net Zero Investment Roadmap (Feb 2023)
[27] Welsh Government: Prosperity for All: A Low Carbon Wales (Mar 2019)
[28] Welsh Government: Net Zero Wales Carbon Budget 2 (Oct 2021)

A pathway and next steps for developing the hydrogen energy sector in Wales [29] (June 2022)	energy sector in Wales consultation on 18 January 2021. The consultation closed on 9 April 2021. This document provides a summary of the responses to the consultation along with outline conclusions and next steps.	production. For example; RWE and Dolphyn Hydrogen projects in Pembroke.
Future Energy Grids for Wales [30] (June 2023)	The Future Energy Grid Wales document (July 2023) sets out several baseline scenarios for the Welsh energy system future.	The report noted an increase in the overall energy system cost in all scenarios where hydrogen was absent. This highlights the key role hydrogen will play in the decarbonisation of the Welsh Energy System.
Heat Strategy for Wales [31] (July 2024)		Wales will support the utilisation of low carbon hydrogen where it enables a sustainable and just transition towards decarbonisation, for example, at localised hydrogen hubs where industries are dependent on high-temperature processes, and for other hard to decarbonise solutions

Table 8 Welsh government policy, strategy & guidance

We have watching briefs on some of the upcoming policies and papers highlighted below.

Upcoming Government Policies	Policy Summary
Improving boiler standards and efficiency	Seeking views in response to proposals on domestic gas boiler efficiency, hydrogen-ready boilers and hybrid heating systems. (Mar 2024)
Hydrogen storage business Model: market engagement on the first allocation round	Seeking feedback on proposals for the first Hydrogen Storage Business Model allocation round. (Dec 2023)
Hydrogen to power: market intervention need and design	Seeking feedback on proposals that market intervention could be required to support hydrogen to power to deploy, including design options. (Dec 2023)
Hydrogen allocation round 2: market engagement	This market engagement document is seeking views on the proposed design of the second Hydrogen Allocation Round (HAR2) that will allocate funding to low carbon hydrogen projects. (Dec 2023)
Proposals for hydrogen production and industrial carbon capture regulations	Seeking views on proposals for revenue support regulations in relation to the hydrogen production, industrial carbon capture (ICC) and waste ICC business models. (Oct 2023)
UK low carbon hydrogen Certification Scheme	Seeking views on the design elements of a low carbon hydrogen certification scheme. (Oct 2023)
Proposals for offshore hydrogen regulation	Seeking views on the design elements of a low carbon hydrogen certification scheme. (Sept 2023)
Enabling or requiring hydrogen-ready industrial boiler equipment: call for evidence	Seeking views and evidence to inform the development of possible options to enable or require hydrogen-ready industrial boiler equipment.

Table 9 Upcoming UK and Welsh government policies

[29] Welsh Government: Hydrogen in Wales (June 2022)
[30] Welsh Government: Future Energy Grids for Wales (June 2023)
[31] Welsh Government: Heat Strategy for Wales

6.2.2 Project Development Journey

The following infographic, shown in Figure 10, demonstrates the journey of the HyLine Cymru project so far.

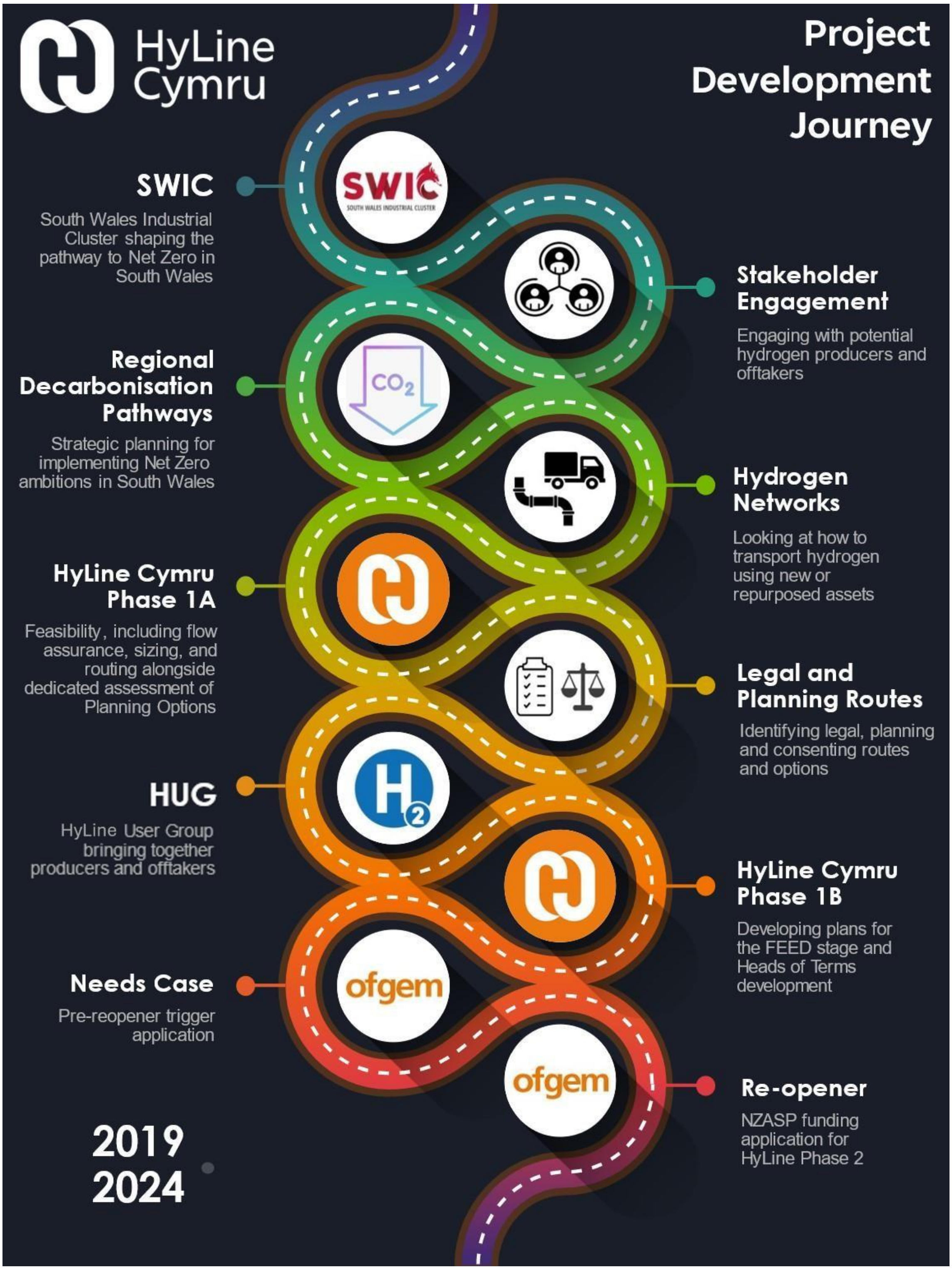


Figure 10 Project development journey

6.2.3 SWIC

WWU is part of the South Wales Industrial Cluster (SWIC). SWIC was formed in 2019 to help plan and shape a path to net zero for industry in South Wales. It now represents the second largest industrial cluster in the UK, emitting 9.1 million tonnes of CO_2e per annum. The Cluster Plan project, which concluded in March 2023, demonstrated the opportunity presented by decarbonisation when considered across a wide geography and multiple sectors, and featured HyLine Cymru as central to this plan.

The SWIC Vision showcases ambitious plans to achieve:

- Net zero industries in South Wales by 2040, equating to 40% reduction of current Welsh CO_2 emissions.
- Retention of 113,000 jobs and a net positive increase in jobs overall.
- Unlocking £30bn investment opportunities in the region.
- Growing the £6bn Gross Value Added from South Wales industry.

The SWIC Deployment project started in March 2021 linking supply and demand centres in the South Wales region to drive the development of hydrogen infrastructure and technology, and to enable industrial decarbonisation in line with the DESNZ (previously known as BEIS (Dept for Business, Energy and Industrial Strategy)) Industrial Cluster Challenge.

As a core SWIC partner, WWU wanted to use their Regional Decarbonisation Pathways project as an evidence base for their next phase of work in the cluster: exploring how hydrogen can be deployed. HyLine is that critical link to understand local hydrogen transmission and deployment.

HyLine Cymru would connect low carbon hydrogen production to energy intensive industrial customers beginning to switch their processes to hydrogen in the 2030s. It could also facilitate the conversion of domestic and commercial heating to hydrogen; enabling South Wales towns to go green while keeping disruption to homes and communities to a minimum.

Figure 11 SWIC

6.2.4 Key Stakeholders

The locations of the key stakeholders for the project are shown in Figure 12.

Figure 12 Stakeholder locations

6.2.4.1 Public Stakeholders

Ongoing support from key stakeholders has enabled us to align the delivery of HyLine Cymru with a number of public sector-led projects. The core of this has been in the delivery of each Local Area Energy Plan (LAEP) for the four local authorities where the HyLine Cymru pipeline will be located.

- Neath Port Talbot Council
- Swansea County Council
- Carmarthenshire County Council
- Pembrokeshire County Council

This not only strengthens the deliverability of each LAEP, but also provides a decarbonisation solution for local industry, prevents deindustrialisation and retains jobs. Furthermore, strategic spurs could provide hydrogen for cities, towns, and rural communities along the pipeline route in the future. The project has also acted as an enabler to demand, where the short, medium, and long-term opportunities presented by a local hydrogen transmission system have unlocked new opportunities such as road transport (mobility) decarbonisation.

Other public-sector backed projects include:

- Local Area Energy Plans (Whole Systems Planning)
- Swansea Bay City Deal (Innovation, Skills and Talent)
- Milford Haven Energy Kingdom (Delivery)
- Pembroke Dock Marine port revamp (Supply Chain)

6.2.4.2 Private Stakeholders

Hydrogen Production

HyLine Cymru is supported by a strong group of regional private sector hydrogen producers.

- **RWE** are developing the Pembroke Green Hydrogen project on the existing RWE Pembroke Power Station site with an initial 110MW green hydrogen production project, with the ambition to increase production in the future subject to demand.

- **Dolphyn Hydrogen** is advancing a 135MW project is the Celtic Sea, which will produce hydrogen offshore using Floating Offshore Wind (FLOW) technology. The company is looking to then expand production to larger scale over the next 10-years, potentially up to GW scale in the Celtic Sea via a series of commercial scale projects.

- **H2 Energy Europe** are developing the West Wales Hydrogen project, which has been successful in being shortlisted for HAR1 funding under the hydrogen production business model set out by DESNZ.

Hydrogen Offtakers

HyLine Cymru is also supported by several potential hydrogen offtakers. Work to onboard additional industrial hydrogen offtakers will continue through 2024 and 2025. The cornerstone commercial offtakers are listed below:

- **Tata Steel** own and operate the Port Talbot steelworks. They have committed to the replacement of their two coal-fired blast furnaces with Electric Arc Furnace (EAF) technology and to achieving net zero by 2045. This will also require abatement of their existing natural gas usage, for which hydrogen will play a role.

- **Heidelberg Materials**, formerly Hanson Cement, own and operate their Port Talbot facility which can produce up to half a million tonnes of cement product per year. They have committed to achieving net zero by 2050 by using hydrogen amongst several supporting technologies.

- **LanzaTech** are constructing hydrogen-fed carbon recycling facilities in Port Talbot to convert industrial emissions into sustainable aviation fuel.

- **Sofidel** manufacture sanitary paper products from their plant in Britton Ferry, are looking to decarbonise their operations and see hydrogen as having a key role in significantly reducing their carbon emissions.

- **Vale** was founded at the turn of the 20th century, Vale's Clydach Nickel Refinery began operations in 1902 and since then has been responsible for refining nickel oxide produced by their mines in Indonesia and Canada. Vale are looking to convert their natural gas usage to hydrogen and to directly use HyLine hydrogen to avoid the need for onsite hydrogen production.

6.2.4.3 Storage Stakeholders

Given the potential requirement for large volume hydrogen storage in certain scenarios, and the potential benefits of hydrogen infrastructure interconnectivity between industrial clusters, National Gas a significant stakeholder with their **Project Union** proposal (see Section 5.5.4 for further details).

ProjectUnion

The issues of storage capacity can potentially be mitigated through management of production rates and thus the hydrogen producers, RWE, Dolphyn Hydrogen, and H2 Energy Europe are also storage stakeholders in this respect.

We are designing HyLine on the basis that it will connect to a storage site, or sites in the future, and have already engaged with a number of storage developers and technology providers in support of this.

- **DCarbonX** are developing large-scale green hydrogen storage projects, such as the Kinsale Head project off the coast of County Cork, Ireland. They focus on repurposing decommissioned gas fields for hydrogen storage to support the energy transition.

- **Vallourec New Energies** are advancing hydrogen storage solutions, particularly in underground salt caverns. Their Delphy system enables large-scale storage of compressed gaseous hydrogen, leveraging their expertise in metallurgy to address challenges like hydrogen embrittlement.

- **Gravitricity** are working on the H2FlexiStore system, which uses lined geological shafts for underground hydrogen storage. This technology aims to provide safe, large-scale storage of pressurised hydrogen, enhancing grid stability and supporting renewable energy integration.

dCarbonX Delivering GeoEnergy

vallourec® NewEnergies

gravitricity

Phase 2B FEED will look at the mechanics of storage and develop operating scenarios to support the asset where storage is a challenge. This could provide a blueprint to other areas within the UK where local geological storage is not possible. This is explained further in Section 7.4.

WWU will also continue to engage in a number of storage related projects, following on from the NIA project which explored the potential for alt cavern storage in and near South Wales', and recently kicked-off study regarding the use of lined rock caverns, both of which are summarised in Section 5.6.2.

6.3 Regional Decarbonisation Pathways[32]

6.3.1 Concept to Creation

We have developed our Regional Decarbonisation Pathway to provide an overarching strategic plan for the network in Wales and the south west of England. This identified where new hydrogen infrastructure would be needed with the ability to facilitate industrial decarbonisation now, whilst also supporting the repurposing of infrastructure in the future. The overarching plan also set out where infrastructure is likely to develop first and provided us with the evidence needed to engage with key regional stakeholders on the development of the first-mover pipelines.

The project was delivered in two distinct phases, the Conceptual Plan (Whole Systems Modelling) and Strategic Plan (Infrastructure Assessment). The combined scope included an evaluation of the capacity of the WWU infrastructure required to deliver the volumes of hydrogen to the main demand centres, and development of conceptual network maps for the required new-build Local Transmission System (LTS) network for each of WWU's sub-regions. Our Regional Decarbonisation Pathways project, part of the SWIC Cluster plan, allowed us to develop HyLine Cymru alongside key stakeholders, which resulted in the initial 130km hydrogen pipeline concept to connect South Wales industry in Port Talbot with low-carbon hydrogen in Pembroke.

The SWIC Deployment project started in March 2021 to create links between supply and demand centres, known as Clean Growth Hubs, in the South Wales region. This project helped us to develop the necessary understanding of the producers and users in the South Wales region, to develop HyLine Cymru from its initial concept into a credible infrastructure project. The SWIC Deployment project was completed in February 2024 and demonstrates the role of HyLine Cymru in addressing the DESNZ Industrial Decarbonisation Challenge[33].

This flagship project will be the first major project in a widespread infrastructure transition across WWU's network area in support of industrial decarbonisation.

The following sections 6.3.1.1-6.3.1.9 detail the conclusions of the Regional Decarbonisation Pathways project, which underpin the early development of HyLine Cymru.

6.3.1.1 Repurposing the Gas Grid is Essential to Delivering Net Zero

To deliver net zero, we need to fully decarbonise the UK's existing energy systems – addressing present day petroleum (40%) as well as electricity (18%) and gas (34%) demand. (BEIS Figures for 2019). Even with the potential for demand reduction due to energy efficiency, demand side management and transition to alternative supply arrangements, in practice, it will be difficult to realise the transition to net zero without developing both low-carbon electricity and gas networks. Based on the modelling undertaken in this study, there is a role for a low-carbon gas network, even in a High Electrification scenario. This would involve the retention and repurposing of most of the existing network infrastructure to realise hybrid heating systems. Any uncertainty is therefore more over the extent and utilisation factor for a future hydrogen gas network, than whether it is required.

6.3.1.2 Initial Projects will be Industry Focused

Reflecting the present UK and Welsh Government's policy and funding approach, initial decarbonisation initiatives will be led by industry: South Wales is one of the six regions designated by the UK Government under the Industrial Cluster's Mission. The projects implemented to address emissions in the industrial clusters will provide foundational decarbonisation infrastructure which will then provide a basis for the energy transition solutions applied to decarbonise the remaining industrial and domestic emissions within these regions, as well as the build-out solutions which will be applied to decarbonise the neighbouring regions.

6.3.1.3 South Wales - A Strategic Location for the Initial Implementation of Net Zero

The LNG import terminals in South Wales and associated pipeline transportation system connecting to the rest of the UK offers a strategic location for initial production of blue hydrogen at scale, and the ability to use LNG as a feedstock to provide an effective hydrogen 'storage' capability. The existing gas import and transport infrastructure also provides the potential to then transition smoothly to green hydrogen importation and indigenous production at scale: providing greater energy security of supply than with present LNG importation operations.

[32] regional-decarbonisation-pathways.pdf (wwutilities.co.uk)
[33] Industrial decarbonisation (ukri.org)

6.3.1.4 Wales is Likely to be a Net Exporter of Hydrogen

Wales, especially South Wales is presently a net energy producer, with capability to export both electricity and gas to the rest of the UK. The region has the potential to continue to do so in a future UK net zero energy system – whether through decarbonisation of existing energy production facilities such as the existing LNG terminals and/or Combined Cycle Gas Turbine (CCGT) power stations, and/or the introduction of new green energy importation and/or production. This includes both onshore and offshore renewable generation, part of which could be used for electrolysis of hydrogen, in particular in the Celtic Sea. Therefore, the region has the potential to export hydrogen to the rest of the UK: across the rest of WWU's supply area to the South West and to the Midlands. North Wales is anticipated to initially import hydrogen from the production facilities developed in the North West by the HyNet programme. In the longer term the region has the potential to become a net exporter of hydrogen, e.g. from offshore wind or potentially from nuclear cogeneration hydrogen production facilities.

6.3.1.5 An Energy System Transition Sequencing Programme is needed

No energy transition sequencing philosophy presently exists for the UK and not all regions will necessarily transition to net zero over the same timescales: If there are areas which will be net producers of hydrogen (e.g. South Wales & the North West), then they arguably will need to decarbonise first so that ahead of other areas (e.g. North Wales & the South West) which can then be transitioned to net zero afterwards. This would mean net zero in South Wales needs to be achieved earlier than 2050 – possibly by 2040 or even sooner. An energy transition sequencing philosophy for the whole of the UK is urgently required to confirm whether strategic regional decarbonisation, such as in South Wales, needs prioritisation.

6.3.1.6 Parallel Natural Gas and Hydrogen Networks will be needed in South Wales

To manage the transition to a future 100% hydrogen network while maintaining security of supply, natural gas importation operations at Milford Haven will need to continue during the energy transition period to provide security of supply to gas consumers in parallel with establishment of a 100% hydrogen grid network. If due to the sequencing of transition, it is identified that there is a need to prioritise hydrogen production in South Wales to deliver net zero across the UK by 2050, then this could necessitate having a 100% hydrogen pipeline operational in South Wales by the late 2020s or early 2030s at the latest.

6.3.1.7 UK Government to provide Long-Term Development and Route-To-Market Certainty

The British Energy Security Strategy published in April 2022 echoes similar previous plans for major new Carbon Capture Utilisation and Storage (CCUS) and nuclear power infrastructure projects which have largely remained unrealised. In addition to the development of a transition sequencing programme, to deliver the individual projects within such a programme, and the associated supply chain capability and skills required to deliver Net Zero by 2050, industry and academia need greater medium to long term policy and development funding programme certainty. Otherwise, the risk of key stakeholders failing to commit to provide the necessary capacity and skills will be significantly increased.

6.3.1.8 Repurposing Existing Gas Network Infrastructure

The majority of WWU's LTS system in Wales and the south west was constructed from pipe material strength grade of X52 (L360) and below. These pipe materials are considered more suitable to the transportation of hydrogen due to the low strength of the alloys, which imparts resistance to hydrogen embrittlement and to other brittle fracture mechanisms. Steels with high tensile strengths can see a greater loss in fracture toughness properties, potential leading to failure. Where pipelines have been constructed of higher strength grade materials then further work may be required to be undertaken prior to conversion to confirm their suitability for hydrogen service. There are several sections of the LTS network in South Wales which are over fifty years old and may potentially reach the end of their useable life shortly. Where these pipelines are to be replaced as part of a planned programme, they are subject to an agreed regulatory policy and approach. A low regret option would be that they are replaced with oversized pipelines with a pipe material grade suitable for hydrogen service.

6.3.1.9 Retention of Domestic and Commercial (non-industrial) Customer Base

Across most areas, a high retention of the existing gas network domestic and commercial (non- industrial) customer base is anticipated, based upon the modelled scenarios. Hybrid heating system installation in the modelled scenarios is a key driver in the evolution and operation of the gas and hydrogen networks. Although the volume of future demand is dependent upon whether selected decarbonisation solutions focus on hybrid or hydrogen boiler solutions. The gas network still retains a major role in meeting peak energy demand.

6.4 HyLine Cymru

The project pathway is shown in Figure 13. The project has been split into 3 phases. At present, Phase 1A Feasibility has been completed, with Phase 1B work still in progress. The re-opener addresses the proposal and funding application for Phase 2. The phases are as follows:

- Phase 1 – Feasibility, Planning, and Pre consenting
- Phase 2 – FEED, Planning and Land Option Agreements
- Phase 3 – Detailed Design, Procurement and Construction

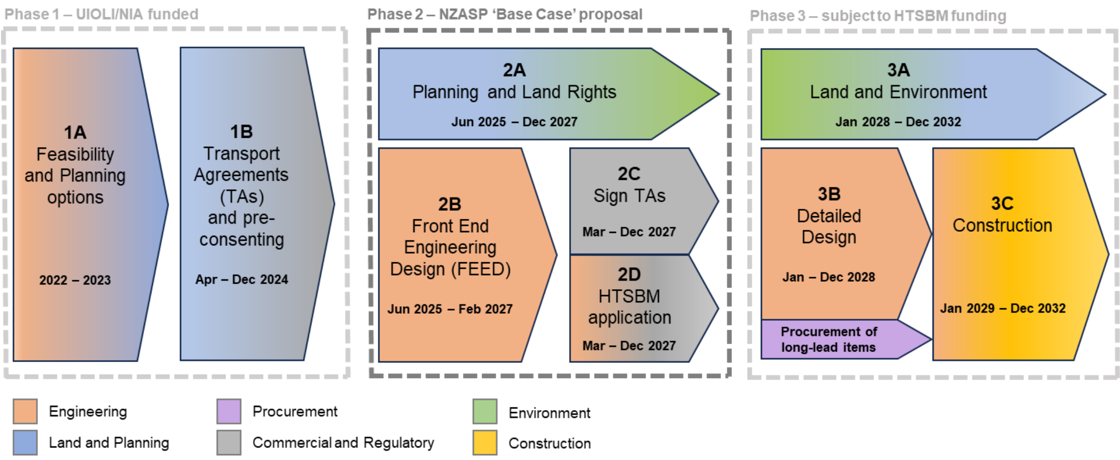


Figure 13 Project phasing

6.4.1 Phase 1

Phase 1 was broken down into two work packages 1A and 1B.

1A consisted of two distinct pieces of work. The first executed by Apollo delivered a technical Feasibility study of such a pipeline in South West Wales. Whilst the second focused on a review of the planning and consenting options, which explored all paths to obtaining planning permission against known legislation for natural gas pipelines. Phase 1B progressed the Phase 1A work and developed a full project delivery plan, updated cost modelling, and a stakeholder engagement plan. This work also provides the framework for a Heads of Terms (HoTs) agreement which explores the commercial mechanism by which WWU will be bound with producers and offtakers such as those within the HUG (see Section 7.1.2).

6.4.1.1 Feasibility Study and Planning Options (1A)

Following on from the Regional Decarbonisation Pathways work, WWU has undertaken a Feasibility study (Phase 1A) for the HyLine Cymru pipeline, working with partners Apollo, ERM, Mabbett and FGP[34]. A copy of this report is provided in Appendix E. The Feasibility study set out to determine a deliverable, cost effective pipeline project and potential pathway to demonstrate the opportunity presented by hydrogen infrastructure. Below are key elements of this study and its approach via an infographic:

[34] 373-004-GRL-RPT-0001-C Hydrogen pipeline feasibility study – Apollo final revision March 24

Figure 14 Feasibility key elements

The Phase 1A Feasibility study looked at four potential routes for the HyLine pipeline, based on available hydrogen generation at Pembroke and demand profiles for domestic, commercial and industrial use. This considers the outputs of direct engagement with industrial partners, whilst also considering forecasted hydrogen demand from industrial gas consumers who are unable to consider alternative means of decarbonisation. These results are detailed in Table 10.

Route ID	Pipeline route	Description
R1	Pembroke – [redacted]	New hydrogen pipeline from Pembroke to th[redacted] that serves domestic and commercial properties (including small industry only)
R2	Pembroke – Port Talbot	New hydrogen pipeline from Pembroke to Port Talbot to serve all industry within the cluster
R3	Pembroke – Port Talbot – South Coast Industrial Demand Centres	Extension of the proposed hydrogen pipeline to serve Port Talbot, with the additional industry demand from Barry, Cardiff, and Newport clusters
R4	Pembroke – [redacted] – Port Talbot & expansion	New hydrogen pipeline from Pembroke that has the capacity to serve domestic, commercial, and industrial demand across all three offtakers in South Wales

Table 10 Summary of the proposed pipeline routes

Further to the above table the following info graphics depict the routes across the South Wales region.

Figure 15 Routing options considered for HyLine Cymru pipeline R1

Figure 16 Routing options considered for HyLine Cymru pipeline R2

Figure 17 Routing options considered for HyLine Cymru pipeline R2

Figure 18 Routing options considered for HyLine Cymru pipeline R2

The above routes were reviewed in line with potential known offtakers, along with consideration of production capabilities, seasonality and storage requirements. To develop independent future hydrogen demand scenarios outside of the known offtakers, external literature sources with future hydrogen forecasts were reviewed and compared. This review identified the following relevant sources:

- Climate Change Committee – Sixth Carbon Budget (CCC – 6CB)
- National Grid Future Energy Scenarios (FES – 2021 and 2022)
- Common Future End States (CFES) – South Wales LDZ

These sources have distinct decarbonisation pathways that achieve Net Zero by 2050, with each pathway based on varying levels of consumer engagement, energy efficiency, fuel switching, and prevalence of carbon removal technologies. The demand scenarios and their evolution are discussed further in Section 7.

The proposed routing of the pipeline was looked at to establish the extents of the pipeline corridor along with an initial review of the planning and consenting challenges that will be faced. The proposed pipeline corridor and route has been developed based on the following criteria:

- Route identified on a suitable scale with areas of interest
- Route corridors to avoid running closely parallel to high density traffic, railways, overhead cables, major pipelines and other buried plant
- Route to be kept to a practical minimum length
- Route corridors were also identified using the following criteria:
    - Pipeline start and finish points
    - Intermediate fixed points
    - Route to avoid, as far as practicable, populated areas
    - Route to avoid, as far as practicable, any significant environmental, archaeological and future
    - developments and engineering constraints
- Route to consider minimum proximity distances (BPD) between the pipeline and normally occupied dwellings.

Taking account of Health and Safety Executive (HSE) Planning Advice for Developments near Hazardous Installations (PADHI) zones which would broadly align with Building Proximity Distance (BPD).

At this early stage a desk top ecological study was also carried out to help minimise the environmental impact of the pipeline and to avoid direct impacts on assets of significance, scheduled monuments, Listed Buildings, Registered Parks, habitat designated sites of high importance and special landscape areas etc.

In addition to the routing, preliminary engineering of the pipeline was conducted. To facilitate this demand analysis flow assurance activities were conducted. For the pipeline itself, consideration given to the materials of construction, which is a critical consideration for Hydrogen pipelines. A range of design scenarios was considered to establish the pipeline sizing along with the required number of block valve stations (used for isolation sections of the pipeline for maintenance), pig traps (used for inserting inspection equipment) and Above Ground Installations (AGI – offtakes etc) that would be required for each routing option.

6.4.1.2 Planning and Legal Delivery (1A)

Following on from Phase 1A: Feasibility and Planning Options, Turley Independent Advisors were engaged to produce a Planning and Legal Delivery Strategy[35] for the HyLine Cymru proposal. A copy of this report is provided in Appendix C. This identified the potential planning routes through government, as well as identifying the high-level requirements of the process to inform WWU of the necessary measures to be taken as the project progresses.

The study concluded that:

- The potential consenting routes for HyLine are:
    - Option 1: planning application(s) under the Town and County Planning Association (TCPA) for the whole project; or
    - Option 2: combination of planning applications and reliance on permitted development (PD) rights for gas transporters under the General Permitted Development Order (GPDO) 1995 for the underground pipeline and associated works (and potentially some above ground structures).
- Option 1 is recommended. Option 2 has some advantages and should be kept under consideration during the ongoing design and engineering phase of the project.

[35] Hydrogen Infrastructure Planning and Legal Delivery Strategy – October 2023 by Turley

- Option 1 would require at least four planning applications to four separate Local Planning Authorities (LPAs) for determination. These applications would relate to the whole of the project located within the relevant local authority area (option 1) or, the parts of the project which do not benefit from permitted development rights (option 2) (such as any sizeable above ground infrastructure).
- Reliance on PD rights is likely to trigger a separate requirement to obtain the consent of the Secretary of State under the 1999 Regulations.
- A full planning application solution would be recommended. Where possible a single Planning Performance Agreement could underpin the project, agreed across the LPAs. This will set a framework and efficient process for the project.
- There is potential to explore the delegation of planning functions to support decision- making, but this would require careful consideration on the balance of merits and challenges.
- The HyLine scheme could be considered to raise issues of more than local importance, and it may be beneficial to request for a call-in of the applications for determination by Welsh Ministers (not the LPA). The implications of this are set out and require careful consideration.
- WWU would need to apply to the Secretary of State for Energy Security and Net Zero for the confirmation of a Compulsory Purchase Order (CPO) under the 1986 Act.
- The Public Affairs (PA) Strategy is integral to any consenting route and should:
    - Develop a coordinated political context within which technical discussions and planning committee decisions can be made;
    - Develop a cross party political steering group made up of political and senior officer representatives from all four local authorities; and
    - Agree terms of reference for the group with Welsh Government before seeking to discuss HyLine and the steering group with the leadership of each of the councils.
- A comprehensive community engagement strategy should be developed early alongside the planning and PA strategy, extending beyond mandatory Pre-Application Consultation (PAC)
- The supporting planning evidence base will be extensive and complex. In particular:
    - An indicative planning validation list is provided at Appendix C.
    - A consistent methodology including on sustainability and economics should be used.
    - The scope of any Environmental Impact Assessment (EIA) should be discussed and identified early in collaboration with the relevant decision-maker(s).
    - Streamlining technical requirements and information should be considered, where this is relevant to one or more consenting/licence/permit route.

6.4.1.3 Transportation Agreements and Pre-consenting (1B)

The core of the Phase 1B work is the production of Heads of Terms (HoTs) and the framework for the future Transportation Agreement. This is necessary to ensure that early technical and commercial responsibilities of the Transporter, Producers and Offtakers are clearly set out by providing the assurances needed to progress into Phase 2: FEED, Planning and Land Rights of the programme under the knowledge that project partners are willing engage in the full Transportation Agreement during the delivery of Phase 2: FEED, Planning and Land Rights and in readiness for a FID. Issues such as capacity booking and flexibility arrangements have direct impacts on how costs fall to the various parties and can also impact the design of the pipeline itself.

The HoTs will be discussed and developed through the HUG initiative which will facilitate the necessary engagement with the producers and offtakers. The HUG initiative is discussed further in Section 7.1.2.

In addition to this, the project has looked at public affairs strategies, stakeholder engagement, and regulatory support to ensure WWU is best positioned to prepare for a planning application through the course of Phase 2A Planning and Land rights.

6.4.2 Phase 2 – Next Steps

Progressing the project to Phase 2: FEED, Planning and Land Rights will require a budget in excess of the £2M limit for the UIOLI fund. Thus, further funding must be applied for under the NZASP re-opener funding mechanism. The project Needs Case was submitted to Ofgem in April 2024. Ofgem were content that the Needs Case has been established in principle and have triggered the re-opener application process to proceed. The project is progressing with Phase 1B and continuing with stakeholder engagement as part of the HUG initiative whilst the NZASP re-opener application process is enacted.

An overview of possible funding options is presented in Section 5.6.4.

7 Supply, Demand & Storage

7.1 Market Stakeholder Engagement

7.1.1 SWIC

The initial market stakeholder engagement work was carried out as part of the South Wales Industrial Cluster, which is discussed in Section 6.2. One of the key outcomes of SWIC was the identification of key industrial offtakers, and through engagement with these companies, a far better picture of potential offtake scenarios was developed. The three main offtakers: Tata Steel, Heidelberg Materials and LanzaTech were able to provide decarbonisation pathways which identified hydrogen as a key component and provided estimated hydrogen consumption requirements between 2030 and 2050. These numbers were then fed into the offtake demand scenarios considered during Phase 1A Feasibility and Planning Options.

7.1.2 HUG

Following the publication of the SWIC Cluster Plan in April 2023, WWU formed the HyLine User Group (HUG) to continue engagement and the development of the wider end-to-end system and programme of works alongside hydrogen producers and offtakers.

The HUG also acts as an interface between these key stakeholders (Section 6.2.4) and other key groups, including Ofgem, Net Zero Industry Wales, the newly formed National Energy System Operator (NESO), and both central and devolved governments.

These interfaces are visualised in Figure 19 which shows how these groups support the development of hydrogen transportation infrastructure in Wales, through the participation of industry in the HUG and further indirect representation by WWU in other enabling groups.

As well as helping to facilitate discussions with producers and offtakers, the HUG has been working to enable the following key outcomes in support of the HyLine Cymru project:

- To identify HyLine Cymru 'offtakers' and further the development of:
    - Hydrogen production volumes, profiles, and planned Commercial Operation Date (COD)
    - Hydrogen demand volumes, profiles, and planned COD
    - Hydrogen storage volumes, types, and planned COD
    - Programme design alongside production and end-use projects
- Seek unified industrial support for the delivery of HyLine Cymru and supporting infrastructure
- Provide evidence for the development of the Hydrogen Transportation and Storage Business Model (HTSBM)
- Identify barriers and solutions to delivery of the required infrastructure
- Support Net Zero Industry Wales (NZIW), with local, regional and national policy and regulatory decision making
- To engage with other regional/national representative organisations both to share "best practise" and provide Wales-specific input to the national hydrogen agenda.

Through the HUG initiative, Sofidel and Vale, the fourth and fifth potential major industrial offtakers have been identified and have supported the revised demand estimates by providing estimated energy consumption in the 2030 to 2050 period.

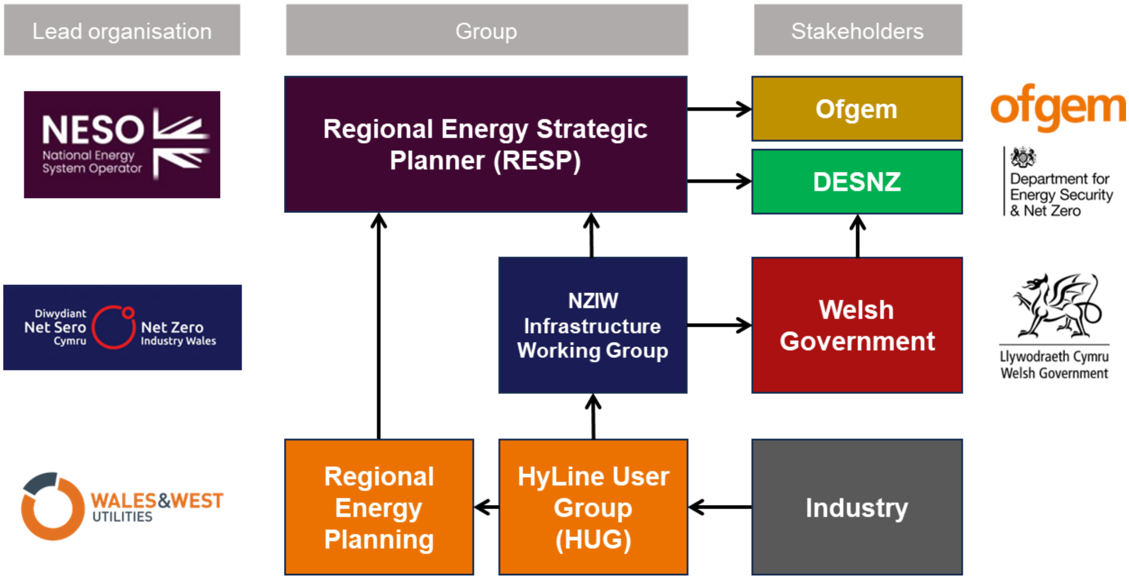


Figure 19 HUG interface with other groups

7.1.2.1 Heads of Terms

In recognition of the criticality of the commercial agreements for the connection of producers and offtakers, WWU has instigated the drafting of Heads of Terms (HoTs) for the future Transportation Agreement. Although non-legally binding at this stage, the HoTs will provide a degree of understanding and confidence that will help progress the offtaker commitment necessary for the producers to negotiate HAR funding. Initial draft HoTs are being prepared for discussion through the HUG in Q4 2024.

By engaging with the potential producers and offtakers in this way, the aim of the HoTs is to develop commitments from the offtakers of the pipeline as to their needs and at the same time, support them in proceeding with their own projects by providing a commitment from WWU that pipeline capacity will be available when required. The Transportation Agreement will deal with capacity rights and obligations, network charging and the other contractual arrangements needed to provide pipeline service to offtakers. It will be capable of adaptation and evolution to accommodate any specific requirements developing from the emerging HTBM and will anticipate future connections and development of the network in its terms.

Good progress has been made with the HoTs to date. Their development is ongoing and agreements are anticipated to be in place prior to the commencement of Phase 2: FEED, Planning and Land Rights. This will support offtaker commitment and a third iteration of the demand data, which is required to ensure that the capacity requirements of the pipeline are well understood and as firm as possible as a project of this nature heads into FEED.

7.1.3 Case Studies

The following section presents case studies for the key production and offtakers identified through SWIC and the HUG.

7.1.3.1 Hydrogen Offtakers

Heidelberg Materials

Heidelberg Materials own and operate a facility in Port Talbot with capacity to produce up to half a million tonnes of cement products per year. They are committed to fuel switching to hydrogen, amongst other measures, to achieve their commitment to reaching Net Zero by 2050. Further information can be found **here**.

Tata Steel UK

Tata Steel UK is a steel producer with a standard output of approximately 3 million tonnes per year and has 4 manufacturing sites in the South Wales region. Low-CO_2 and resource-efficient steel will be vital for future UK sustainability and in achieving the country's net-zero ambition. Steel making and processing is energy intensive and associated CO_2 is hard to abate. Low-carbon hydrogen is likely to be a contributor towards Tata Steel's plan to achieve net-zero by 2045 with applications potentially including steam generation, for steam used in steelmaking and processing, reheating of steel prior to rolling, and heat treatment of steel. Whilst electrification of these processes may be possible, it can be challenging, disruptive and costly. Further information can be found **here**.

LanzaTech

LanzaTech is planning to build pioneering carbon recycling facilities in and around Port Talbot to convert industrial emissions into Sustainable Aviation Fuel (SAF). 'Project Dragon' will reduce emissions from industry and help to deliver lower emission flying. Building on the area's industrial strength, the facilities will enable Neath Port Talbot to play a leading role in creating carbon reduction industries and high skilled jobs in South Wales that are critical to delivering the UK's net zero economy and tackling the climate emergency. Further information can be found **here**.

Sofidel

At its plant in Baglan, South Wales, Sofidel UK intends to participate in a project to convert an industrial oil refining installation into a green hydrogen production plant. Its participation envisages the withdrawal of a significant amount of hydrogen to replace methane gas. The project will link to H2 Energy Europe's production proposals, who have been awarded a grant by the UK government. Further information can be found **here.**

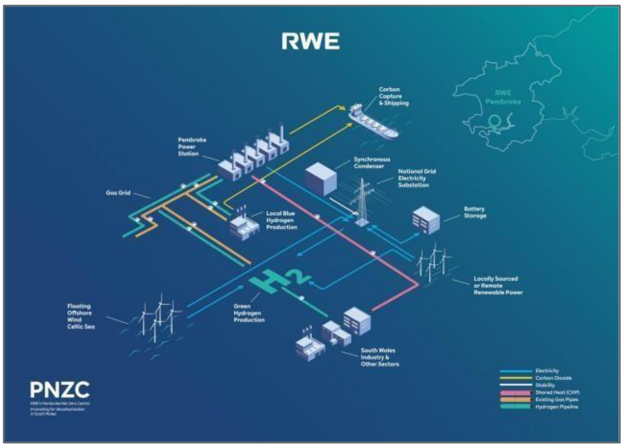
Vale

Founded at the turn of the 20th century, Vale's Clydach Nickel Refinery began operations in 1902 and since then has been responsible for refining nickel oxide produced by their mines in Indonesia and Canada. Vale currently use natural gas for fuelling process equipment and heating their commercial premises. Additionally, they currently use Steam Methane Reforming (SMR) to produce hydrogen as a feedstock for their production process. Vale are looking to convert their natural gas usage to hydrogen and could use hydrogen from HyLine in the future. Further information can be found **here**.

7.1.3.2 Hydrogen Producers

RWE

RWE's Pembroke Green Hydrogen is being developed on the existing RWE Pembrokeshire site with an initial 110MW green hydrogen production project, with the ambition to increase production at the site in the future subject to demand. The new facility would be located on RWE's site to the west of Pembroke Power Station and be capable of producing 2 metric tonnes of hydrogen every hour. Further information can be found **here**.



Dolphyn Hydrogen

Dolphyn Hydrogen has been established to develop its patented technology for producing hydrogen from Floating Offshore Wind (FLOW). The first UK project (135MW) will be off the coast of Pembrokeshire in the Celic Sea, and feasibility for this project is currently underway. Further expansion is planned with the ambition of achieving hydrogen production at GW scale in the Celtic Sea and elsewhere in the UK. Dolphyn Hydrogen aims to combine the most advanced floating wind and electrolysis technologies, which have the highest technological readiness level available. Dolphyn Hydrogen are working in partnership with WWU, Net Zero Industry Wales, Celtic Sea Power, and the Offshore Renewable Energy Catapult on the Milford Haven Hydrogen Kingdom Project (MHHK). Further information can be found here & here.

H2 Energy Europe

The West Wales Hydrogen project, developed by H2 Energy Europe, has been successful in attaining HAR1 funding from DESNZ. The proposal is for a 20MWe PEM (Proton Exchange Membrane) electrolyser facility, located in Milford Haven. The project is set to create 17 permanent jobs, contributing to the local economy and community sustainability. The production site is located in Impala Energy's hydrocarbon storage and distribution terminal in Milford Haven, situated on a former oil refinery. The terminal, part of the Celtic Freeport. Further information can be found here.

7.2 Demand

Following the completion of the Phase 1A Feasibility study, there have been some significant changes to the offtaker demand data. Tata Steel has announced that they will cease primary steel production at the two remaining iron ore-fed blast furnaces at their Port Talbot steelworks, this year (2024). Tata Steel plan to replace the existing blast furnaces with a single Electric Arc Furnace (EAF), which changes the high demand scenario. This altered the demand scenarios considered as part of the Feasibility study, which have been updated and are discussed further in Section 7.2.2, where Tata Steel remain as a potential offtaker even with their move towards EAF technology. Meanwhile Sofidel, who manufacture sanitary paper products in Port Talbot, and Vale who operate a Nickel refinery in Clydach, have been identified as additional significant industrial offtakers.

Future demands for hydrogen in the distribution network are uncertain. The Welsh Government recently issued the Heat Strategy for Wales, which anticipates electrified heating solutions for the majority of residential heating. However, UK policy on heating is not yet confirmed, and the document also states that, "Wales will support the utilisation of low carbon hydrogen where it enables a sustainable and just transition towards decarbonisation, for example, at localised hydrogen hubs where industries are dependent on high-temperature processes, and for other hard to decarbonise solutions".

In order to clearly present the impact of these changes, the Phase 1A Feasibility demand scenarios are described and presented as they were developed in Section 7.2.1. Thereafter, Section 7.2.2 updates these to provide the latest demand scenarios as a result of engagement under the HUG, and explains how these are reconciled against the Feasibility study work.

7.2.1 Feasibility Demand Data (Superseded)

Based upon the decarbonisation pathways identified in the CCC, FES and CFES literature, three levels of consumer demand categories were considered in the Phase 1A Feasibility study: High, Central and Low. These are summarised in Table 11, with respect to Domestic, Commercial, Industrial and Cornerstone Industrial demand (LanzaTech, Tata Steel and Heidelberg Materials) offtakers. Using the three categories, Table 12 shows the base decarbonisation pathways in terms of high, central, and low demand cases. This was used to generate a range of possibilities which was further down selected to 5 credible scenarios for further development. The low demand scenarios were not considered because it was deemed the least likely scenario given the trajectory of industry and policy, and to ensure suitable headroom in the pipeline capacity to provide for additional offtakers to benefit.

- [redacted] **– S1:**
  - This scenario will only consider the assumptions for the central demand scenario (10% domestic hydrogen, 10% domestic hybrid, 15% commercial, 30% general industry). This is because the low demand scenario assumes 0% conversion of the domestic and commercial sectors, which would not make this a viable case. The high demand scenario assumes that there will be extensive uptake of hydrogen for heating in the domestic and commercial sectors and it is deemed unlikely that this would be limited to [redacted] only.
- **Port Talbot Industrial (Central) – S2:**
  - The low demand scenario has been excluded because there would be low hydrogen demand and would not present a strong case for developing a pipeline to Port Talbot. [redacted]

[redacted]

- **Port Talbot Industrial (High) – S3:**
  - It was decided that an additional sensitivity scenario be created for the Pembroke to Port Talbot pipeline route. This is because this is a key industry specific route and therefore, it is imperative to understand the potential maximum demand for this option. [redacted] This would represent the maximum demand for Port Talbot. As per the central scenario, [redacted]
- **Expansion South Coast – S4:**
  - The low and central demand scenarios assume that only 20% and 30% respectively of industrial demand would convert to hydrogen. It is deemed unlikely that there would be a strong case to extend the pipeline past Port Talbot for relatively low conversion estimates. Hence, it was determined that the high demand scenario was the most appropriate for this pipeline route option.
- **South Wales LDZ – S5:**
  - As with Scenario 4, this is an expansion route option where the project would look to capture hydrogen demand across South Wales. This pipeline route option would only be considered if there was widespread hydrogen demand across South Wales and if additional assets were required in support of Project Union, otherwise it would not make commercial sense. Hence, it was determined that the high demand scenario was the most appropriate for this pipeline route option. Figure 20 quantifies the future hydrogen demand pathways up to 2050 for each of the scenarios. These pathways have been used for the pipeline sizing cases. Figure 21, shows the breakdown of the projected 2050 demand by offtaker group. The anticipated seasonality of demand, across the scenarios considered is shown in Figure 22.

	Domestic	Commercial	Industry	LanzaTech	Tata Steel	Heidelberg Materials
LOW	10% if homes with H2 boilers 10% of homes with hybrid systems	0% gas demand converts	20% gas demand converts	[redacted]	[redacted]	[redacted]
CENTRAL	10% if homes with H2 boilers 10% of homes with hybrid systems	15% gas demand converts	30% gas demand converts	[redacted]	[redacted]	[redacted]
HIGH	60% if homes with H2 boilers 19% of homes with hybrid systems	30% gas demand converts	50% gas demand converts	[redacted]	[redacted]	[redacted]

Table 11 Future hydrogen demand scenarios considered

Route ID	Base route description	Use case	ID	LOW	CENTRAL	HIGH
R1	Pembroke – [redacted]	[redacted]	S1		X	
R2	Pembroke - Port Talbot	Port Talbot industry (central)	S2		X	
		Port Talbot industry (high)	S3			X
R3	Pembroke – Port Talbot – South Coast industrial demand centres	Expansion (South Coast)	S4			X
R4	Pembroke - [redacted] - Port Talbot & expansion	South Wales LDZ	S5			X

Table 12 Selection of future hydrogen demand scenarios for each pipeline route option considered

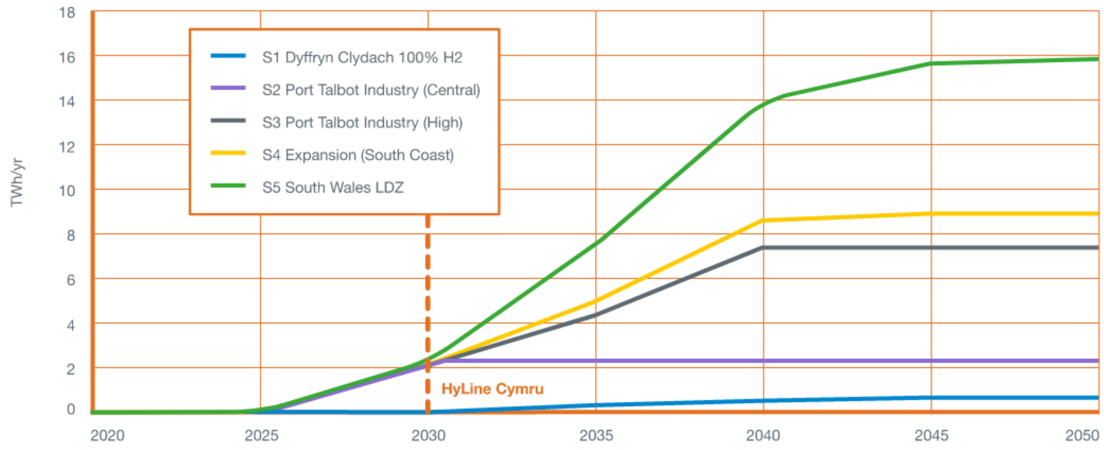


Figure 20 Hydrogen demand ramp up over time for considered scenarios

[redacted]

Figure 21 2050 (annual) hydrogen demand for pipeline routes considered

Figure 22 Seasonality of the scenarios considered

7.2.2 Current Demand Data

7.2.2.1 Scenarios

Following the completion of Phase 1A Feasibility, the Welsh Government issued the policy document, "Heat Strategy for Wales[36]". This policy document suggests electrification would be the primary low carbon solution for home heating, although still emphasising supporting hydrogen for industrial hubs and other hard to decarbonise consumers. As a result, the Feasibility scenarios which have a reliance upon domestic heating demand, i.e[redacted] (S1) and the South Wales LDZ (S5), are not core scenarios for this reopener application, although WWU notes that UK decisions on the role of hydrogen for domestic heat are yet to be taken, and considers that hydrogen is likely to play a more significant role in heating than the Heat Strategy for Wales suggests.

The South Coast expansion (S4) scenario carries a significant uncertainty as, due to the challenges and resources required, there has been little engagement with potential offtakers. Thus, the demand estimates are not at the same reliability level as those for the Port Talbot Industrial scenarios.

Given these two factors, the proposed project will progress on the basis of providing for the quantified demand from known industrial producers in the Port Talbot area, although now considering only the known industrial offtakers. Moving forward, the Low, Central and High demand scenarios shall be considered.

Further demand requirements can be explored in the proposed Phase 2B FEED, where additional industrial and commercial offtakers along the pipeline route and in the Port Talbot area will be sought and engaged.

7.2.2.2 Latest Demand Data

Following Phase 1A Feasibility, the demand figures were revised for the remaining offtakers and scenarios, utilising the HUG forum to engage with the offtakers directly. Two new offtakers, Sofidel and Vale, were identified as part of this round of engagement and are members of the HUG.

The Tata Steel figures have seen significant change due to the plan to move to EAF technology in favour over alternatives. Tata Steel's potential demand stems from both their Port Talbot and Trostre sites. The split of demand between these sites is shown below.

[36] Welsh Government: Heat Strategy for Wales

[redacted]

The latest 2050 demand data is shown in Figure 23, with the related 2050 hourly peak demand being shown in Figure 24. The figures shall be considered as the opening premise for the proposed Phase 2B FEED study.

Table 14 and Table 15, show comparisons of the working 2050 demand data with that of the 2050 Feasibility data to highlight the recent change.

Hourly peak demand is a driving factor in the design of the pipeline. However, at this stage of the energy transition it is challenging for the offtakers to provide accurate data of this nature. Thus, for the purpose of best possible pipeline sizing, a professional judgement based approach has been adopted. This approach uses industry peak hour norm factors in addition to the existing natural gas metering data (where future production intent is analogous to the present day) in order to arrive at a sensible value for each offtaker. The values adopted are shown in Table 13.

Offtaker	Peak hour factor (multiplier on average hour)	Comment
Tata Steel	[redacted]	[redacted]
Sofidel	[redacted]	[redacted]
LanzaTech	[redacted]	[redacted]
Heidelberg Materials		
Vale		

Table 13 Peak hour to average hour factor

Given the limited number of offtakers it is assumed all peak demand occurs at the same time (a diversity factor of 1.0). Given the % weighting of the key offtaker (Tata Steel) this approach is not considered excessive at this time.

The hourly peak demand and peak demand diversity factors will be further scrutinised at FEED to develop a robust pipeline design.

[redacted]

Figure 23 Annual demand scenarios (2050)

[redacted]

Figure 24 Hourly peak demand scenarios (2050)

	LOW (TWh/yr)		CENTRAL (TWh/yr)		HIGH (TWh/yr)	
	Feasibility	Latest	Feasibility	Latest	Feasibility	Latest
LanzaTech	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Tata Steel	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Heidelberg Materials		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sofidel	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Vale	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other industry	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	0.00	1.11	2.25	1.39	7.64	2.17

Table 14 Comparison of estimated 2050 annual offtake demand between Feasibility and the latest data

	LOW (GWh/h)		CENTRAL (GWh/h)		HIGH (GWh/h)	
	Feasibility	Latest	Feasibility	Latest	Feasibility	Latest
LanzaTech	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Tata Steel	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Heidelberg Materials	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sofidel	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Vale		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other industry		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	0.00	0.32	0.31	0.40	1.05	0.65

Table 15 Comparison of estimated 2050 peak hourly offtake demand between Feasibility and the latest data

7.3 Production

All of the hydrogen producers identified through SWIC and the HUG are located in Pembroke or Milford Haven and are developing projects to produce green hydrogen from electrolysis using renewable electricity. Their respective projects and project phasing is detailed in Table, where the Dolphyn Hydrogen and H2 Energy Phase 2 projects support the dedicated capacity required for the provision of hydrogen to HyLine Cymru. For RWE's projects, HyLine Cymru also provides the option of transporting hydrogen from these projects to offtakers in the Port Talbot area.

Producer	Phase	Capacity (not cumulative)	Commercial Operation Date
RWE	1	110MW | 48,000kg/day | 1.6GWh/day	2028
	2	200MW | 84,000kg/day | 2.8GWh/day	2030-32
Dolphyn Hydrogen	1	10-15MW | 2,500-3,750kg/day | 0.11GWh/day	2028
	2	100-150MW | 25,000-37,500kg/day | 0.99GWh/day	2031
	3	300MW | 75,000kg/day | 2.58GWh/day	2035
H2 Energy Europe	1	20MW | 4,000-5,000kg/day | 0.15GWh/day	2025
	2	300MW | 100,000kg/day | 3.44GWh/day	2032

Table 16 Peak hour to average hour factor

The figures presented above are the proposed production figures released by the producers as part of their own plan developments. However, the producers have advised that actual production will be highly based upon the required hydrogen demand. Should demand increase above current proposed production before or through the course of Phase 2B FEED, there is potential for expansion to meet this.

The combined proposed annual production capability, as provided by the main production stakeholders, reaches 4.26 TWh/y by 2035. The breakdown of contribution is highlighted in Figure 25. It should be noted that the producers also have plan for the supply of hydrogen to local users in and around Pembroke and Milford Haven.

Whilst the three identified green hydrogen producers can supply sufficient volumes of hydrogen to satisfy the current customers and their demand, WWU will remain open to the possibility of additional producers as the project develops. This includes a fourth party who have completed feasibility on a blue hydrogen production facility in Pembroke, and whose supply of low-carbon hydrogen would benefit the system balancing requirements necessary in their absence.

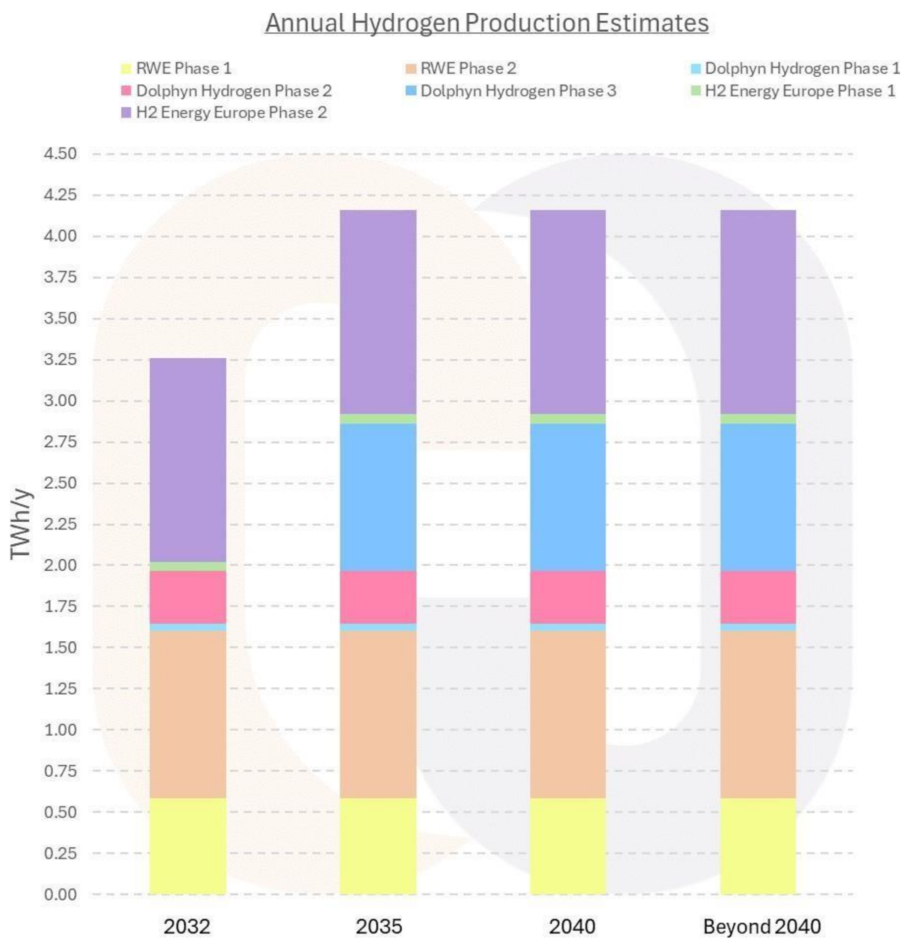


Figure 25 Estimated cumulative hydrogen production capability 2030 and beyond

Some use of national grid electricity will potentially be required to support hydrogen production in times of low renewable output which could locally impact upon Pembroke / Celtic Sea based hydrogen supply to HyLine. The use of such grid electricity would be subject to the establishment of power purchase agreements to ensure that the power can be purchased in accordance with the supporting production business models.

7.4 Supply Reliability & Storage

The storage requirements are highly linked to the demand scenarios and associated supply reliability requirements. The following section details the work carried out in Phase 1A Feasibility and the approach to be adopted as the project moves forward, and as WWU's understanding of demand develops before commencement of Phase 2B FEED.

7.4.1 Feasibility Demand Storage Requirement (Superseded)

The monthly hydrogen demand for each pipeline route (S1-S5) reveals a demand for the [redacted] and South Wales (LDZ) routes that is significantly dependent on the season. This is due to these routes considering domestic demand, which peaks in the winter months due to increased demand for heating. The other scenarios (S2, S3 and S4) are mainly industry-driven and hence have a much lower seasonal fluctuation.

Wherever there is a mismatch between the demand and the production profiles, storage is typically required in some form. The exception to this is if there is flexibility in the demand (e.g. consumers accept lower volumes of hydrogen during periods of high overall demand/low production), or flexibility in the production (e.g. output from hydrogen production facilities is reduced at times of low demand).

Large scale storage options, such as salt caverns and depleted gas fields, are limited in the South Wales region and so it is important to determine how much storage is likely to be required for each of the scenarios.

The table below offers two options for consideration in Phase 2B FEED, that being continuous production and variable production:

- Continuous refers to green hydrogen production having a constant power source, likely though a combination of private wire, power purchase agreements and backup grid support. This means the production can match the demand profile and ramp up and down as required.
- Variable production means the hydrogen generation is linked to green renewable power only and H2 is linked to the wind load factor and variable nature.

	Storage capacity, continuous production (TWh)			Storage capacity, variable production (TWh)		
	2030	2040	2050	2030	2040	2050
S1 Dyffryn Clydach 100% H2	0.02	0.09	0.12	0.02	0.09	0.12
S2 Port Talbot Industry (Central)	0.00	0.00	0.00	0.07	0.07	0.07
S3 Port Talbot Industry (High)	0.00	0.00	0.00	0.07	0.24	0.24
S4 Expansion (South Coast)	0.00	0.00	0.00	0.07	0.27	0.28
S5 South Wales LDZ	0.22	1.25	1.42	0.23	1.34	1.53

Figure 26 Storage capacity requirements for the scenarios considered

Above ground hydrogen storage typically takes the form of pressurised hydrogen in storage vessels, such as steel storage bullets.

However, the capacity of a storage bullet is on the MWh scale, similar to a standard 380 kg steel tube trailer and having around 12.5 MWh hydrogen storage capacity, assuming an energy density of 33 kWh/kg. The number of tube trailers that would be required to meet the storage capacity for the project are therefore in the order of thousands to hundreds of thousands. The large number of tube trailers required makes them an unviable solution for this project.

For variable production and scenarios S1 and S5 for the quantities required the only practicable solution would be geological storage (salt caverns). No suitable geological formations have been identified in the region to facilitate this. This assumption was supported by the outputs of the NIA project ‘Potential for Salt cavern storage of hydrogen in and near South Wales’.

7.4.2 Supply Reliability

7.4.2.1 HyLine Development Strategy

Given the predicted storage requirements for the project it is evident that geological storage (salt caverns) would be the only practical measure to provide this capability. Although the UK as a whole has favourable geological characteristics for long term hydrogen storage facilities, there are no suitable geological formations in the South Wales region to provide this facility. See Figure 27.

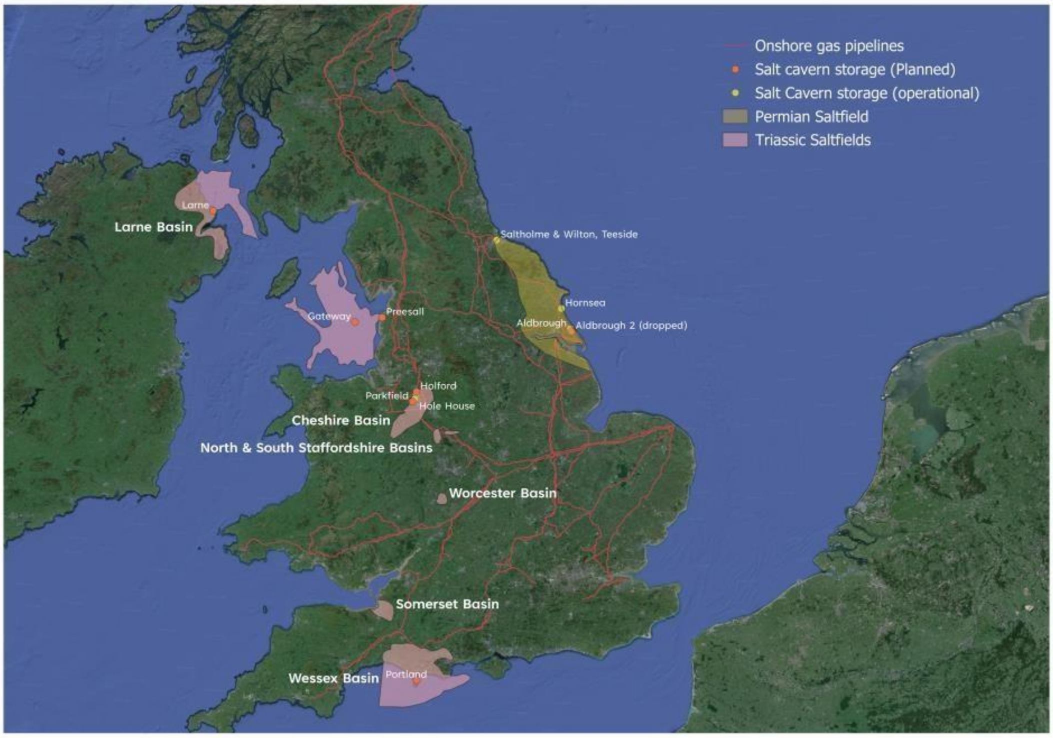


Figure 27 Location of halite basins (salt fields) in England, Wales and the east Irish Sea

Consideration has been given to the various supply reliability management and storage options. This is presented in Table 17 Hydrogen supply reliability strategy options. [redacted]

When looking at the wider UK picture. Given the restrictions on geological storage opportunities, HyLine will likely not be alone in facing storage challenges. It therefore presents the opportunity for the project to support the development of an operating model for other regions with the same absence of geological storage, an activity which will be progressed into Phase 2 (FEED, Planning and Land Rights). Connection to Project Union will also continue to be explored.

[redacted]

Hydrogen Supply Reliability Strategy Options	Discussion	Feasibility for HyLine
Local Geological Storage	There is no local geological storage opportunity in the South Wales region. Connecting to the Somerset Basin (nearest location) would double the pipeline length, also requiring an offshore section of pipeline to cross the Bristol Channel.	No
National Geological Storage	Connecting to national geological storage would require connection to Project Union. Assuming this project develops into the execution phase South Wales is the lowest priority for connection and would be completed last.	Not in the required timeframe

Local Above-Ground Storage Tanks	The number of tube trailers that would be required to meet the storage capacity for the pipeline routes are of the order of thousands to hundreds of thousands. This is clearly unfeasible.	No
Linepack	Linepack is expected to cover intraday variations, but it is unlikely to have sufficient storage capacity to cover seasonal variations or production down-time.	Can contribute
Production Asset Redundancy	Building additional capacity and redundancy into the hydrogen production facilities is of course feasible, but this will come at a cost penalty. The extent of viable additional capacity required for feasibility purposes will need to be assessed further in FEED, along with other contributing methods of satisfying the reliability requirements for the project.	Can contribute
Production management	There would need to be a requirement to work with producers to manage the demand profiles through power purchase and private wire arrangements. This may involve commercial obligations.	Can contribute
Demand Management	There may need to be a requirement to work with offtakers to support in managing their demand profiles. This may involve commercial obligations (incentives and penalties).	Can contribute

Table 17 Hydrogen supply reliability strategy options

A key factor in determining the reliability of HyLine will be establishing a better understanding of the producers supply variability and resilience, and how producers will interface with the HyLine asset in Pembroke. To aid this cause, WWU are currently working with Arup and Dolphyn Hydrogen as part of the Milford Haven Hydrogen Kingdom (MHHK) to explore how best to connect to sources of hydrogen production. This project is called OptiFLOW and focusses on the optimisation of Floating Offshore Wind, from the Celtic Sea, to provide offtakers with a reliable supply of hydrogen through HyLine Cymru.

The key aspects of the OptiFLOW project are:

Engineering

- Supply scenario definition
- Supply and demand optimisation solutions
- Hydrogen reception facility Feasibility
- Multi-point network entry
- Option evaluation

Economic Impact

- Economic impact appraisal
- Gross Value Added (GVA) analysis

For the engineering scope, OptiFLOW is focused on the development of the interface between the offshore pipeline, connecting Dolphyn Hydrogen assets in the Celtic Sea to HyLine. Demand scenarios, aligning with HyLine and that of the MHHK project, will be defined and used to determine cost effective solutions to manage production variability and resilience of supply, with the aim of achieving maximum value for hydrogen producers and offtakers in the network. This investigation will consider a range of potential solutions including storage and intermittent hydrogen supply, to support the option down-selection upon continuation to Phase 2B FEED.

Proposals for a hydrogen entry point at RWE Pembroke Net Zero Centre shall be developed. This entry point will include filtration, fiscal metering of each producer, pressure measurement and control including any required compression systems. The development of the entry point will also address the optimisation of supply and demand by considering how the connection of multiple producers can facilitate reliable flow of hydrogen.

The work will also explore how hydrogen producers to the north of the Haven waterway, such as H2 Energy Europe, will connect into the HyLine pipeline. This will include collaboration with key stakeholders in the area who are exploring similar proposals.

The outcome of the work will be a Feasibility design for a number of hydrogen entry scenarios, alongside Class 5 cost estimation for each scenario, and a preferred option for supporting Phase 2B FEED.

To justify the development, it is necessary to demonstrate the economic and societal impacts. To this end, Gross Value Added (GVA) and Cost Benefit Analysis (CBA) shall be carried out in collaboration with the Offshore Renewable Energy Catapult (OREC) to quantify the benefit.

8 Options Considered

8.1 Alternatives to Hydrogen

Meeting net zero targets in South Wales using only electricity to replace existing hydrocarbon energy sources presents significant challenges and risks negative impacts on industries which are vital to national and regional economies and employment.

South Wales is home to various heavy industries like steel, cement and chemical production, to name only a few. These are hard to decarbonise industries where the role of hydrogen is recognised for use where electrification is not feasible or is too costly. Hydrogen can replace natural gas and other fossil fuels in industrial processes, such as these, where high-temperature heat is required, which is impractical to generate with electricity due to the replacement of assets, reconfiguration of processes, and disruption to production and extended downtime losses.

Electricity from renewable sources, such as wind and solar are intermittent. At times there will be insufficient electrical production and conversely, there will be time when too much electrical energy is produced. Production of hydrogen, through electrolysis, can be used for grid balancing during periods of low and peak demand.

Full reliance upon electric energy supply to replace hydrocarbon sources would drive major upscaling to the existing electrical distribution network. Although this is always going to be inevitable, to some degree, this can be minimised by the adoption of hydrogen to help leverage the use of existing gas infrastructure. This also aids in the diversification of future energy supply, giving choice to consumers and building resilience in the energy network.

For HyLine Cymru the initial project pathways and stakeholders with regards to offtaker demand have all indicated a preference for hydrogen as part of their decarbonisation pathway. This has been further emphasised within the HUG initiative and therefore the focus has been given to the transport of hydrogen from point Pembroke to the offtakers centred around Port Talbot. The next sections explore the forms of hydrogen and the transport methods considered.

8.2 Hydrogen Forms

8.2.1 Form Consideration

Hydrogen can be transported in a variety of forms. Pros and cons for each are presented below in Table 18.

Form	Pros	Cons
Gaseous	**Customer Demand**: The offtakers have stipulated a desire for gaseous hydrogen to be supplied. Thus, there is no need for costly conversions from different states or forms. **Established Technology**: The technology for producing and transporting gaseous hydrogen has been developed and used in various industries, providing a level of reliability and established infrastructure. Gaseous hydrogen requires less compression than liquified hydrogen.	**Energy density:** Although hydrogen has high energy per unit mass, its low energy density per unit volume requires large storage tanks or high-pressure containment, which is challenging for transportation and storage. **Safety:** Gaseous hydrogen is highly flammable and can form explosive mixtures with air, making safety precautions critical during handling, storage, and transport. It has some qualities which make it more complex to handle than natural gas.
Liquified	**High Energy Density**: Liquid hydrogen has a higher energy density compared to gaseous hydrogen, allowing more hydrogen to be transported in the same volume. **Storage Efficiency**: Liquid hydrogen can be stored in smaller, more compact containers, making it more efficient for	**Cryogenic Temperatures:** Hydrogen must be cooled to -253°C (-423°F) to become liquid, which requires significant energy (around 30% of its energy content) **Boil-off Losses:** Liquid hydrogen naturally evaporates (boils off) over time, leading to potential losses during storage and transport.

	long-distance transportation and space-constrained applications. **Established Technology**: The technology for liquefying and transporting hydrogen has been developed and used in various industries, providing a level of reliability and established infrastructure. **Reduced Pressure Requirements**: Liquid hydrogen is stored at low pressures compared to gaseous hydrogen, reducing the need for high-pressure containment systems.	**High Production Costs:** The process of liquefying hydrogen is energy-intensive and expensive, contributing to higher overall costs. **Infrastructure Requirements:** Specialised, insulated containers and transportation systems are required to handle liquid hydrogen, necessitating substantial investments in infrastructure. To practically handle the quantities required, a pipeline would most likely be required. **Safety Concerns:** Hydrogen is highly flammable and handling it in liquid form at cryogenic temperatures presents unique safety challenges, including the risk of leaks and explosions.
Ammonia	**Higher Hydrogen Density**: Ammonia contains more hydrogen per unit volume than liquid hydrogen, making it a more efficient carrier. **Ease of Liquefaction**: Ammonia can be liquefied at -33°C (-27.4°F) at atmospheric pressure and has lower boil-off rates compared too liquified hydrogen.	**Energy Conversion Losses:** Converting hydrogen to ammonia and then back to hydrogen requires energy-intensive processing steps and reduces the overall efficiency of the hydrogen supply chain. **High Production Costs:** The process of making, transporting and then converting hydrogen to ammonia is energy-intensive and expensive, contributing to higher overall costs. **Handling and Infrastructure Requirements:** Specialised equipment and safety measures are necessary to handle ammonia safely. To practically handle the quantities required, a pipeline would most likely be required. **Toxicity:** Ammonia is highly toxic and corrosive, posing significant health and environmental risks in the event of a leak or spill.
Liquified Organic Hydrogen Carriers (LOHCs) I.e. Methylcyclohexane - MCH	**Conversion Energy**: LOHCs can require less energy for hydrogenation and dehydrogenation than ammonia or liquid hydrogen. **Low Explosion Risk**: Methylcyclohexane (MCH) and other LOHCs are less flammable and less hazardous compared to liquid hydrogen, reducing risks associated with transportation and handling. LOHCs can be stored and transported at ambient temperature and pressure, eliminating the need for cryogenic temperatures and high-pressure containment systems.	**Energy-Intensive Release Process**: The complete cycle of hydrogenation, transportation, and dehydrogenation requires energy-intensive processes, which will reduce the overall efficiency and increase operational costs. **Handling and Infrastructure Requirements**: Specialised equipment and safety measures are necessary to handle LOHCs safely. To practically handle the quantities required, a pipeline would most likely be required. **Hydrogen Purity**: The process of releasing hydrogen from LOHCs may produce impurities, requiring additional purification steps to ensure hydrogen of sufficient quality for specific applications, such as fuel cells.

		Handling Chemical Byproducts: After releasing hydrogen, the remaining chemical (e.g., toluene) needs to be safely handled, transported back, and re-hydrogenated, adding complexity to the logistics.
Metal hydrides	**High Hydrogen Density**: Metal hydrides can store hydrogen at high densities in liquid or powder form, making them efficient for storage and transport. **Safety**: Metal hydrides are generally safer than gaseous or liquid hydrogen as they can be stored at low pressures and are less flammable, reducing risks associated with leaks and explosions.	**Energy-Intensive Processes**: Charging (hydrogenation) and discharging (dehydrogenation) metal hydrides requires significant energy input, which will reduce the overall efficiency and increase operational costs. **Handling and Infrastructure Requirements**: Metal hydrides can be heavy, which may limit their use in applications where weight is a critical factor, such as for transportation. Moving metal hydrides would necessitate road or rail transport for all or part of the route, which is likely to be impractical given the quantities required. Some metal hydrides have slow hydrogen absorption and release rates, which can limit their practicality for applications requiring rapid fuelling or defueling. **Cost**: The metals used in hydrides, such as palladium, titanium, or rare earth elements, can be expensive, increasing the overall cost of storage and transportation systems. Over time and with repeated cycles of hydrogenation and dehydrogenation, the capacity of metal hydrides to store hydrogen can degrade, reducing their effectiveness and lifespan.

Table 18 Hydrogen form comparison (pros & cons)

Both green and blue hydrogen production technologies produce gaseous hydrogen. Offtake demands are anticipated to require hydrogen to be supplied in gaseous form. Thus, all of the forms above would require conversion of the hydrogen to and from its gaseous state. In all the processes there is an energy/cost penalty for the conversion which will likely increase inefficiency and costs, above that of gas compression. Furthermore, the current proposals for the Hydrogen Transport Business Model (HTBM) indicate it will likely be required to transport gaseous hydrogen as part of the eligibility criteria. Thus, from a project viability perspective, it is something of a necessity.

Liquefied hydrogen, ammonia and LOHCs would all likely require a pipeline to facilitate practical, efficient transportation in the volumes required. Significant insultation would be required and liquid hydrogen will likely be impractical. For LOHC's the carrier substance would need to be re-used for economy, requiring a second pipeline to back flow the carrier substance to the location of hydrogen production.

Solid state metal hydride hydrogen is a developing technology, which is better suited to storage rather than transport, due to the weight. As an example, Hydrexia[37] – a metal hydride technology company recently announced a new Heavy Goods Vehicle (HGV) towable 40ft containerised metal hydride storage unit. This is quotes as having 15t of magnesium alloy, with 1t of hydrogen capacity. In terms of hydrogen storage by mass, this is similar to the capability of gaseous hydrogen tube trailers, but with the added penalty of the costly absorption/desorption processes. The

[37] Hydrexia Metal Hydride Technology Mar 2023

carrier metal would need to be re-used for economy, requiring it to be transported back to the location of hydrogen production.

8.2.2 Qualitative Selection

As a screening exercise, the following criteria was used to assess the various hydrogen form options considered:

- Technical Feasibility
  - Technology maturity & practicality of implementation
  - System efficiency
  - Scalability
- Economic Viability
  - Capital cost
  - Operation and Maintenance cost
- Safety & Environmental
  - Regulatory compliance
  - Risk to people
- Logistics and Supply Chain
  - Handling and transport
  - Transportation reliability
  - Availability of key materials/capital equipment

Hydrogen Form	Criteria	Assessment
Gaseous	Tech feasibility	Good: Requires compression so fair efficiency and good scalability.
	Economics	Fair: Capital Expenditure (CAPEX) & Operational Expenditure (OPEX) costs – assumes pipeline.
	Safety	Fair safety: Not that dissimilar to existing natural gas transmission.
	Logistics & supply chain	Good: Well established transportability and handling using pipelines.
Liquid	Tech feasibility	Good: Feasibility, poor efficiency due to conversion from gas to liquid to gas again efficiency & boil-off losses and good scalability.
	Economics	Fair: CAPEX & OPEX costs – assumes pipeline but downrated due to additional conversion costs over gaseous.
	Safety	Fair: Not that dissimilar to existing LNG natural gas transmission.
	Logistics & supply chain	Poor: Transportability and handling using pipelines over long distances. Significant cooling requirement.
Ammonia	Tech feasibility	Good: Poor efficiency due to conversion from gas to liquid to gas again efficiency and good scalability.
	Economics	Fair: CAPEX & OPEX costs – assumes pipeline but downrated due to additional conversion costs over gaseous.
	Safety	Fair: Low explosion risk but toxic and requires additional industrial processes.
	Logistics & supply chain	Fair: Established transportability and handling using short pipelines.
LOHCs	Tech feasibility	Poor: No similar projects, poor efficiency due to conversion from gas to liquid to gas and poor scalability due to carrier chemicals.
	Economics	Poor: CAPEX & OPEX costs – assumes pipeline but downrated due to additional conversion costs over gaseous + requirement for secondary pipeline to re-use carrier chemicals.
	Safety	Fair: Low explosion risk but double the length of pipeline to manage

	Logistics & supply chain	Poor: Well established transportability and handling using pipelines but requires second pipeline.
Metal Hydrides	Tech feasibility	Poor: Feasibility – no similar projects, poor efficiency due to conversion from gas to liquid to gas and poor scalability due to handling requirements for carrier metal.
	Economics	Poor: CAPEX & OPEX costs – heavy and impractical to transport at quantities required. Carrier metal would need to be returned for re-use.
	Safety	Fair: Likely to require significant quantities of road or rail or sea significant.
	Logistics & supply chain	Poor: As difficult to transport heavy storage medium and carrier metal would need to be returned for re-use.

Table 19 Hydrogen form assessment

The following scoring was applied to the options in order to rank them with a further explanation following the table.

- Good: 3
- Fair: 2
- Poor: 1
- Unacceptable: Do not take the option further

Forms	Tech Feasibility	Economic Viability	Safety	Logistics and Supply Chain	Scoring X/12
Gaseous	3	2	2	3	10
Ammonia	2	1	2	2	7
Liquified	2	1	2	1	6
LOHCs	1	1	3	1	6
Metal Hydrides	1	1	2	1	5

Table 20 Hydrogen form: Option screening

On the hydrogen production side, it is gaseous hydrogen that is produced. On the demand side, the offtakers require the hydrogen to be supplied in gaseous form. Thus, all other forms would require conversion of the hydrogen to and from its gaseous state. In all the processes there is an energy/cost penalty for the conversion which will likely increase inefficiency and costs, above that of gas compression. Furthermore, the current proposals for the Hydrogen Transport Business Model (HTBM) indicate it will likely be required to transport gaseous hydrogen as part of the eligibility criteria. Therefore, from a project viability perspective, it is something of a necessity.

8.3 Transportation Options

Transporting the necessary quantities of gaseous hydrogen between Pembroke and Port Talbot/[redacted] is not practicable without a pipeline. The DESNZ Hydrogen Transport and Storage Cost Report[38], is used for high level cost comparison purposes. A number of alternative transport options have been considered and dismissed:

8.3.1 Pipelines

Pipeline licensing limitations are a key driver for the pipeline options as Wales and West Utilities do not have the required licensing to develop and operate an offshore pipeline. Furthermore, the DESNZ Hydrogen Transport and Storage Cost Report highlights the increased cost of offshore pipelines vs onshore pipelines across their lifespan.

[38] DESNZ Hydrogen Transport and Storage Cost Report

See Figure 28. In addition to the greater cost of an offshore pipeline, there are no opportunities to provide additional offtake sites to provide provisions for future expansion of the supply network.

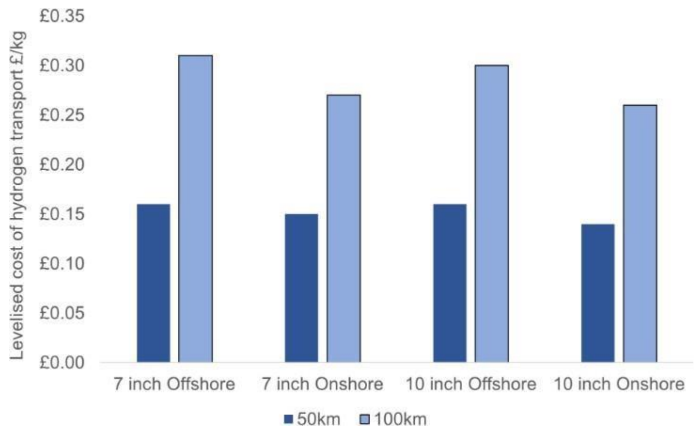


Figure 28 Comparison of levelised cost for onshore and offshore pipelines

8.3.2 Road: Tube Trailers

Of the alternative transportation methods, trucking hydrogen by road is the most technologically mature option. Hydrogen "tube trailers", hauled by Heavy Goods Vehicle (HGV) tractor units, are typically employed for this purpose. The hydrogen gas is compressed and stored in gaseous form (~200 to 500bar). It is possible to transport hydrogen in its liquid form, which is more energy dense. However, the conversion from gas to liquid comes at a significant energy and cost penalty, due to the very low temperatures that are required to achieve this (<-253^{0}C). Thus, gaseous transport is the more viable option at this time.

Steel cylinder tube trailers are the most common at present. These operate at the lower pressures (~200bar) and have capacities of between 300kg and 500kg of gaseous hydrogen. However, composite (aluminium and carbon fibre) cylinder tube trailers, which operate at higher pressures (~500bar) are beginning to appear on the market and these have a higher capacity of up to 1300kg. In either case the storage quantity is low when considering the mass required for the South Wales offtake scenarios considered in the Phase 1A Feasibility.

Considering scenario 3, there is a required average daily offtake of 632,877kg of hydrogen at peak levels, which are envisaged to be realised in 2040. Assuming a 10% increase for peak offtake levels in the winter months, then "1392" 500kg capacity tube trailers are required to make the 256km round trip, daily. The number of trailers would reduce to "536" when considering 1300kg capacity composite tube trailers. Thus, the existing road network between Pembroke and Port Talbot would also need to be upgraded to accommodate this significant increase in road traffic. This, new or upgraded road would face the same, or greater challenges as a pipeline with a cost base an order of magnitude above.

- 500kg tube trailers (1392No.)
    - Nose to tail length (17m per unit) = 23.6km
    - Length of road to accommodate 70m stopping distance between units = **121.1km**
- 1300kg tube trailers (536No.)
    - Nose to tail length (17m per unit) = 9.1km
    - Length of road to accommodate 70m stopping distance between units = **46.5km**

The reliability of the road transportation network would not be sufficient to sustain a "just in time" supply for the offtakers. The trucks would be susceptible to delays and disruption due to accidents, maintenance and adverse weather. Thus, it would be necessary to provide storage at the offtakers locations to account for delays and disruption. Storage of around 7days supply or more, would require provision for 4,430,137kg of hydrogen. This is equivalent to the capacity of "3408" 1300kg tube trailers. At present, the world's largest liquid hydrogen storage tank (25m diameter Cryo-Sphere), at Nasa's Kennedy Space Centre in Florida, can hold 335,262kg of liquid hydrogen. 13 of these would be required. Therefore, putting cost aside, it can be seen that storage of this level near the offtakers locations is impractical.

In addition to the two major impracticalities highlighted above, there are numerous other issues with road transportation. The list below highlights but a few of the significant points.

- Emissions:
  - There is a huge emissions penalty associated with building the infrastructure and trucks to facilitate road transport. From a practical standpoint, without quantification, this can clearly be seen to be in excess of that associated with a pipeline. I.e. new road infrastructure would likely balance with pipeline, additional storage requirements, additional compression costs due to inefficiency in filling individual tube trailers. This is obviously counter to the aims of "Net Zero".
- Efficiency:
  - 536 1300kg tube trailers a day equates to a 195,640 fill and offload cycles each year. It is likely that around 50 compression filling stations would be required, assuming a need to fill 10% of the trucks at any one time (assumes a 2-hour fill period). Furthermore, the trucks will require fuelling for the ~250km round trip journey. It is assumed that hydrogen powered vehicles will be employed in this task. Electric vehicles are likely to be unfeasible due to the journey distance which may necessitate charging at Pembroke and Port Talbot keeping the vehicles out of service for too long, requiring even more vehicles to be purchased. Although difficult to quantify, this can be seen to be significant inefficiency when compared to the compression required for the pipeline.
  - Whilst a pipeline will have a typical design life of 50 years, the tube trucks are estimated to have a life span of 15 years[38] although this could vary between 10 and 30 years. Thus, the tube trailer trucks are likely to require replacement at least once, but likely 2 or three times over the equivalent pipeline lifetime.
- Safety:
  - The huge number of trucks on the road will undoubtedly pose a far higher risk (medium consequence and high probability) to public safety than a pipeline (high consequence but extremely low probability).
- Cost:
  - Due to the additional infrastructure requirements for new roads and storage, the cost of this option will far exceed that of pipeline. The cost discrepancy between road and pipeline transport is clearly highlighted in the DESNZ report on Hydrogen transport and storage[38]. This is highlighted in Figure 29, which is an extract of the summary of this report. The costs do not include for the new roads to accommodate the vehicles.

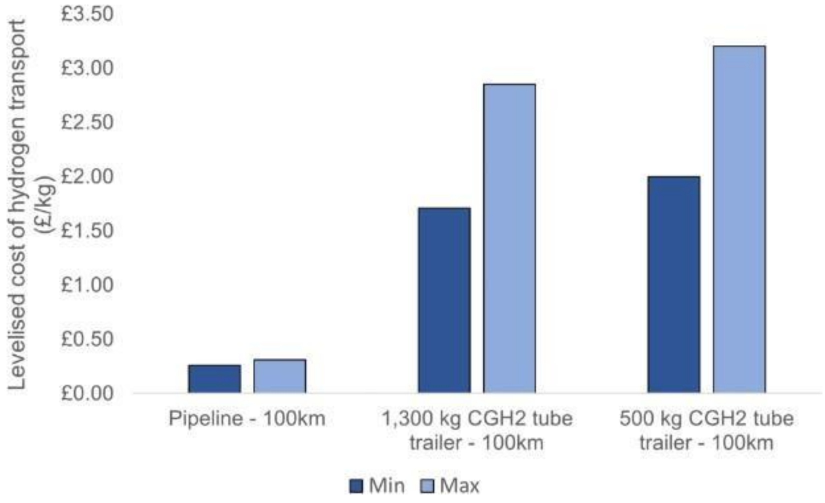


Figure 29 Comparison of levelised costs between pipeline and road hydrogen transport

8.3.3 Rail: Tube Trailers

There is little in the way of documentation on the practicalities of hydrogen transport by rail. It is not specifically covered in the recent (Dec 2023) DESNZ report on Hydrogen transport and storage[38]. However, from a practical standpoint it is likely to face many of the same challenges as road transport.

Rail wagons are only slightly larger than road trailers. See Figure 30 On this basis, it is crudely estimated that 7 to 13 freight trains would be required daily, hauling 1300kg composite tube wagons. This equates to around 1 train every 2 to 3.5 hours (each way). If the smaller 500kg tubes are considered, then around 18 to 32 freight trains would be required daily. This equates to around 1 to 2 trains every hour (each way). These figures are based upon the assumptions that a single freight train can haul 76 lorries worth of freight (source: Network rail website) and that the maximum length of a freight train is around 775m.

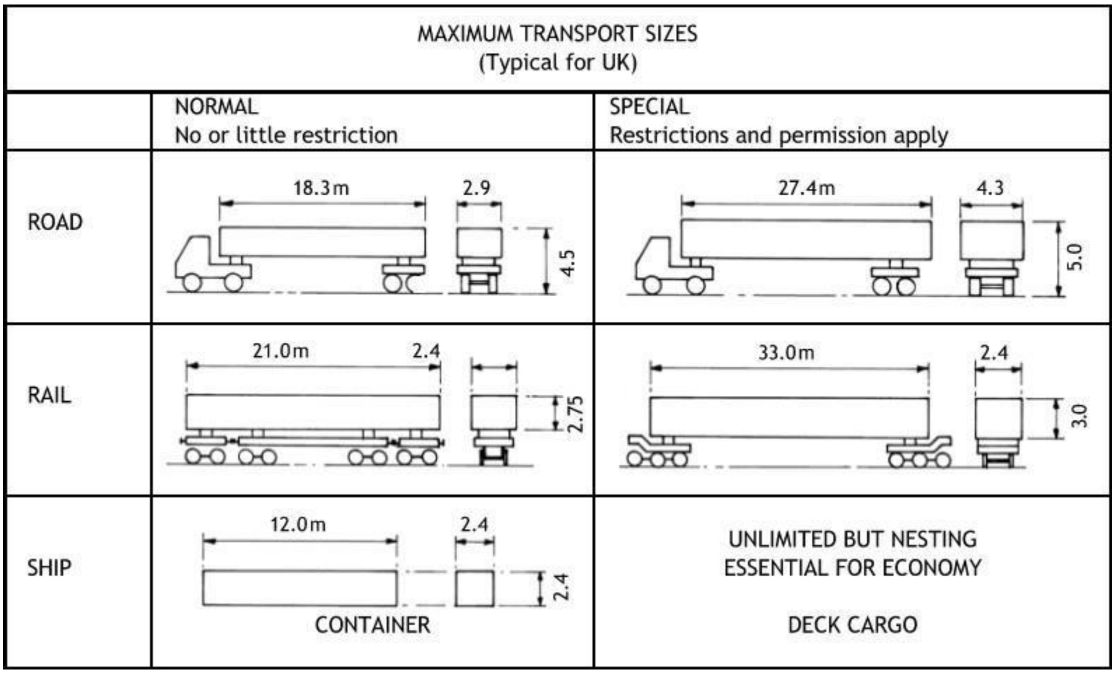


Figure 30 Comparison of typical UK road and rail goods transportation limitations

The existing rail line between Port Talbot and Pembroke is approximately 126km long. See Figure 31. It is dualled from Port Talbot to Whitland (~100km), where the line splits to Fishguard and Pembroke. The line between Whitland and Port Talbot is single track (26km). With a 52-minute journey time from Pembroke to Whitland, this section of single track will not be able to handle any more than 1 train per hour unless new sidings or dualling upgrades are carried out. Additionally, a branch line section will be required to reach the hydrogen production plant as the existing rail line runs into the centre of Pembroke which is a residential area. The dual track section can likely handle 6-8 trains per hour, per direction depending on signalling and operating conditions. Further assessment would be required to determine if this level of additional rail traffic could be accommodated in addition to existing scheduled services, although it initially appears potentially feasible.

Figure 31 Map showing the railway line between Pembroke and Port Talbot

New stations with loading (compression)/offloading facilities would be required at either end of the track. The loading and offloading facilities would need to be much larger than the equivalent for road haulage as each train would be delivering around 76 tubes at a single time, hence more compression units would be needed.

Whilst more reliable than the road network, the reliability of the rail network would still not be sufficient to sustain a "just in time" supply for the offtakers. The trains would be susceptible to delays and disruption due to accidents, maintenance and adverse weather. Thus, it would be necessary to provide storage at the offtakes to account for delays and disruption. Similarly to road transportation, storage of around 7 days' supply, or more, would require provision for 4,430,137kg of hydrogen. This is equivalent to the capacity of "3408" 1300kg tube trailers or 13 25m diameter Cryo-Sphere tanks for liquid hydrogen. It can be seen that storage of this level near the offtake is impractical.

In addition to the impracticalities highlighted above, there are numerous other issues with rail transportation. The list below highlights but a few of the significant points.

- Efficiency:
  - It is likely that around 80 compression filling stations (1 per wagon) would be required to allow expedient compression for each train, with a similar number of offloading stations also being required. It is not clear how practical it is to load a full freight train before the next arrives so double the facilities (160) may be required. Furthermore, the trains will require fuelling for the ~250km round trip journey. Although difficult to quantify, this can be seen to be significant inefficiency when compared to the compression required for the pipeline.
  - Whilst a pipeline will have a typical design life of 50 years, the tube trains are estimated to have a life span of <50years. Thus, the freight trains will need to be replaced at least once, over the equivalent pipeline lifetime.
- Cost:
  - Due to the additional infrastructure requirements in addition to the ongoing cost of operating the trains, the cost of this option will likely far exceed that of pipeline. The cost discrepancy between road and pipeline transport is clearly highlighted in the DESNZ report on Hydrogen transport and storage[38]. This is highlighted in Figure 29. No figures are presented for rail transport in this report. However, the road cost is made up of about 50% compression cost and 50% trailering cost. Thus, as the compression cost will be equivalent for road/rail transport, it can clearly be seen that rail will still be more expensive than a pipeline, even if travel costs were significantly reduced.
- Technological maturity:
  - At present transporting hydrogen by train is not carried out in commercial quantifies in the UK. There is likely to be regulatory and safety issues to be considered which could well affect the viability of this option.

8.3.4 Sea: Liquified Hydrogen Carrier

At present there is only one sea going hydrogen carrier in the world. The Suiso Frontier was launched in 2020 to demonstrate the technical viability of transporting hydrogen commercially by sea. This vessel has a capacity of 1250m^3 (88,563kg) of liquid hydrogen. At this scale, seven vessels would be required, each day, to meet the peak demand assumed under Scenario 3. Given the influence of weather on the reliability of the vessels, it is not practicable to provide a "just in time" supply for the offtakers. Thus, a storage facility of similar size to that envisaged for tube trailer delivery would be required. Additionally, new jetty facilities would be required at both Pembroke and Port Talbot. If future connection of the [redacted] is required, this would still require a pipeline connection from Port Talbot. Given these considerations, sea transport is not considered viable at the present time.

There is potential for future development for larger vessels. A handful of companies are seeking funding for bulk carrier projects at this time. However, the path and timeline to the realisation of these vessel is unclear. As such, the technology is considered too immature for serious consideration at this time. To give an indication on costs, assuming a £100,000 per day charter cost (LNG tankers have recently been above £150,000 per day and as low as £40,000) the cost of operating two LNG tankers over the equivalent pipeline lifetime (50yrs) would be in the order of £3.65B (negating inflation). Thus, this cost far exceeds that of the pipeline option.

8.3.5 Qualitative Selection

As a screening exercise, the following criteria was used to assess the various hydrogen transportation options considered:

- Technical Feasibility
  - Technology maturity & practicality of implementation
  - Efficiency
  - Market compatibility
- Economic Viability
  - Capital cost
  - Operational cost
  - Lifecycle costs
- Safety & Environmental
  - Regulatory compliance
  - Risk to people
  - Environmental impact
- Reliability
  - Reliability of supply
- Regulatory
  - Licensing

Hydrogen Form	Criteria	Appraisal
Onshore pipeline	Tech feasibility	Good: Pipelines have a proven track record for H2 application
	Economics	Good: Onshore pipeline is cheapest option
	Safety & environment	Good: Onshore pipelines have a good safety track record
	Reliability	Fair: Supply will need to balance with demand due to lack of large-scale storage
	Regulatory	Fair: No obvious regulatory issues subject to updating
Offshore pipeline	Tech feasibility	Good: Pipelines have a proven track record for H2 application
	Economics	Fair: Offshore pipeline is more expensive than onshore
	Safety & environment	Good: Onshore pipelines have a good safety track record
	Reliability	Fair: Supply will need to balance with demand due to lack of large-scale storage

	Regulatory	Good: No obvious regulatory issues subject to updating but note WWU is not licensed for subsea pipelines
Road transport	Tech feasibility	Poor: Hugely impractical due to number of tube trailers required
	Economics	Poor: Significant cost with option. Likely needs new road to accommodate trucks and filling plus large offloading facilities for a large number of trucks plus large CAPEX cost for trucks (replaced x2/3 times over life of a pipeline) and local storage
	Safety & environment	Poor: Large number of trucks on the road would present a very high risk of road traffic accidents, with much higher likelihood of injury to people
	Reliability	Unacceptable: Relies on 100% availability of road network due to lack of large-scale storage
	Regulatory	Good: Currently used for transport
Rail transport	Tech feasibility	Poor: Slightly more feasible than road transportation, but large number of tube trailers and required supporting infrastructure means it will still be impractical.
	Economics	Poor: Significant cost with option. Needs upgrade of existing rail lines and filling plus large offloading facilities for a large number of tube tanks plus CAPEX for tube tanks and local storage plus large CAPEX cost for trucks (replaced x2/3 times over life of a pipeline)
	Safety & environment	Fair: Frequency of refilling operations is likely to present and increased risk to safety.
	Reliability	Unacceptable: Relies on 100% availability of rail network due to lack of large-scale storage
	Regulatory	Fair: No obvious regulatory issues subject to updating
Sea transport	Tech feasibility	Poor: No hydrogen bulk carriers of suitable size available at this time or in near future
	Economics	Poor: CAPEX/OPEX or charter costs for vessels (min x2) far exceed cost of pipeline
	Safety & environment	Poor: Bulk carriers likely need to run on hydrocarbons for the foreseeable future as very challenging to decarbonise
	Reliability	Fair: Large scale vessels would provide a degree of storage
	Regulatory	Fair: No obvious regulatory issues subject to updating

Table 21 Transport option assessment

The following scoring was applied to the options in order to rank them. An onshore hydrogen is used as a baseline for a comparative assessment of the other forms.

- Good: 3
- Fair: 2
- Poor: 1
- Unacceptable: 0 - Do not take the option further

Forms	Tech Feasibility	Economic Viability	Safety & Environment	Reliability	Regulatory	Scoring X/15
Onshore pipeline	3	3	3	2	2	13
Offshore pipeline	3	2	3	2	2	12
Road transport	1	1	1	0	3	0
Rail transport	1	1	2	0	2	0
Sea transport	1	1	1	2	2	7

Table 22 Hydrogen transport options: Option screening

It is clear a pipeline is the only feasible option. The DESNZ report on Hydrogen transport and storage[38] highlights the increased cost of offshore pipelines vs onshore pipelines across their lifespan. See Figure 28. In addition to the greater cost of an offshore pipeline, there are no opportunities to provide additional offtake sites to provide provisions for future expansion of the supply network. Therefore, the best solution for transporting hydrogen in South Wales is an onshore pipeline.

9 Engineering Justification

This section supports the requirement set out in the guidance document for the Engineering Justification Paper (EJP). It has been included within the main body of the report, rather than appendices, to reduce duplication and to ensure sufficient information is available for the reader.

Some of the EJP requirements, such as Related Projects, have been covered elsewhere in this document and will be referenced accordingly.

9.1 Summary Table

Name of Project	HyLine Cymru Phase 2 – FEED, Planning and Land Rights	
Scheme Reference	GD2-142	
Primary Investment Driver	DESNZ Net Zero commitment and Customer requirements	
Project Initiation Year	2025	
Project Close out Year	Phase 2: FEED, Planning and Land Rights – 2028 (Phase 3: Detailed Design and Construction – 2033)	
Total Installed Cost Estimate **Base Case / FEED Lite** **(2024/25 prices)**	Phase 2: FEED, Planning and Land Rights – **£29,324,689.92 / £7,916,574.28** (Phase 3: Detailed Design and Construction – [redacted])	
Cost Estimate Accuracy (%)	Class 4 (-30% to +50%)	
Project Spend to Date (core projects)	£2,526,718 (using NZARD UIOLI, Network Innovation Allowance and UK Research and Innovation funding)	
Current Project Stage Gate	SG1 – Feasibility	
Outputs included in RIIO-GD2 Business Plan	No	
Spend Apportionment **Base Case / FEED Lite** **(2024/25 prices)**	**RIIO-GD2** **£8,544,702.00 / £4,673,221.82**	**RIIO-GD3** **£20,779,987.92 / £3,243,352.46**

Table 23 Summary Table

2018/19 prices for both Phase 2 funding options can be found, and is further broken down in Section 5.6.4, Section 12.7, Appendix A and Appendix I respectively.

9.2 Opportunity Statement

a) <u>Why are we doing this and what happens if we do nothing?</u>

In June 2019, the UK became the world's first major economy to legally commit to a net zero greenhouse gas emissions (GHG) target by 2050. In 2021 the UK government issued the Hydrogen Strategy, which set out the approach for developing a thriving low carbon hydrogen sector in the UK to meet the ambition for 5GW of low carbon hydrogen production capacity by 2030. Following the advent of the COVID-19 pandemic and the conflict in Ukraine the UK government issued the British Energy Security Strategy in April 2022. In this policy document the government doubled down on the commitment, "to produce vastly more hydrogen, which is easy to store, ready to go whenever we need it, and is a low carbon superfuel of the future", leading to the increasing of the hydrogen production ambition to 10GW.

South Wales industrial cluster accounts for around 12% of the UK's industrial emissions. It is home to industries like steel, cement and chemical production, to name only a few. These are hard to decarbonise industries where the role of hydrogen is recognised for use where electrification is not feasible or is too costly. The proposed development of the Celtic Sea for wind power and location of the two LNG terminals in Pembroke, which supply over 20% of the UK's natural gas demand, make Pembroke a very attractive location for the production/supply of both green and blue hydrogen. Pembroke, is located around 100km away from the nearest of the South Wales offtakes, located at [redacted] which would enable connection to the existing natural gas Local Distribution Zones (LDZ) and the public and commercial consumers in this region. The cornerstone commercial users, who are primarily located in the region of Port Talbot, to the east of Swansea in the Dowlais LDZ, are located an additional ~25km fr[redacted].

At present there is no significant infrastructure for the cost-effective transportation of hydrogen in South Wales. This stifles the development of both demand and production opportunities. With nothing in place to provide this service, either side of the hydrogen market will struggle to get off the ground.

Therefore, pre-investment in this area is of utmost importance to kick-starting the South Wales hydrogen economy. Given the quantity of hydrogen that is required to be transported, from the point of production to the end-users, a pipeline is the only practicable method for transportation envisaged at this time.

b) Under what circumstances would the need or option change for this project?

The following is a list of potential circumstances which could impact upon the need or cause significant change to the project:

- The project is sensitive to changes in hydrogen demand.
  - Given the nature of the project and all those like it, there is significant uncertainty in the future funding of hydrogen projects and government price controls (I.e. HTBM & HAR) and the commercial viability of hydrogen in the wider realm of renewable energy which could impact upon the hydrogen demand beyond the viable range of the pipeline.
- The project is sensitive to changes in hydrogen production capability.
  - Given the nature of the project and all those like it, there is significant uncertainty in the future funding of hydrogen projects and government price controls (I.e. HTBM & HAR) and the commercial viability of hydrogen in the wider realm of renewable energy which could impact upon the commercial viability of hydrogen production.
- The project is sensitive to hydrogen storage requirements.
  - Given the inaccessibility of large-scale geological storage, the project is looking to mitigate this issue by the design of production facilities which will need to accommodate flexibility to cope with the required demand fluctuations, in conjunction with line packing and potentially some minimal local storage. This may need to be supplemented with management of demand profiles and commercial obligations (incentives and penalties), on both sides of the pipeline, to allow management of the challenge this poses.
  - When looking at the wider UK picture, given the restrictions on geological storage opportunities, HyLine will likely not be alone in facing storage challenges. It therefore presents the opportunity for the project to essentially develop the operating model for other areas with no geological storage.

c) What are we going to do with this project?

The aim of the proposed FEED study is to optimise the engineering solution for the pipeline, including the routing and design configuration, as well as developing procurement and construction plans at a strategic level and ensuring environmental impact mitigation, regulatory compliance and ultimately developing robust cost and programme estimates for the execution phase. In parallel to the FEED, work will commence to flesh out the planning feasibility by development of; a detailed planning & delivery strategy and program, a public affairs strategy, an environmental impact assessment, liaising with stakeholders and securing the necessary consents, licenses and permissions. Additionally, work will be carried out to secure the acquisition of land rights for the pipeline and the associated above ground infrastructure including liaising with the landowners throughout the program.

d) What makes this project difficult?

The main challenges for the HyLine Cymru project can be summarised as follows:

- Uncertainty in supply and demand:
  - It's clear that hydrogen will play a critical role in the decarbonisation of the South Wales and the wider UK, given the need to balance the supply/demand fluctuation that are so difficult to manage with wind and solar sources. However, at the current stage of the energy transition, without an existing transportation network in place, the organic growth of the hydrogen market is choked at both the supply and demand ends of the chain. Thus, perhaps the greatest challenge of the HyLine project is connection of producers and offtakers to build the case for the

pipeline. Much work has been carried out to identify offtakers through pre-FEED and since via the HyLine User Group (HUG) initiative. The project continues to attract a growing hydrogen customer base. Should the project progress into FEED this will only increase user confidence allowing further uptake of offtakers.

- System resilience:
  - Matching supply and demand variance is critical to the system resilience, and minimising or negating the requirement for hydrogen storage. This aspect of the engineering feasibility will be a key aspect of the FEED study.
- Planning and consenting:
  - The HyLine Cymru project will be submitted under a Town and Country Planning Act (TCPA) 1990 because the application cannot be approved through a Development Consent Order (DCO) or Development of National Significance (DNS) because it's a gas pipeline project in Wales. The recently passed Infrastructure (Wales) Act 2024 also doesn't cover pipeline construction under the Infrastructure of National Significance (INS). Therefore, the only option left is to apply for planning permission under the Town and Country Planning Act 1990. This application will be assessed by local authorities unless it's escalated to Welsh Ministers for determination. Due to the number of parties involved this is likely to be significantly more challenging process than if it were to be carried out under a DCO.
- Land rights acquisition:
  - The pipeline passes through close to 300 different landowner's properties. Therefore, attaining the land rights will undoubtedly be a significant hurdle which will likely face multiple objections and potential challenge, which may result in project delays and increased costs.

e) Key milestone dates for project delivery

The following are key milestone dates for project delivery:

NZASP Re-opener application:

- Needs Case approval: May 2024
- NZASP re-opener application submission: October 2024
- Anticipated NZASP approval from Ofgem: May 2025
- Stage Gate 1: May 2025

Phase 2 – FEED, Planning and Land Rights:

- Project initiation: June 2025
- FEED completion: February 2027
- Submission of Planning Application: April 2027
- Secure Land Rights: December 2027
- Stage Gate 2 / FID: January 2028

f) How will we understand if the project has been a successful?

Delivery of the key project deliverables will be the main indicator of project success. The key deliverables or the project are:

<u>FEED:</u>

- Full FEED report
- Summary FEED study report
- Complimentary public update report

<u>Planning:</u>

- Planning and project delivery strategy
- Public affairs strategy

- Planning and delivery programme and budget
- Environmental impact assessment
- Planning application

Land Rights:

- Land acquisition strategy
- Landowner liaison strategy
- Land acquisition programme and budget
- Acquisition of permanent and temporary land rights
- Delivery of land related enabling works
- Post-works compensation management

9.3 Related Projects

Related Projects and key stakeholder ambitions are detailed in Section 6.2.4 and Section 7.

Linked and Supporting Projects are detailed in Appendix G.

9.4 Project Boundaries

The proposed scope of this project covers a hydrogen pipeline, with final size to be confirmed, running from Pembroke to the [redacted] and then onward to the Port Talbot area. As previously stated, it includes a FEED study, Planning and Land Rights.

Listed in Table 24 below are elements which are excluded from the proposed project covered under this NZASP re-opener application.

Scope element	Description
Development of the hydrogen supply in Pembroke	• The proposed producers shall develop their own plans for the production of green and blue hydrogen
Development of hydrogen systems and infrastructure upstream of the designated producers	• The producers shall develop the necessary means to process the hydrogen for their own specific use 'in front of the meter' • HyLine Cymru will not address any offshore infrastructure
Development of hydrogen systems and infrastructure downstream of the designated offtakers	• The offtakers shall develop the necessary means to process the hydrogen for their own specific use 'behind the meter'
Expansion of the pipeline system East of Port Talbot	• This may be explored in the future, but is excluded from this work and application
Detailed Design of the pipeline	• The project is intended to optimise the pipeline design to a FEED level only. Phase 3 will address Detailed Design
Construction of the pipeline	• Phase 3 will address Construction

Table 24 Project boundaries

10 Preferred Option

10.1 Engineering Feasibility Study

A summary of the methodology behind the work carried out as part of the engineering Phase 1A Feasibility study is presented in Section 6.4. This section presents a summary of the results and conclusion of the work.

10.1.1 Routing

The proposed pipeline corridor that the study identified shown in Figure 32 has zones of similar nature in terms of population density, land type, constraints, crossing etc. This means that the route within these zones can move around throughout the Phase 2B FEED to optimise a 25m corridor width for construction. An iterative route has been established within the zone to take forward as the current optimised pipeline route, avoiding as many obstacles and constraints as feasible and where possible at a maximum distance from populated areas and buildings.

As far as practicable, the pipeline routing adheres to the previously stated criteria described in Section 6.4. Given the heavy demand offtakers are located in the Port Talbot area, the pipeline routing corridor was developed to suit this requirement. Passing to the North of Swansea, the route also allows for connection the existin[redacted] (zone 6).

The pipeline route was developed in accordance with the principles of IGEM/TD/1 guidance (Level 1), by means of a desk top study. The route will comprise of an underground pipeline for the full length. The project route would be constructed by trench excavation, pipe laying, then reinstatement to original profile and vegetation covering. Where infrastructure or obstacles are encountered, such as principal highway routes and river estuaries, Horizontal Directional Drilling (HDD) methodology will be deployed. The number of crossings for each zone are shown in Table 25. Construction techniques and methodologies shall be considered further in the proposed FEED.

[redacted]

Figure 32 Proposed corridor for HyLine Cymru pipeline

Zone	River Crossing	Streams	HV Overhead Electricity Cables	HP Pipeline Crossings	Railway Crossings	Dual Carridgeways	Single Carridgeways
1	0	0	0	0	0	0	4
2	0	5	0	0	1	0	3
3	0	25	4	6	1	1	12
4	2	7	8	0	1	0	6
5	1	22	6	15	3	2	6
6	1	1	0	4	0	0	2
7	3	7	8	5	0	5	5

Table 25 Proposed pipeline corridor crossings

A desktop environmental study was conducted for the proposed route. The study looked at the followings areas and reported the key conclusions & recommendations to inform the next steps:

- Ecology
  - The route should avoid statutory and non-statutory designated sites as well as ancient woodland, where this is feasible
  - Undertake further detailed site specific ecological / environmental surveys to inform more detailed routing decisions and avoidance or mitigation requirements
  - Prepare a Construction Environmental Management Plan (CEMP) outlining environmental constraints and protection measures.
- Landscape and Visual Impact
  - In all seven zones there may be the prospect to 'design out' potentially significant landscape impacts and secondary landscape effects from each of the zones, if built development was set back a sufficient distance from wooded areas to avoid felling, and by routing the proposed pipeline along field margins for example, where practical to do so.
  - Where above ground infrastructure is required to be located in each zone, potentially significant landscape effects could likely be 'designed out' by strategically locating the elements in locations where landform and woodland could be used to provide a visual screening influence.
- Transport & Traffic
  - A number of railway lines, major roads and rivers will need to be crossed by the pipeline. HDD installation techniques will be required for these locations, but access to these areas to facilitate the work seems to be generally achievable.
  - There are a high number of locations where crossings of minor roads will be required which will likely be done using open cut methods. These works are likely to cause some localised delay and disruption.
  - There will also be some impacts on local settlements associated with construction traffic. We do not foresee any significant impacts that cannot be successfully mitigated through careful planning of the access strategy and the implementation of a comprehensive Construction stage Traffic Management Plan.
- Noise
  - The potential for noise and vibration impacts associated with the project have been considered and it is suggested that there may be impacts associated with temporary construction noise and potential noise from the operation of fixed plant associated with the proposed development. The potential for adverse effects will be mitigated through implementation of Best Practical Means as described in a Construction Environmental Management Plan.
  - The potential for adverse effects associated with operational noise from the proposed development will be reduced through the design and mitigation methods to levels commensurate with no significant adverse impact.
  - The proposed development, through the EIA process, should be assessed with regard to potential noise impact, set against baseline background sound levels and taking into account the potential for specific mitigation with regards to sensitive receptors.
- Air quality

  - It is understood that the pipeline will be underground and will be installed through trench construction methods. It is also understood that HDD will likely be the pipeline construction method under roads and watercourses. Construction will be required for connection stations at either end of the pipeline. Additional above ground construction will be required for a number of pressure reduction stations, where there are offtakes, and these will typically be containerised compounds around 20m x 5m in area. Similarly, there will likely be block valve stations every 20 miles.
  - A construction phase dust assessment will need to be undertaken in accordance with the Institute of Air Quality Management (IAQM) guidance. This will focus on nuisance dust and particulate matter (PM10) effects on human health as well as ecological effects. As part of the Air Quality Assessment, dust control measures will be recommended, commensurate with the dust risk.
  - Air quality dispersion modelling will be undertaken for the roads where the pipeline construction phase will generate traffic in exceedance of the above criteria. The results of the modelling scenarios (without pipeline and with pipeline) will be compared to determine the significance of effect.
  - The operational phase of the pipeline is not expected to generate any significant air emissions during normal operational activities. During abnormal operations however, it is possible that emergency venting of hydrogen may be required along sections of the pipeline.
- Flood risk & hydrology
  - Whilst under construction, care should be taken in areas highlighted to be at flood risk, that construction works such as temporary works and watercourse diversions do not exacerbate flood risk to nearby areas.
  - Following completion of the project, the proposed pipeline will likely wholly be positioned below ground with no planned changes to above ground levels along either route Option. The completed development is therefore expected to have negligible impact on flood risk along both routes and through the surrounding areas.
  - There is potential for fluvial flooding to occur if any nearby watercourse overtopped its banks during or following an extreme rainfall event. The siting of AGIs therefore needs to take account of the potential for flood risk impacts.
- Historical environment
  - The pipeline feasibility route crosses a landscape that is demonstrably rich in archaeology from the prehistoric to modern periods. Within a 1km study area based on the feasibility route there are 28 scheduled monuments, 71 listed buildings, two Registered Historic Parks and Gardens, one conservation area and four Registered Historic Landscapes. There are 21 non-designated historic assets within close proximity to the pipeline route that are potentially of regional or higher heritage value, although these are a small proportion of the known resource within the study area, which includes assets dating to the prehistoric to modern period along the route.
  - The study has identified that there are some particular 'hot spots' within the route corridor, comprising:

    [redacted]
- Biodiversity
  - The approach to Biodiversity Net Gain in Wales is to deliver an overall improvement in biodiversity. the emphasis is on proactive consideration of biodiversity and wider ecosystem benefits within a placemaking context early in the design process.
  - The aim is that the planning system will encourage the use of high calibre ecological expertise and early discussions with planning teams to design developments on a case-by-case basis that positively impact ecosystem resilience.
  - The nature of the HyLine Cymru project, with a 125km pipeline, will require detailed focus on any potential impacts on designated sites, e.g. sites of specific scientific interest (SSSIs), as protection here will be enhanced. For most of the route a lighter approach may be appropriate, but one still acknowledging and responding to the climate emergency and need for protection and general enhancement where appropriate of biodiversity.

In general the desk top environmental study concluded that there were no obvious show stoppers but that a further detailed review of the routing would be required in order to develop an optimal proposed route, minimising the impact of the pipeline.

The above topic summaries provide, to some extent, an idealistic response, whereby the project would have no impacts on any environmental asset whatsoever. Taking such an approach, however, is unrealistic as moving the pipeline route to avoid areas where there are for example non-designated assets or areas of medium landscape character or quality, will likely flag other constraints from similar assets.

The preferred approach should be one that seeks to avoid direct impacts on assets of significance, scheduled monuments, Listed Buildings, Registered Parks, habitat designated sites of high importance and special landscape areas etc. However, in some instances there may be a logistical requirement to route the pipeline on the edge of such designations or that impact on lower value designations. The temporary nature of most of the potential impacts, that is during the construction phases, means that they can be more easily managed, mitigated where necessary, and ultimately demonstrating no residual effects. it is strongly advised that detailed route refinement avoids all scheduled monuments, Listed Buildings, Registered Historic Parks and Gardens and Conservation Areas within the feasibility route corrido[redacted]

Further route refinement should be supported by a more detailed historic environment desk-based assessment.

10.1.2 Preliminary Pipeline Design

The following section presents the results of the pipeline sizing work carried out in Phase 1A Feasibility. It should be noted that these design scenarios are now out of date, so the following section will look to reconcile the results against the latest demand data.

10.1.2.1 Feasibility Demand (Superseded)

Table 26 presents the proposed optimised design summary for each of the five scenarios considered in Feasibility. For CAPEX optimisation, efficient solutions are based on pipelines with minimum wall thickness and optimised design pressure.

Scenario		Pipeline					Other Facilities		
Scenario	Design pressure (barg)	Nominal diameter (inch)	Steel Grade	Wall Thickness (mm)	Schedule	Length of pipeline (km)	No. of block valve stations	No. pig traps	No. offtakes (AGI's)
S1	60	12”	X52	8.38	SCH 30	106.5	7	2	1
S2	60	12”	X52	8.38	SCH 30	128.1	10	4	1
S3	60	24”	X52	14.3	SCH 30	128.1	10	4	2
S4	60	24”	X52	14.3	SCH 30	128.1	10	4	2
S5	60	32”	X52	17.5	SCH 30	128.1	11	4	3

Table 26 Recommended hydrogen transmission pipeline design for all scenarios

Potential future requirements for the pipeline and how it might fit into the wider UK energy transition may generate the need to operate at higher pressures.

Increasing the pipeline design pressure to 75 barg instead of 60 barg would have the following impacts:

- S1, S2, S3 and S4 all increase to SCH 40 which would increase CAPEX by 22% - 28%
- S5 would require a non-standard pipe size which would increase the CAPEX by 32% - 35%

For each scenario there is some available capacity beyond the design flowrate, although this headroom will depend upon various operational factors.

10.1.2.2 Latest Demand Data

Given the changes to the demand data after the completion of the Feasibility, it has been necessary to re-evaluate the pipeline sizing.

The driving factor in the pipeline sizing is the peak hourly demand. The latest peak hourly demand data is shown in Table 27, expressed as energy flow (GWh/h). This data considers peak demand for all offtakers to occur simultaneously, which is likely a conservatism, although given the % weighting of the key offtaker, this is not considered excessive.

For comparison, Table 28 gives the pipeline design flow rates expressed as both volumetric flow (scm/h) and energy flow (GWh/h), for 40barg inlet pressure, as well as for different outlet pressures of 25barg / 12.5barg. Contrary to the previous study work, the pipeline operating pressure of 40barg is proposed as the preferred operating pressure, as this will be close to the anticipated outlet pressure of the producers' electrolysers that will feed Hydrogen into the pipeline. Adopting this operating pressure will negate the requirement for costly compression at the pipeline entry points.

The figures consider schedule 30 pipe for each of the listed sizes. To make comparisons easier, Figure 33 **Error! Reference source not found.** highlights the same data in chart form, graphically indicating pipe flow rates against peak hourly demand.

Offtaker	LOW (GWh/h)	CENTRAL (GWh/h)	HIGH (GWh/h)
LanzaTech	[redacted]	[redacted]	[redacted]
Tata Steel	[redacted]	[redacted]	[redacted]
Heidelberg Materials	[redacted]	[redacted]	[redacted]
Sofidel	[redacted]	[redacted]	[redacted]
Vale	[redacted]	[redacted]	[redacted]
Total	**0.32**	**0.40**	**0.65**

Table 27 Latest peak hourly demand scenarios

	40barg (inlet) (scm/h) / (GWh/h)	
Pipe Dia	**25barg (outlet)**	**12.5barg (outlet)**
8"	38,126 / 0.11	46,966 / 0.13
12"	109,085 / 0.31	134,874 / 0.38
16"	198,335 / 0.56	243,884 / 0.69
20"	359,219 / 1.02	441,477 / 1.25
24"	607,924 / 1.72	746,806 / 2.12

Table 28 Pipeline flow rates for different inlet / outlet pressures

For the LOW demand scenario, a 12 inch pipeline, with 25barg outlet pressure, is just short of the flow needed for the lower scenario. Although, a 12 inch pipeline with the lower 12.5barg outlet pressure case would be sufficient for this scenario. However, the 12 inch pipe would be far short of the flow requirements for either of the CENTRAL or HIGH scenarios.

At the other end of the spectrum, for the HIGH demand scenario, a 16 inch pipeline, with the lower 12.5barg outlet pressures can provide adequate flow for this scenario. However, for the higher outlet pressure it would be necessary to step up to a 20 inch pipeline. A 20 inch pipeline however presents challenges during construction and over its operational lifetime, given that it is a 'non-standard' diameter, 24 inch will therefore continue to be considered as the project moves to FEED.

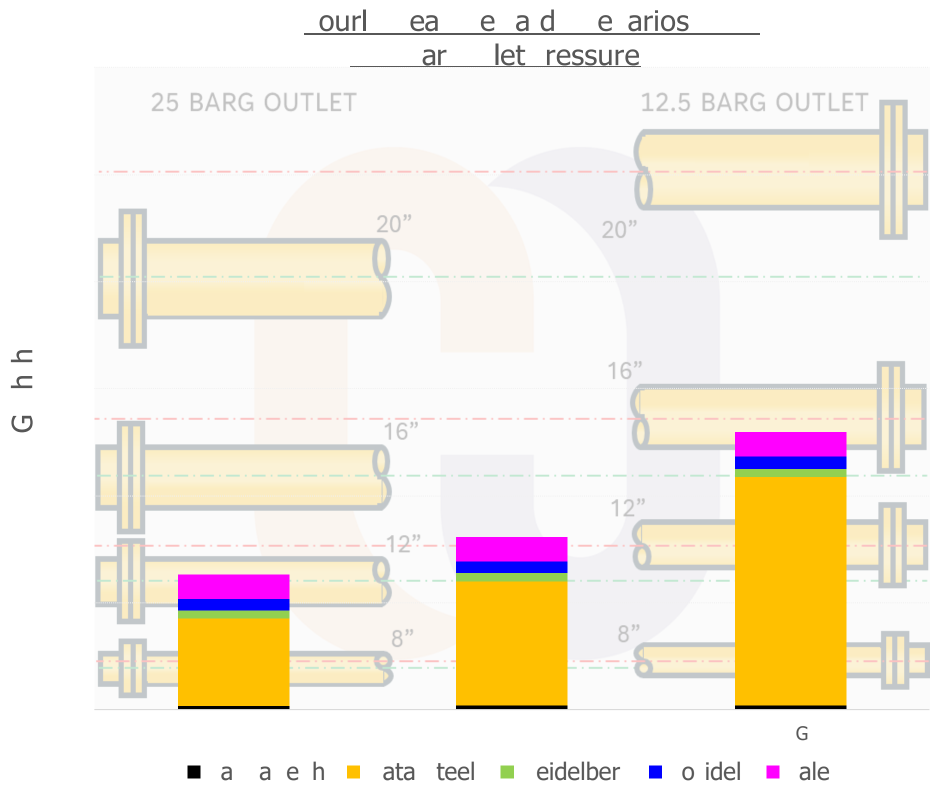


Figure 33 Hourly peak demand with pipe flow capacity at 40barg operating pressure

At this stage of the energy transition, demand is somewhat throttled by the uncertainty in the availability of Hydrogen. However, once the pipeline is constructed, this constraint will be significantly softened and it is likely that future demand will rise above current expectations. Furthermore, there is also potential that current estimates prove to be lower than future requirements due to underestimating demand. Thus, having additional capacity in the pipeline, within reason, is practically and politically the far better scenario be in. It would be prudent and preferable to upsize the pipeline to have capacity for future unseen demand.

Table 29, indicates indicative capacity (headroom) if choosing to upsize the pipeline to future proof the project. The figures are predicated on the assumptions of industrial customers equivalent in size/demand to [redacted] and domestic properties having an average peak hourly demand of 5.9566e-6 GWh/h. Line packing requirements are also not considered in reference to these values.

Pipeline size @ 40barg operating pressure (inlet)	Outlet pressure (barg)	Pipeline Headroom			
		Approximate No. of additional industrial customers		Approximate No. of potential homes heating with 100% hydrogen	
		CENTRAL	HIGH	CENTRAL	HIGH
12”	25	-	-	-	-
	12.5	-	-	-	-
16”	25	6	-	28,500	-
	12.5	11	2	50,000	9,500
20”	25	22	14	105,000	64,500
	12.5	30	22	144,500	103,500
24”	25	47	39	223,500	182,500
	12.5	61	52	289,500	249,000

Table 29 Indicative capacity for upsizing pipeline

10.1.2.3 Pipeline Design Options for FEED

Given the current range of foreseeable demands, it is proposed to carry three pipeline size options through to Phase 2B FEED, for further consideration. Retaining the flexibility in the sizing will be highly beneficial to the project. This will provide more time for engagement with offtakers and will allow for better development of the Heads of Terms and Transportation Agreement, which will further bolster confidence and help to ensure the full benefits can be realised upon completion of Phase 3: Detailed Design and Construction.

- 12 inch (X52 carbon steel)
- 16 inch (X52 carbon steel)
- 24 inch (X52 carbon steel)

Whilst the pipe size will significantly impact upon the "installed" cost of the pipeline, there is a negligible impact upon the proposed engineering FEED costs associated with preserving this versatility.

10.1.3 Project Risks

10.1.3.1 Risks

A risk workshop was held as part of the Phase 1A Feasibility work. Table 30 below highlights the top unmitigated risks in the project. Further detail can be found in Appendix D, including mitigations.

Item	Risk title	Description	Risk reduction		
			HS	LH	RR
SS1	Supply of hydrogen to the pipeline	There are a number of parties interested in supplying hydrogen to the pipeline but no commitments or agreements in place. Risk that hydrogen supply is insufficient, or schedule of supply does not match pipeline construction schedule.	5	4	20
DA1	Demand / supply match up	Significant work has been undertaken at pre-FEED for supply and demand requirements but it is clear that there are many variables and significant work to do in order to match supply and demand and finalise pipeline design	5	4	20
C1	Commercial agreements	Reaching FID will require commercial agreements to be made between suppliers and consumers, as well as the entire supply chain. These are likely to require significant external funding, no agreements or funding mechanisms are currently in place.	5	5	25
C6	Economics	Lack of H2 business model, CFD arrangements, increased operation costs	5	4	20
C7	Supply chain	Material supply (steel) and labour rates	5	4	20
T1	Managing variation in demand and supply	Initial estimates for above ground storage to manage variation in demand are huge. Plan is to investigate if this can be controlled at source via power station or electrolysers but risk this may not be feasible.	5	4	20
T8	Planning approval	Complex process with an unknow route through the process currently in consultation (Welsh gov)	5	4	20
T9	Regulatory approval	Complex process and could be driven by policy (2026), Ofgem	5	4	20
SC8	Supply chain	With labour shortage, there may be insufficient skilled labour resource available to meet the schedule	5	5	25
SC10	FID approval	Stage gates delayed, financial commitment/funding etc	5	5	25
SC11	Legal	Arrangements for all stages of the project	5	5	25

		Hazard severity (HS)				
		1	2	3	4	5
Likelihood index (LH)	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

High	High risk - Unacceptable Design change or special precautions required to be communicated fabricator/manufacturer/contract or/end user
Medium	Medium Risk - Tolerable Residual risk to be communicated fabricator/manufacturer/contract or/end user
Low	Low Risk - Acceptable No further action required

Table 30 Summary of un-mitigated risks identified in risk workshop

11 Proposed Phase 2 Delivery Plan

11.1 Aims and Objectives

The aim of the Phase 2B FEED study scope is to optimise the HyLine Cymru pipeline design and to develop the technical and engineering project detail sufficiently to allow for a suitable cost and programme estimate to be produced to facilitate the Final Investment Decision (FID). Running in parallel with the FEED it is proposed to address the planning, public consultation and consenting aspects of the project to confirm the viability of the project from the stakeholder, environmental, legal and regulatory perspectives.

The project goals are:

- Support the UK and Welsh governments in achieving low-carbon hydrogen and net-zero targets
- Provide system resilience and flexibility to the South Wales energy system
- To enable the decarbonisation of multiple hard-to-abate industrial sectors, in the UK's largest industrial cluster
- To develop a feasible network connecting supply and demand in South Wales
- To catalyse wider system benefits for the South Wales region and beyond

11.2 Project Team Structure

The project team will be structured and will consist of the positions shown in Figure 34.

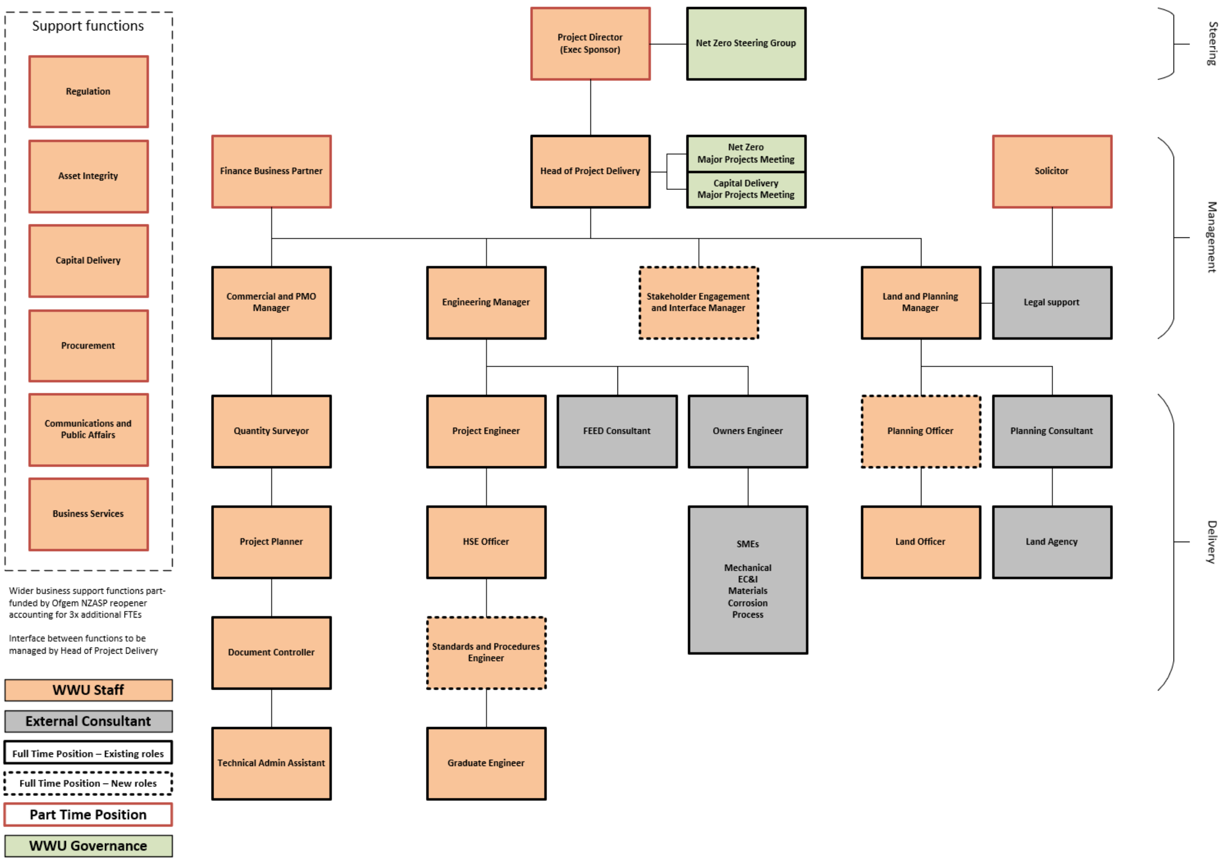


Figure 34 Project team structure

11.3 Scope and Work Packages

The HyLine Cymru programme is split into three phases, where the work set out in this section represents the work to be undertaken through Phase 2 FEED, Planning and Land Rights. This follows on from the Phase 1A Feasibility and Planning Options work delivered in 2023 (Appendix B), and Phase 1B development of proposed hydrogen Transportation Agreements and Pre-consenting work which will be delivered in 2024.

The purpose of Phase 2 is to deliver a full Front End Engineering Design (FEED) study, secure adequate land rights, prepare for and submit a planning application, and apply for any necessary environmental consents.

11.4 Execution Plan

The Phase 2 contracts have been set out as follows:

- Lot 2A - Planning and Land Rights
- Lot 2B - FEED Design

WWU will measure the performance of the project delivery against Key Performance Indicators (KPI) to ensure that critical success factors are achieved. Those critical success factors are as follows:

- Conclude Phase 2 on time
- Minimise WWU cost exposure
- Manage WWU cashflow
- Secure land rights
- Secure back-to-back supply/ offtake agreements
- Establish Cost Base using competitively tendered figures
- Submit Planning Application
- Submit Statutory Licenses application

Key Performance Indicators aim to provide accurate monthly data on Project Health and Status for the Executive Management Team. A RAG system will be used to evaluate team performance and guide necessary interventions for successful project delivery.

11.5 FEED Strategy

The strategy for delivering the key Phase 2B FEED engineering work package involves several steps. First, it will be essential to confirm that the existing demand, supply, and storage data remain accurate, updating them as necessary. This will ensure that the subsequent delivery of the planning strategy is based on the most current information. A thorough review of the existing Phase 1A and 1B work will also be undertaken by WWU, particularly in relation to the need for an additional production spur linking Milford Haven to Pembroke and supporting production from H2 Energy Europe. This review will help determine any changes required against the outcomes of the Feasibility work.

Determining the optimal pipeline routing will be needed to minimise construction challenges and operational risks in Phase 3 of the programme (Detailed Design and Construction). WWU will employ careful consideration of land use planning zones and Local Development Plans to ensure that the revised pipeline routing is both practical and compliant with local regulations. Consideration will be made of any impact to the Environmental Impact Assessment (EIA) throughout, as it will identify potential environmental risks and the necessary mitigations to address them. Defining hydrogen quality standards and the required gas treatment equipment will also be important to ensure that the hydrogen produced meets the necessary quality standards for use by the offtakers.

Reviewing all options for hydrogen supply and demand optimisation through flow assurance modelling, as well as storage solutions, is essential to meet peak demand requirements. This includes optimising the pipeline diameter and pressure to ensure adequate flow rates, and alignment with expectations from producers and offtakers. The FEED phase also incorporates above-ground installations (AGIs) and control systems, the design of which will be impacted by flow assurance activities.

Ensuring compliance with national and international standards for design, engineering, planning, procurement, and construction is a fundamental part of the FEED strategy. Accurate cost estimation for detailed design and construction, including capital equipment and specialist service requirements, will be carried out to AACE Class 3 standard. Additionally, lifetime maintenance costs will be estimated to provide a clear picture of the project's long-term financial implications. Finally, risk and cash flow analysis will be conducted to identify potential financial risks and ensure the project remains financially viable throughout its lifecycle.

Consideration of constructability, whilst developing construction specifications and an execution plan is also required to ensure that the project can be carried out efficiently and effectively. A comprehensive bill of materials will be developed by WWU, identifying long lead items to avoid delays. Supply chain evaluation and gap analysis will help identify any potential issues in the supply chain and address them proactively through early engagement.

11.6 Planning and Consenting Strategy

The HyLine Cymru project will be submitted under a Town and Country Planning Act (TCPA) 1990 because the application cannot be approved through a Development Consent Order (DCO) or Development of National Significance (DNS) because it's a gas pipeline project in Wales. The recently passed Infrastructure (Wales) Act 2024 also doesn't cover pipeline construction under the Infrastructure of National Significance (INS). Therefore, the only option left is to apply for planning permission under the Town and Country Planning Act 1990. This application will be assessed by local authorities unless it's escalated to Welsh Ministers for determination.

Delivery of the planning and consenting strategy will focus on efficiency to optimise timescales and ensure the submission is accurate. To achieve this, the following approach will be adopted:

Establish the Planning Baseline (approx. four months; months 1 to 4)

The project team will finalise the Planning Strategy to explain the planning pathway and identify key planning and environmental issues, including the scope of policy designations along the pipeline corridor. This will involve setting up relevant workshops and stakeholder groups in alignment with the Planning Application and planning strategy.

Timescales are crucial to allow planning for other workstreams related to the project and to avoid delays that could drain resources. For example, the project team will:

- Utilise Service Level Agreements (SLA), Statements of Common Ground (SoCG), and Memorandums of Understanding (MoU) with key stakeholders. The SLA should encompass various LPA functions including planning, highways, Lead Local Flood Authority (LLFA)/Sustainable Drainage Approving Body (SAB), biodiversity officers, etc., to obtain a consolidated agreement.
- Establish early scoping-out of assessments that do not need to be included in any submission.
- Ensure that the full 'project description' including associated works is clearly articulated in a digestible format for consultation/engagement.

Proactive Early Strategic Engagement (approx. four months; months 1-4)

Prior to the 'pre-application' phase, the project team will undertake informal discussions with the relevant planning authorities at a senior level, Welsh Government officials, and key local politicians. This will be alongside the final site selection and the initial design processes. The objectives will be to make subsequent phases more efficient by establishing senior officer and member support from planning authorities, identifying potential issues quickly, and enabling the LPA to understand early on where resources might be needed. Early public engagement will run in parallel. To assist, WWU will prepare a vision document (infographic-led) to explain in a non-technical format the purpose of the project, the benefits, the alignment, consenting process, and timescales. A Memorandum of Understanding (MoU) between WWU and the four local authorities will then be put in place to address arrangements around working proactively to arrive at a decision.

Pre-application prior to EIA Scoping (approx. six to nine months; months 2-11 – dependent on project start and survey seasons)

The project team will ensure the essential planning performance agreements (PPAs) are in place with the relevant planning authorities (RPAs) and stakeholders to underpin effective and timely delivery. Given the scale, bespoke and consistent agreements across the LPAs will be important to explore and implement as early as possible. It would also be prudent to consider whether one LPA will lead on the application, which could be dealt with under the MoU.

The project team will set out the "project description" so that the scope of the works is clearly defined and can be communicated to stakeholders in advance of the stakeholder consultation. Early stakeholder engagement should be allowed for.

The project team will undertake surveys across the proposed route as soon as reasonably practicable. Any survey seasons should be taken into account as certain windows are very narrow and if they are missed, this could delay the scheme by up to 12 months whilst waiting for the survey window to reopen.

Engineering and design work will be ongoing, with relevant freeze and gateway milestones created in this period to align with planning and consenting. A level of fix will be required to inform scoping.

In parallel, WWU will work closely with its consultants to scope the planning reports and plans required for any application. This can take place in parallel with the later stages of the pre-application process, allowing for early and comprehensive pre-application engagement. This will support streamlining the formal scoping process. The statutory period for LPAs to issue a scoping opinion is 8 weeks. Given the cross-boundary and complex nature of such a project, additional time should be allowed for at this stage.

A robust EIA scoping process will inevitably lead to a better and more efficient EIA. The project team will seek to confirm the scope of and approach to the EIA as early as possible in the process to assist in initiating workstreams. It will also assist in building relationships with key consultees and stakeholders with whom WWU would be liaising throughout the period of EIA and beyond.

EIA Scoping (approx. 3 months; months 11-13)

An EIA scoping request will be made to the respective LPAs. The statutory period for LPAs to issue a scoping opinion is 8 weeks. Given the cross-boundary and complex nature of such a project, additional time should be allowed for at this stage. Early and comprehensive pre-application engagement at Stage 2 above will support streamlining the formal scoping process.

Pre-application post EIA Scoping (approx. two months; months 15-17)

A final scheme fix for planning and Environmental Statement (ES) purposes will be critical early in this stage to allow time for technical assessments to respond to a fixed design. Time will be required to complete assessments, respond to scoping, and develop the full draft ES and planning application(s). This will be required for PAC (see below). Engagement with stakeholders, LPAs, Natural Resources Wales (NRW), and others will remain ongoing throughout this period.

Statutory Pre-application Consultation (approx. two months; months 18-19)

The key steps that WWU will manage through the Statutory Pre-Application Consultation (PAC) are set out below:

- Establishing the type of development.
- Making a draft version of the planning application available for the consultation – this would also be covered as part of the steps above.
- Starting the 28-day consultation period - A minimum of a 28-day statutory consultation period must be held ahead of submitting the planning application. This will start once:
    - Site notices (in English and Welsh) are displayed for public viewing around the application site,
    - A copy of the site notice has been sent to the owners or occupiers of land adjoining the application site and community consultees,
    - The information as set out in Schedule 1C under Article 2D - Consultation Before Applying for Planning Permission - DMPWO (The Town and Country Planning (Development Management Procedure) (Wales) Order 2012) has been sent to the specialist consultees,
    - A copy of the draft planning application is made available for public viewing in an accessible place.
- Preparing a Pre-application Consultation Report - This report is a validation requirement for planning applications and will form part of the final application submission. It will evidence how WWU has carried out the consultation.

Finalisation and Submission (approx. 2 months; months 20-22)

WWU will respond to points raised during the PAC, update documentation, collate feedback, and finalise the submission.

11.7 Land Rights Strategy

The majority of the route of the HyLine Cymru pipeline will run through land, which is privately owned and will, therefore, require agreement for its installation and maintenance. As mentioned in section 11.6, a DCO (or similar) cannot be obtained by WWU for HyLine Cymru. For that reason, land rights, both for the pipeline and above ground installations, will need to be obtained by voluntarily negotiation or by compulsory acquisition under the Gas Act 1986.

To prepare for the FID, WWU will negotiate option agreements with affected landowners which will allow us to acquire Deeds of Easement for the pipeline or transfers/leases for above ground installations ahead of the start of construction. Option agreements will provide WWU with the ability to obtain the necessary rights without binding us into payments in the event the project does not progress thus balancing the need for certainty with the flexibility to respond to changing circumstances [redacted]
The Deeds of Easement will allow for the construction of the pipeline, future maintenance and contain restrictions to ensure its safety and integrity.

Alongside voluntary negotiation with landowners, WWU will prepare for a compulsory acquisition of rights under the Gas Act 1986 should any landowner or occupier not wish to voluntarily grant the relevant land right. Such an order will only be used as a last resort and will require a robust evidence base to justify the granting of compulsory rights by the Confirming Authority. By 'twin tracking' voluntary negotiation with a compulsory purchase order, WWU will ensure that the project can be delivered once the FID is made.

Voluntary licence agreements will be offered to landowners for access to undertake non-intrusive and intrusive surveys as required as part of the engineering or environmental investigations. Set payments will be made to landowners, based on the particular type of activity, which will be benchmarked against other payment rates offered by utility and infrastructure companies. Where voluntary agreements cannot be reached, WWU will rely on serving statutory notices of entry to undertake the required surveys.

Landowners will be entitled to professional representation in negotiating both the option agreements and survey access licences. WWU will reimburse the reasonable surveyor and legal costs incurred in accordance with WWU's Fee Guidance Note.

11.8 Supportive Works

Alongside the core Phase 2A Planning and Land Rights work, and Phase 2B FEED work, WWU will also be preparing for FID in January 2028. To ensure this transition does not cause an undue delay to the project plan, two supportive Phases have been proposed:

- Phase 2C – Transportation Agreements
- Phase 2D – HTBM Application

11.9 Project Plan and Programme

A summary of the programme of works for Phase 2: FEED, Planning and Land Rights and Phase 3: Detailed Design and Construction, taken from the detailed master programme, can be seen below in figure 35.

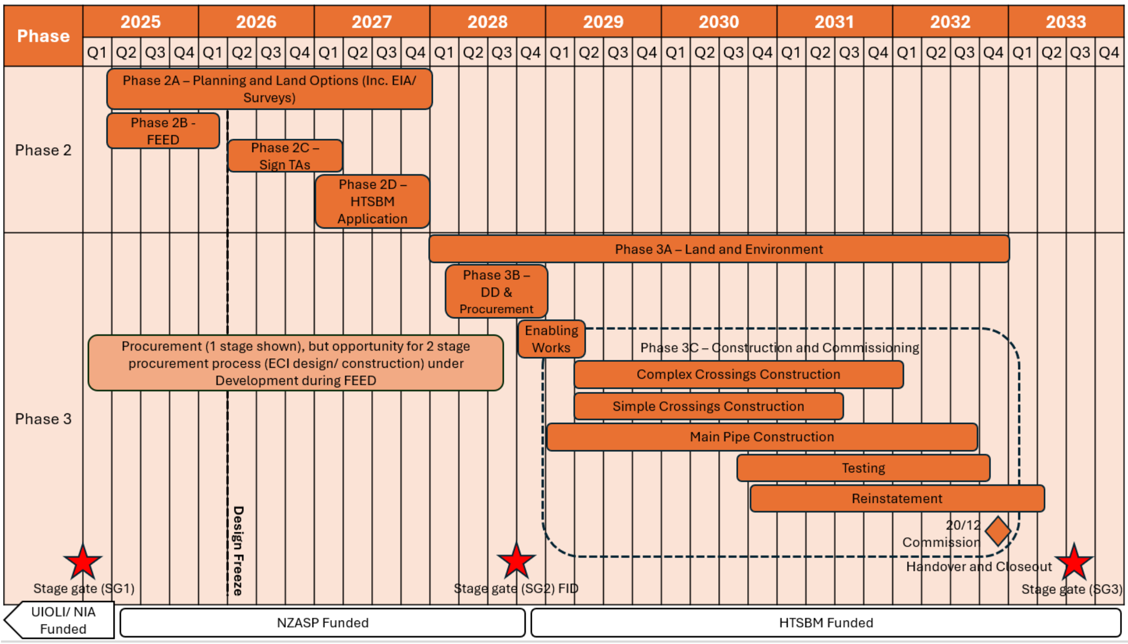


Figure 35 Phase 2 & 3 programme of works

The Phase 2: FEED, Planning and Land Rights programme has been split into two primary phases (2A and 2B) and two supportive phases (2C and 2D) that collectively run from 2025 to 2028. A summary of the programme of works for these phases, taken from the detailed master programme, can be seen in Figure 36.

The primary Phase 2A Planning and Land Rights work, and Phase 2B FEED work, have been awarded to preferred suppliers subject to contract (see Section 11.4), and constitute the core work required to prepare the project for FID:

- **Phase 2A – Planning and Land Rights**: Securing Land Rights for the final route alongside a full Planning application
- **Phase 2B – FEED**: Undertaking a comprehensive Front End Engineering Design study for the pipeline

Alongside the core Phase 2A Planning and Land Rights work, and Phase 2B FEED work, and to adequately prepare WWU for FID in January 2028. Two supportive Phases have been proposed:

- **Phase 2C – Transportation Agreements**: Signing the overarching commercial agreements binding WWU with Producers and Offtakers
- **Phase 2D – HTBM Application**: Applying for and negotiating funding under the DESNZ Hydrogen Transport and Storage Business Model (HTBM)

As part of the Phase 2: FEED, Planning and Land Rights works, the procurement of the Phase 3: Detailed Design and Construction contractors shall be carried out. This will allow for award shortly after FID and, along with the four Phases described above, maintain the continuity of the project. A breakdown of the construction tender procurement programme and the lots of work can be seen in Table 31.

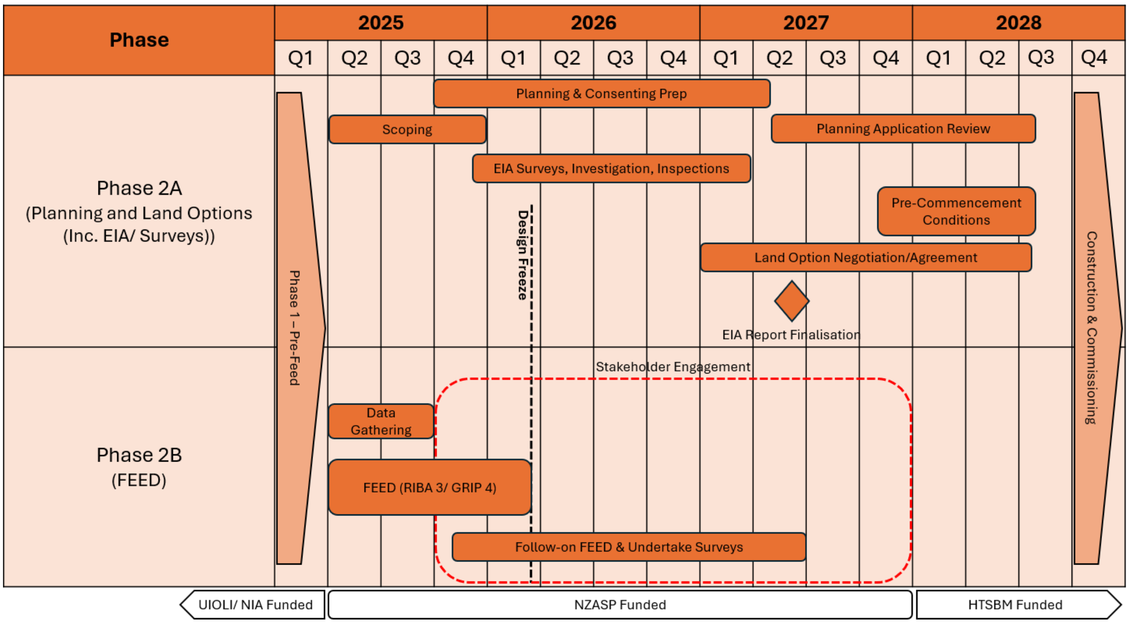


Figure 36 Phase 2A and 2B Detailed programme of works

		Delivery Date						
Phase	FEED Procuremenet Activity	Lot 3.1 Main Contract Excavation & Pipeline Installation	Lot 3.2 Direction Drilling (HDD)	Lot 3.3 Bored Tunelling (BHD)	Lot 3.4 Professional Services	Lot 3.5 Steel Pipe	Lot 3.6 Bespoke Plant/Equipment	Lot 7 Land Option Agreements
Funding System		HTSBM						NZASP
1	Agreement on Core/Option/Lot Contracts	PRE-FEED			TBC	TBC	TBC	managed via a different mechanism
2	Identify Suppliers/Contractors	Jan-27	Jan-27	Jan-27				
3	Expressions of Interest	Apr-27	Apr-27	Apr-27				
4	Invitation to Treat (2 Stage)	Jul-27	Jul-27	Jul-27				
5	Award ECI (Detailed Design RIBA Stage 4)	Apr-28	Apr-28	Apr-28				
7	Main Works - Pre Award Negotiation	Sep-28	Sep-28	Sep-28				
8	Award Main Works	Oct-28	Oct-28	Oct-28				

Table 31 Phase 3 construction tender procurement programme

11.10 Programme and Delivery Risk

Strategic Risk Workshops were conducted during the Phase 1A Feasibility Phase, which identified risks that were collated into the resulting Risk Register. At this stage, risks identified are determined to generally all be significant, with a better assessment being able to be undertaken at Phase 2, when greater detail and sensitivity of these risks can be achieved. Twenty-four risks have been identified and recorded. Below is a summary of the highest evaluated risks identified.

Risk					
Risk ID	Status	Category	Impact Type (Time, Money, Quality)	Causes	Effects
4	Open	Legal/ Insurance/ Regulations/ Funding	Money	Legal challenge on Compulsory Purchase	increased cost/ delayed programme
6	Open	Planning, Third Parties & Programme	Time, Money	Landowners put in permission for solar ahead of formal planning to increase value of land.	increased cost to purchase land
10	Open	Design & Scope	Time, Money	Unforeseen archaeological, environmental, ecological, geological Conditions,UXO	Prolongation of construction phase impacting on revenue and increasing delivery costs
13	Open	Construction/ Logistics/ Safety	Time	Construction Schedule assumptions are incorrect	Construction takes longer than expected with impact on revenue and prolongation costs.
17	Open	Legal/ Insurance/ Regulations/ Funding	Time, Quality, Money	Changes to regulations and legislation relating to funding, and/or delivery during project duration	Aborted design work, sunk costs and delayed delivery
20	Open	Commercial, Procurement & Stakeholders	Money	Volatility of supply chain materials	Drives up cost

Table 32 Key programme and delivery risks

11.11 Project Reporting

11.11.1 Project Reporting

The project has been organised into Workstreams with an appointed Workstream Lead. The Workstream Lead will report on the monthly progress of their Workstream through the populating of WWU's project reporting template for major projects. This will be used to show performance and progress against a number of agreed KPI's and provide confidence that the design will be finished in line with the programme.

11.11.2 Cost Management

The Cost Manager will implement a cost management system to monitor and track actual and projected costs for the development. This system, which may be part of/ integrated with a contract management system, will manage contractual agreements and cost outturns. It will allow the supply chain to notify the employer of prospective or actual design/contract changes likely to affect costs.

The objective is to create a standardised, auditable, and efficient process for managing costs, enabling the employer to make timely decisions, take corrective actions, and address potential risks to safeguard the budget.

11.11.3 Cost Reports

The Cost Manager will prepare and issue Cost Reports/Models on a periodic basis (at least monthly), before the Employer's Cost Review and executive meetings. To enable this, the supply chain must report in advance, allowing the Cost Manager sufficient time to review and compile the data. Contractual agreements should explicitly define the deadlines, format, and required details to ensure standardisation and deliverability.

Early warnings and potential budget variations should be regularly reported to the Employer's Project Manager and Representative and included in a review report for the Employer.

11.11.4 Change Management

Throughout the project, scope changes may be required by either the Employer or the supplier. These changes can arise from unforeseen issues discovered during the work, changes in the Employer's requirements, or pre-agreed changes triggered by certain conditions.

To ensure adherence to the "Change Control Procedure," the following points should be noted by all WWU team members:

- All alteration or variation requests must be submitted to the Project Manager for approval.
- Designers, Contractors, or Sub-contractors should not act on verbal instructions until approved by the Project Manager and WWU.
- All variations must be fully auditable, with relevant correspondence submitted for approval.
- No changes are permitted unless the "Change Control Procedure" is followed, considering technical, program, and cost implications, with all associated documentation.

Preferably, these communications should be managed via a formal contract management system to maintain workflow and audit trails. Consistency is recommended using NEC nomenclature, with change management conducted through the following pro-forma:

- Request for Information (RFI)
- Project Manager Instruction (PMI)
- Early Warning Register (EWR) – Held by PM
- Early Warning Notice (EWN) – Issued by Suppliers

11.12 Governance

The project is sponsored at the executive level within WWU. The project team will be split into four delivery teams:

- Commercial & Project Management Office (PMO)
- Engineering
- Stakeholder Management
- Land & Planning

Each team will be led by a delivery team manager responsible for ensuring timely delivery of required outputs and reporting updates up to the Head of Project Delivery. The Head of Project Delivery will coordinate the teams, establish delivery principles, and chair the Net Zero Major Projects Meetings and Capital Delivery Major Project Meetings as required. They will also provide project updates to the Project Director (Exec. Sponsor), who chairs the Net Zero Steering Group.

Whilst the Project Director is not part of the project team, they play a crucial role in representing the team at the Net Zero Steering Group and acting as a liaison between the delivery team and other members as needed. The governance structure and lifecycle stages for the project are outlined as follows:

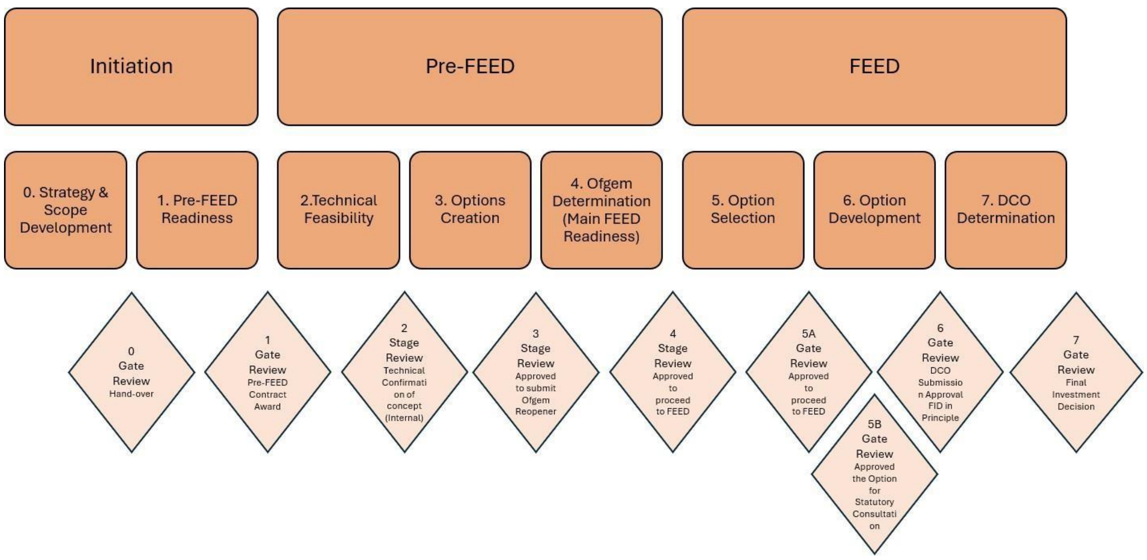


Figure 37 Project structure and stage gates

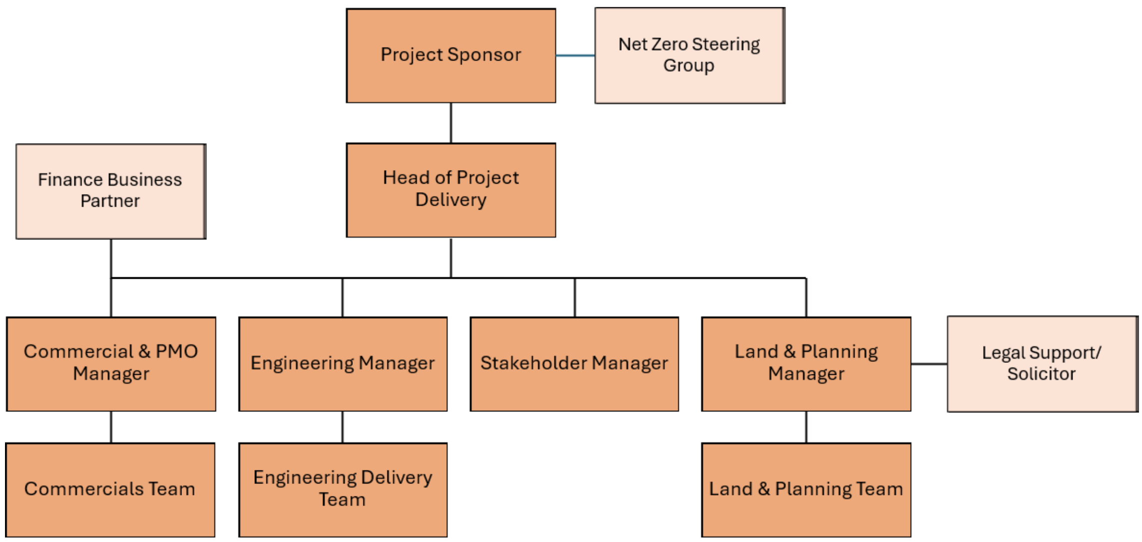


Figure 38 WWU's governance structure

12 HyLine Cost Estimate

12.1 Cost Plan Summary

The HyLine pipeline represents a significant step toward developing hydrogen infrastructure in Wales, contributing to the region's energy transition and decarbonisation goals. The costing of such an asset for Wales is a key part of the Feasibility and Front-End Engineering Design (FEED) stage of the project to ensure the project is deliverable within the econometrics set out, which drives a positive Net Present Value for project stakeholders. It is therefore key for stakeholders that realistic, robust and clear estimates are set at the earliest stage possible. Through the Phase 1B work, WWU have engaged Apollo, ERM, and Gardiner & Theobald (G&T) to support this utilising the SQEP (Suitably Qualified & Experienced Person) and defined processes pre-contract to set out a robust estimate based upon the data available at the Feasibility stage.

A team was brought together by WWU led by Apollo, to develop a Class 4 estimate for both Phase 2 (FEED, Planning and Land Rights) and Phase 3 (Detailed Design and Construction). The team build-up and responsibilities are presented in Figure 39 below and a phased check and review process was implemented as the estimate developed, which ensured the know-how, expertise and cost intelligence for the development of linear assets brought by the four parties was fully incorporated.

Figure 39 Project team and responsibilities

12.2 Basis of Estimate

The Basis of Estimate (BOE) outlines the methodology, assumptions, and data sources used to develop the Feasibility stage estimate for constructing a 128km hydrogen pipeline in Wales, UK. The estimate has been prepared using the Association for the Advancement of Cost Engineering (AACE) Class 4 standard, suitable for conceptual and feasibility studies, and typically involves a range of -30% to +50% in accuracy. This standard of estimate has been developed using the IPA (Infrastructure Projects Authority) estimating guidelines of which of supply partners G&T were a co-author.

During Phase 1B, as we have an outline geo-spatial coordinated design based upon a 500-metre-wide proposed high-level route corridor, we have provided the specific route and undertaken a full breakdown for the route as it is currently planned in the GIS (Gas Industry Standard) database. This was broken down into the seven design zones from Pembroke to the Port Talbot offtaker point as set out in the Phase 1A Feasibility work. The Estimate is then broken down into two separate elements.

- The Phase 2 (FEED, Planning and Land Rights) estimate which will be subject to a funding request under the NZASP re-opener mechanism.
- The Phase 3 (Detailed Design and Construction) estimate which will deliver the project up to and inclusive of commissioning. This element is detailed further in Section 13.

The pipeline will be designed and constructed to the IGEM/TD/1 specification, which is the standard for onshore steel pipelines in the UK. Key project components include:

- Route survey and land acquisition
- Procurement of pipeline materials and equipment
- Construction and installation of the pipeline
- Testing and commissioning
- Environmental and regulatory compliance

This BOE document should be reviewed and updated as the project progresses to more detailed design and planning stages, ensuring that assumptions and cost components remain accurate and reflective of any changes in scope or conditions.

12.3 Methodology

The estimate for both the Phase 2 (FEED, Planning and Land Rights) and the following Phase 3 (Detailed Design and Construction) has been developed using a combination of parametric and analogous estimating techniques, supported by sector expertise and historical data from similar projects.

Based upon this, G&T have prepared the estimate to a Class 4 standard with a detailed breakdown undertaken based upon the current geo-spatially planned route.

The following steps were undertaken:

- **Data Collection**: Relevant data was gathered from past projects, industry standards, vendor quotes, and market trends.
- **Parametric Modelling**: Cost relationships were established based on key project parameters such as pipeline length, diameter, and terrain type.
- **Analogous Estimating**: Costs were benchmarked against similar projects in the region and UK wide against large bore gas pipeline and other linear asset estimates (water, fibreoptics, power, Biogas etc)
- **Sector Expertise**: Input from experienced professionals in the pipeline construction field was incorporated to validate assumptions and estimates.

12.4 Phase 2 Procurement

The procurement event was to establish contractors to deliver against three discrete Lots:

- Lot 1 – FEED
- Lot 2 – Planning
- Lot 3 – Land Rights

These could be delivered individually or delivered as a group of two or three dependent on specific expertise of the lead organisation. Bidders were allowed to tender for more than one Lot provided they had the in-house skills and capabilities for the lead elements of the specific Lots.

WWU has responsibility for overall Project Management and expect that in any case:

- Each deliverable to be delivered by the respective Lot delivery partner
- Full coordination with corresponding Lot delivery partners, as required to deliver the work, should a combination of partners be successful in the award of each Lot

The estimated contract value was above the Utilities Contract Regulations 2016 (UCR 2016) financial threshold value (currently set at £429k for services). The award was competitively tendered to ensure value for money and in full compliance with the UCR 2016 and the WWU Procurement Policy.

A sourcing event for the works was launched 25th April 2024. The event was initiated with an Expression of Interest (EOI) request published through the Achilles Utilities Vendor Database (UVDB) to which 35 suppliers responded to advise of their interest. All 35 companies were invited to complete a combined Pre-Qualification Questionnaire (PQQ) and Invitation to Tender (ITT) via Jaggaer Bravo once they'd signed a Non-Disclosure Agreement (NDA), 16 companies responded to the combined event.

The pre-qualification process includes questions on the following key areas.

- Business & Professional Standing
- Financial
- Health & Safety
- Environmental
- Quality
- Data Governance
- Social Responsibility
- Experience & Capability

The ITT contained commercial, project management and technical questions to assess both the tenderers cost competitiveness and their ability, competence and experience in delivering the required scope of the project. The tender element of the process was split into the following category weightings for scoring purposes:

	Lot 1	Lot 2	Lot 3
Technical Scoring	40%	35%	40%
Project Management	20%	15%	20%
Commercial Scoring	40%	50%	40%

Following the initial desktop assessment shortlisted suppliers were invited to present their proposal to the team, subsequent to this there was a Best and Final Offers round (BAFO). This involved not only reviewing the commercial submissions but also the resource and hours allocated to the project by each supplier.

Following conclusion of the tender event, subject to satisfactory terms and conditions being agreed, awards were made to:

- Lot 1 FEED – Wood Group UK Ltd
- Lot 2 Planning – Turley Associates
- Lot 3 Land Rights – Dalcour Maclaren

12.5 Assumptions and Exclusions

12.5.1 Phase 2 Costing Assumptions

In line with the Phase 2B FEED Procurement strategy outlined in the previous section, certain aspects of the Phase 2 scope are more advanced than others. This is typical at this stage, and the HyLine team is fully aware of which areas are sufficiently developed to permit accurate pricing and which areas are less progressed due to design maturity and project development. The table below details the level of detail and the expected commercial mechanism, providing cost certainty and confidence in the overall estimate.

Scope item	Detail (1-3)*	Description
Engineering Design	3	Mature understanding of Phase 2 engineering and technical development requirements enabling WWU to develop a scope and the market to offer a fixed price.
Desktop Surveys	2	Mature understanding of Phase 2 engineering and technical development requirements enabling WWU to develop a scope and the market to offer a fixed price.
Planning and EIA	2	Mature understanding of significant elements of the scope needed based upon Phase 1B services completed. This has allowed WWU to develop a scope and the market to offer a fixed price for the developed scope, alongside contingency costs for items which may be required during the delivery of Phase 2.
Onsite Surveys	1	Mature understanding of significant elements of the scope needed based upon Phase 1B services completed. This has allowed WWU to develop a scope and the market to offer a fixed price for the developed scope, alongside contingency costs for items which may be required during the delivery of Phase 2. A number of surveys will iterate/develop as the route is identified and its specific topology and location become fixed. This early FEED work will inform Phase 2 Geotechnical Investigation (GI), geo mapping, ground water monitoring, ecology and environment surveys as needed to reach a FID.
Land Access	2	Mature understanding of significant elements of the scope needed based upon Phase 1B services completed. This has allowed WWU to develop a scope and the market to offer a fixed price for the developed scope, alongside contingency costs for items which may be required during the delivery of Phase 2.
Procurement	2	The number of surveys and enabling works/services are well understood through supplier engagement. The onward procurement strategy has been informed by G&T based upon similar schemes.
Stakeholder Management	2	WWU has developed a scope based upon experience of similar projects and schemes, whilst drawing on the developed Stakeholder Engagement plan as an output of Phase 1B.
Legal	2	Mature understanding of significant elements of the scope needed based upon Phase 1B services completed. This has allowed WWU to develop a scope and the market to offer a fixed price for the developed scope, alongside contingency costs for items which may be required during the delivery of Phase 2.
Project Management	3	Well defined and understood, built up using WWU best practice and alignment with existing BAU roles, teams, and processes. The programme has been developed with consideration to suitably qualified and experienced teams, and timelines to reach FID are mature.
Risk and Contingency	2	Applied in accordance with the Class 4 principles whereby WWU have reviewed a number of scenario's which have informed application of the contingency.

**1: Low definition requiring FEED stage input before Contract can be released.*

**2: Scope is understood but requires Supply chain input – Elements of the Scope can be fixed or set a ceiling price.*

**3: Mature understanding of scope enabling procuring of Services/works on fixed or lump sum arrangement for a known scope.*

This allows pricing for a known scope but can still be subject to change during contract as the design progresses and matures.

Table 33 Scope maturity

The below are the current Assumptions that the Phase 2 costing is modelled upon:

- Scenario Route 2 Scenario 3 Modelled (S4 S2U4).
- Pipeline to be developed to IGEM/TD/1 Edition 6 Specification plus supplement 2 – high pressure hydrogen pipelines (revised for hydrogen).
- Route corridor currently 80% + arable/soft dig and avoids running closely parallel to high density traffic, railways, overhead cables, major pipelines and other buried plant where possible and surveys/engineering has been defined as such.
- An outline (desktop) Environmental Impact Assessment (EIA) has been undertaken and was used to determine the broad route corridor. This initial EIA will be developed upon and iterated during Phase 2 to support the planning application and approval.
- The project shall run underground for the full length, unless otherwise agreed with WWU.
- Route to be kept to a practical minimum length and a cost calculator developed during Phase 1B will be utilised to review proposed diversions/amendments to the route.
- A 500m wide easement corridor has been determined and during Phase 2 will be refined to a 25m wide corridor.
- Route to avoid, as far as practicable, any significant environmental or known archaeological features.
- Route shall minimise proximity distances between the pipeline and normally occupied dwellings, taking account of HSE PADHI zones.
- Special Engineering Obstacles (road, rail and deep topographical features (rivers)) shall be crossed via directional drilling and horizontal boring – with associated ancillary supporting engineering controls (NR/L2/CIV 044). These have been fully identified within the estimate and PMP as Major or Minor crossings
- Some single carriageway and dual carriageway crossings will not require trenchless techniques as a partial or full road closure will allow the crossing to be executed via standard trench excavation. During Phase 2, these will be value engineered and refined further.
- Risk mitigation of the Environmental Impact and the impact to existing land users, populations and topography characteristics shall be a controlling factor when determining the pipeline route and shall be factored into the programme for Phase 2.
- Onsite surveys have been scoped based upon design/engineering principles, but the actual requirement will be refined by the supply chain during phase to at the earliest possible opportunity.
- Project Manager (PM) /Quantity Surveyor (QS) and Client management costs are based upon the 36-month programme set out.

12.6 Phase 2 Estimation Method

An estimate was built up for the Phase 2 (FEED, Planning and Land Rights) funding request for HyLine. The teams are confident that the tolerances associated with this are compliant with a Class 4 estimate under the AACE guidelines.

A Class 4 estimate was developed using a combination of techniques, including parametric and analogous estimating, supported by sector expertise and historical data from similar projects as well as the build-up of rates where required. This has involved aggregating the following:

- Budget quotations following a procurement exercise for FEED (2A) and Planning and Land Rights (2B)
- Build-up of rates for associated works including surveys and pilot works where required, as well as supporting activities such as Transportation Agreements (2C) and HTBM support (2D)

The following steps were undertaken:

- **Data Collection and estimate development**: Relevant data was gathered from past projects (e.g. previous pipeline projects across gas, water and power etc., industry standards, contractor quotes.
- **Benchmark Modelling**: Cost curve models were then utilised as well as market available data to benchmark the Class 4 estimate produced.
- **Review and Approval**: The estimate was then peer reviewed and is now presented for comment.

Estimate scope has been priced based upon the information made available within the Phase 2 scope of work found in Appendix I.

12.7 Phase 2 Cost Plan and Spend Profile

12.7.1 Phase 2 Estimate

The Phase 2 Base Case option cost is set out below, identify the Class 4 budget needed to deliver the Phase 2 Services (A, B, and C). It is WWU's proposal that to reach completion of Phase 2 a budget of £23.02m is required (2018/19 prices). See below the full estimate breakdown. The equivalent FEED Lite option cost is shown in Appendix I.

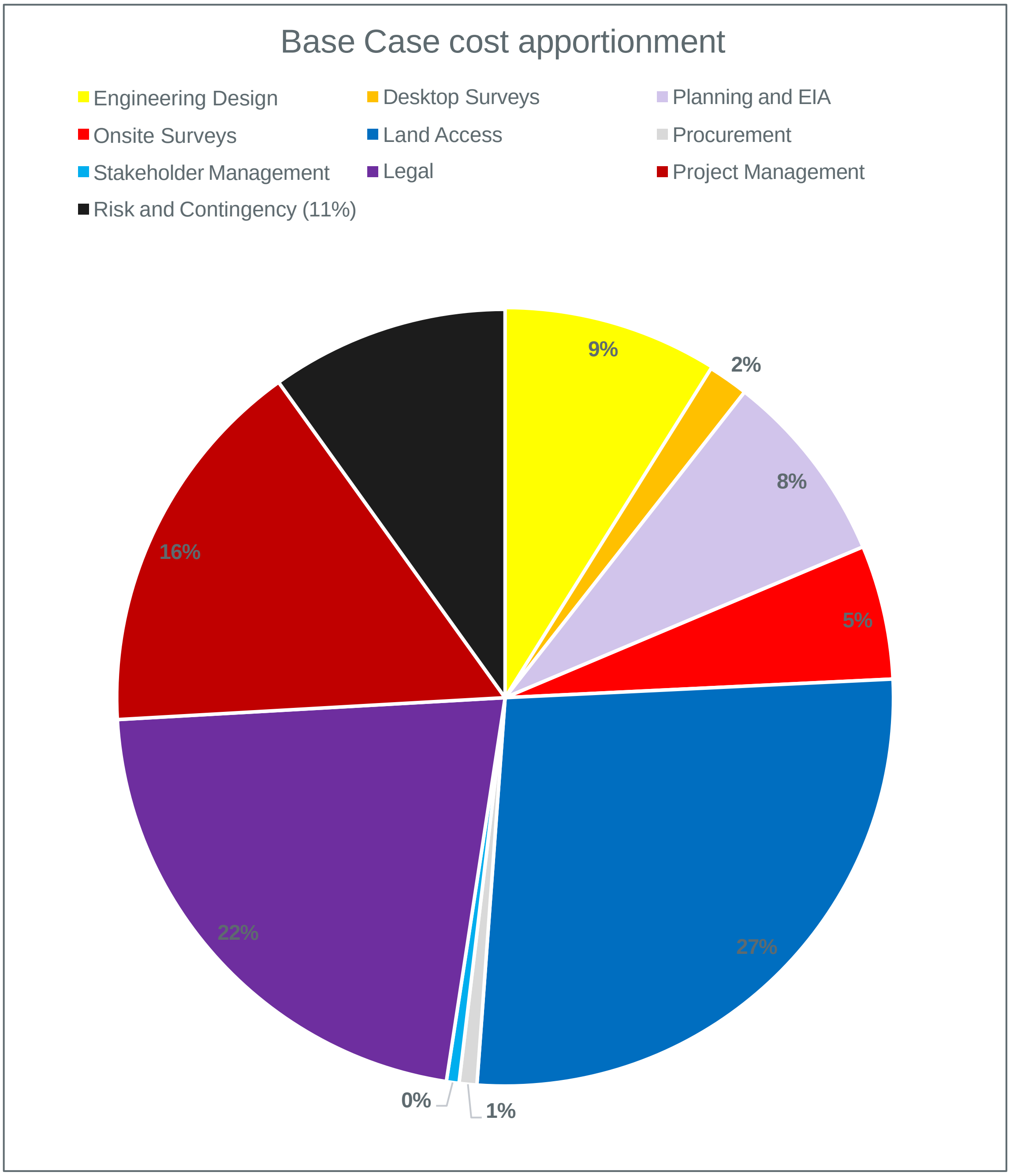


Table 34 Base Case cost apportionment

The below table details the cost breakdown of the proposed Phase 2 Base Case option costs:

Phase 2 Scope item	Delivery cost (£m) 2018/19 prices	Delivery cost (£m) 2024/25 prices
Engineering Design	[redacted]	[redacted]
Desktop Surveys	[redacted]	[redacted]
Planning and EIA	[redacted]	[redacted]
Onsite Surveys	[redacted]	[redacted]
Land Access	[redacted]	[redacted]
Procurement	[redacted]	[redacted]
Stakeholder Management	[redacted]	[redacted]
Legal	[redacted]	[redacted]
Project Management	[redacted]	[redacted]
Risk and Contingency (11%)	[redacted]	[redacted]
Total	**23.02**	**29.32**

Table 35 Base Case activity costs

12.7.2 Phase 2 Spend Profile

The Spend Profile is based upon the planned programme set out within Section 11 of the Re-opener. The risk and contingency pot was then robustly challenged with a number of scenario tests (Scenario Modelling) to ensure WWU will be able to cover the required outcomes set out for Phase 2 (FEED, Planning and Land Rights) within the budget set and including the risk and contingency pot. Scenarios included late starting, demand within the market due to surveys heating the market and delays in route finalisations by 6 months.

The analysis shows the estimate to be robust and deliverables for the outcomes within Phase 2 achievable.

12.7.3 Phase 2 Sensitivity Analysis

The Phase 2 estimate has been put together using supply chain input and where the scope is robust and clearly understood.

Where the scope for elements such as surveys and onsite enabling surveys are to be further determined, an allowance has been made based upon the metrics described in the table and uses recent competitively offered market rates against estimated quantities to generate the Phase 2 scope item costs.

The above method has been utilised to derive a base cost of £20.73m (2018/19 prices). This has then been uplifted for risk and contingency to allow for scope development and sensitivity changes of 11% giving an additional base cost of £2.28m.

The final proposed cost of delivering Phase 2 of the HyLine pipeline is **£23,015,092.86** (2018/19 prices) Ex VAT

13 HyLine Installed Cost Estimate (Phase 3)

During Phase 1B, the HyLine team engaged Apollo/G&T to assess the deliverability of the scheme, building on the estimate completed in Phase 1. This exercise, which supports a bottom-up approach and full benchmarking, focuses on the construction costs of both Phase 2: FEED, Planning and Land Rights and Phase 3: Detailed Design and Construction. The goal is to ensure the scheme is deliverable within the demand economies defined in Phase 1B. WWU has invested significantly to develop a robust, comprehensive estimate based on the current available information.

Currently, this estimate is broken down into the following future phases post this Phase 1B:

Phase	Description
Phase 2	Includes the FEED, Planning and EIA and the Land Access strategy and stakeholder engagement prior to full planning.
Phase 3	The construction phase of the works through to full commissioning and handover of the pipeline back to the Client. This includes everything required to install the pipeline and reach handover to enable flow of hydrogen to the designated customer demand, including first Hydrogen fill.

Table 36 Project phasing

HyLine Total Installed Cost Estimate (Phase 3) In accordance with Ofgem EJP guidance (24 inch pipeline)	
Phase 3 Scope item	**Delivery cost (£m) (2024/25 prices)**
Engineering Design	[redacted]
Project Management	[redacted]
Materials	[redacted]
Main Works Contractor	[redacted]
Specialist Services	[redacted]
Direct Company Costs	[redacted]
Indirect Company Costs	[redacted]
Total Installed Cost (excl. Risk)	[redacted]
Hydrogen Fill	[redacted]
Contingency and Risk	[redacted]
Total Installed Cost	[redacted]
Cost Estimate Accuracy	Class 4 Estimate as per AACE Estimate Classification

Table 37 HyLine Total Installed Ofgem Breakdown cost estimate

The estimate in Table 37 shows the Total Installed Cost breakdown from build to handover. This is for the Phase (Detailed Design and Construction) delivery only, and does not include the Phase 2 (FEED, Planning and Land Rights) costs as requested in this reopener.

Please note that this estimate excludes the anticipated upstream (entry) and downstream (exit) pipeline Pressure Reducing Stations (PRSs) required. These are currently excluded as the cost of installation is currently unknown and is to be further defined during Phase 2 (FEED, Planning and Land Rights).

The CAPEX budget outlined below, is what is expected to be allocated to deliver these assets.

PRS	Number	Price (£m) (2024/25 prices)	Total (£m)
Entry site in Pembroke (OptiFLOW)	1	[redacted]	[redacted]
Intermediary pig trap site/spur line	2	[redacted]	[redacted]
Downstream AGI/pig receiver	4	[redacted]	[redacted]
Total	**7**		[redacted]

Table 38 Pressure Reduction Station CAPEX cost

13.1 Phase 3 Costing Assumptions

For the Main Construction Phase the following key Assumptions have been made:

- The pipeline is based upon a 24 inch (6,110mm OD) Schedule 30 steel pipeline with associated cathodic protection with uplifts to Schedule 40 for all crossings under infrastructure assets.
- Temporary vehicle track to be laid adjacent to pipe route, with crossing points and welfare areas as required.
- Topsoil is stripped ahead of substratum excavation and stored separately to avoid over consolidation and damage.
- Where tolerance allows, the pipelines are laid to contours with adequate depth of cover, not less than 1.1m. For road crossings, adequate depth of cover will not be less than 1.2m. The width of the trench is usually equal to the pipe diameter plus approx. 400 mm clearance on both sides.
- Adequate crossings should be made for the passage of people, equipment, livestock, etc.
- Crossings are normally agreed and approved by the relevant authority, such as Natural Resources Wales (NRW). Crossings should be prepared in a manner to avoid disruption to normal traffic flow. For rivers and water crossings, consideration shall be given to future bed movement and dredging.
- Minor / medium sized crossings will be traditionally trenched;
    - Minor river/ stream/ wet crossings (less than 5m wide) will be flumed and reinstated where there is an economic benefit vs drilling.
    - A and B roads that are not subject to tourism restriction, or that can be undertaken during less constrained periods and where the local Highway Authorities and Utilities Committee (HAUC) agree, will be traditionally trenched lane by lane with associated traffic management and reinstatement where required.
    - Ancient woodland/ SSSI and any other protected zone that cannot be trenched through that HyLine cannot be diverted around will be directionally drilled.
- Consideration should be made for future cleaning and deepening of any drainage ditches. Consideration may include protective slabbing.
- Horizontal Directional Drilling (HDD) - HDD is usually the preferred method for shallow crossing obstacles (<10m maximum depth), such as shallow rivers, motorways, railways etc. HDD is a method of drilling a steerable shallow arc from a launch hole to a receiving hole, therefore, the pipelaying activities do not disturb the soil along the whole length of pipe, interrupt the development of buildings or infrastructure or disrupt traffic flows.
- Horizontal Boring (HB) – HB is usually the preferred method for deeper crossing obstacles (>10m maximum depth), such as significant rivers. A vertical shaft is constructed to a depth commensurate with the maximum depth achieved and using standard horizontal boring and shield jacking techniques and pipeline route is established.
- The pipe will be hydrostatically tested in line with the requirements of IGEM/TD/1. Golden welds will be kept to a minimum as far as is reasonably practicable, and the exact commissioning plan shall be created during Phase 2 (FEED, Planning and Land Rights).

13.2 HyLine Installed Procurement Strategy (Phase 3)

The solution will require associated enabling works, temporary works, pipeline installation, testing and commissioning to deliver the project successfully. The key elements to deliver the project are as follows:

- Professional Services and Technical Consultation
    - Client's Engineers
    - Client's Quantity Surveyor
    - Client's Project Manager
    - Wayleave Administrators and Permitting Team (can be outsourced)
    - Coring Team (to ensure reinstatement is compliant)
- Compressor Station Build – Pembroke (if required)
- 128km Pipeline Build
    - Pipeline
    - Valves
    - Pigging
    - Stone
    - Sand

    - Concrete
    - Corrosion Protection
    - Offtake PRS
- Storage Facilities & Welfare
- Testing and Commissioning
- Operation and Maintenance

13.2.1 Procurement Principles

Certain factors should be considered whilst proposing a procurement strategy to optimise cost, time and quality efficiencies:

- Eligibility for Public Funding through the Department of Energy Security and Net Zero (DESNZ)
- Compliance with industry standards
- Familiarity of contract terms with suppliers
- Allocation of Work Breakdown Structure (WBS) Items and Sub-Items between Client and Contractor

The evaluation criteria, assessed to provide the "ideal" procurement profile, are:

- **Lowest Possible Cost** - is highly important, however it must be a viable price
- **Cost Certainty** - absolute cost certainty at the outset is crucial
- **Risk Transfer** - transfer of price and programme risk are fundamental, whilst transferring risks relating to the design.
- **Shortest Programme to Completion** - is important to complete the works before the 2032 date.

13.2.2 Tendering Strategy

Due to the significant investment needed, it is recommended to engage multiple contractors. This approach leverages a broader knowledge base for efficient delivery and spreads project risk. Industry tendering strategies typically fall into two categories:

- Multi-contracting – splitting works packages with more than one Contractor
- Joint Venture (JV) – Two or more Contractors forming an alliance to deliver the works.

Given the significant investment, selecting the right contractors is crucial. To fulfil SWIC's commitments, contractors should ideally be based in South Wales, supporting the local economy and leveraging local knowledge.

It is recommended to use the NEC4 ECC (Engineering and Construction Contract) for the Design and Building of the HyLine Pipeline. The FIDIC (International Federation of Consulting Engineers) Yellow book could also be considered.

13.2.3 Procurement Route Analysis

As previously detailed, independent assumptions have been used to build a profile for an ideal outcome. The views and opinions of the criteria were quantified into a score out of ten and are expressed in Figure 40.

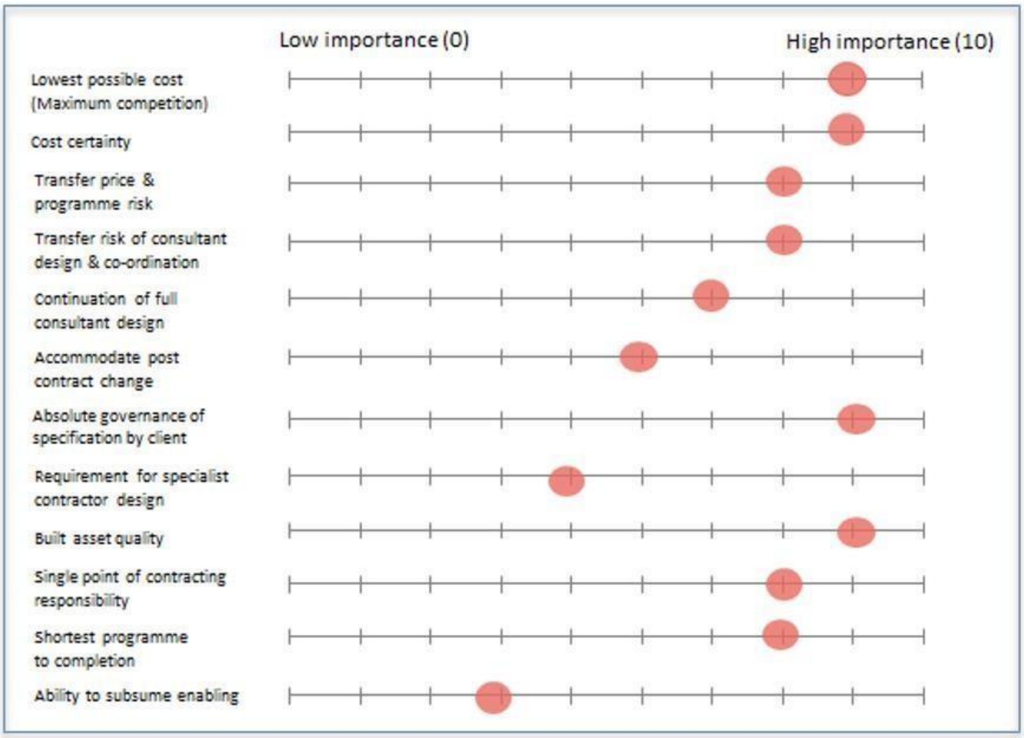


Figure 40 Ideal outcomes scoring

Of the diagrammatic comparisons, the best fit for an ideal procurement profile corresponds with a Two Stage Design & Build Procurement route.

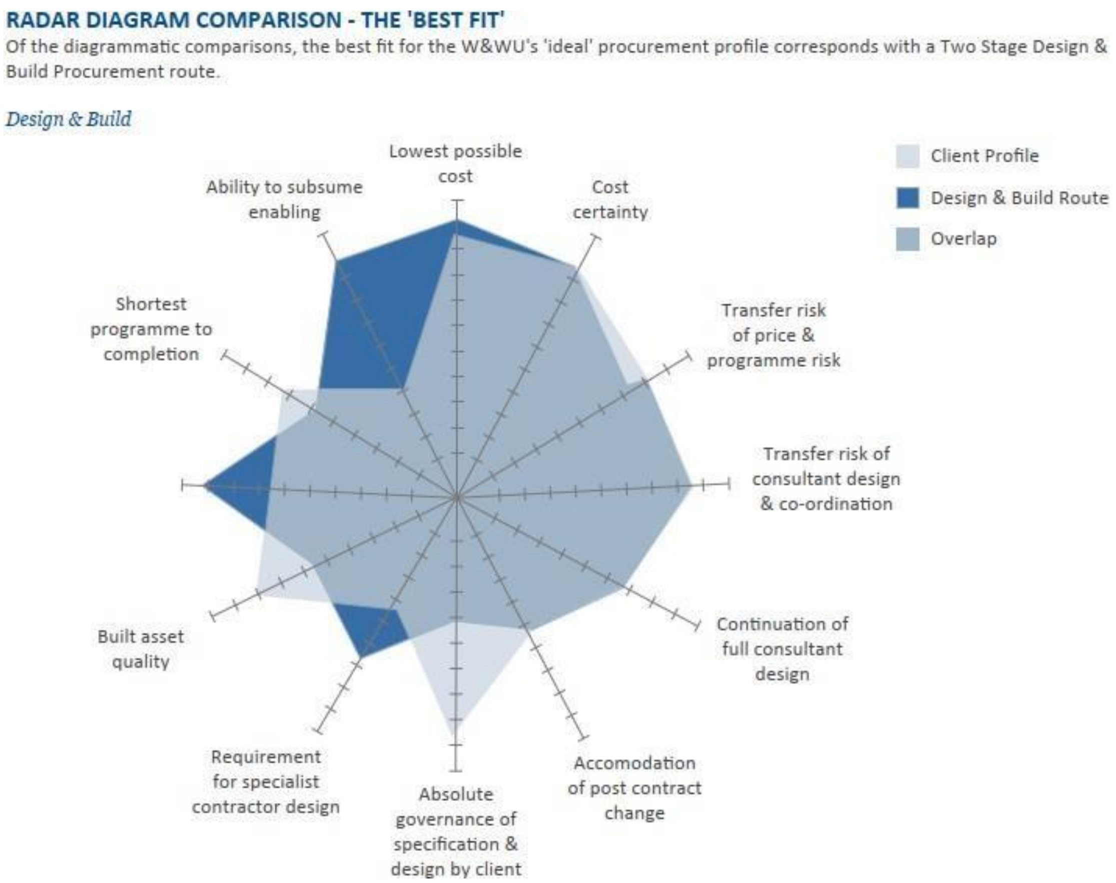


Figure 41 Design and build procurement route - radar diagram

It should be noted that no standard procurement route will ever align directly with a client's bespoke requirement. Therefore, consideration must be given to the areas where variances/mismatches occur.

The areas of relative variance are:

- Absolute governance of specification & design
- Built asset quality
- Requirement for specialist design

13.2.4 Recommendations

Given the various packages, investment, complexity, specialist work, and risks, a Two-Stage Design & Build contract is recommended for the build, installation, and commissioning. To address quality and specification control, a concept design and Feasibility supporting information (such as survey data) should be provided before tendering.

Tendering in a competitive market allows for a greater risk transfer to the contractor, reducing WWU's risk exposure. To achieve the most competitive price, a two-stage design and build contract is recommended to be tendered, which is suitable for a Multi-Contracting or JV strategy and allows for an ECI (Early Contractor Involvement) phase to support mitigating build risks. An appropriate NEC4 ECC contract with amendments should be utilised to contract the build with specialist packages utilising a similar contract form.

Whilst, a full transfer of all risks may not ultimately be achieved, this method shall produce the most favourable risk profile currently available to WWU:

- Highly reduced risk profile
- Cost Certainty
- Programme Certainty

Selecting the right procurement option is crucial in construction contracts, as it aligns project characteristics with risk and responsibility. At this early stage, as the scope and data mature, the procurement strategy will be refined to ensure the most efficient delivery method.

13.3 Risk and Contingency Within the Estimates

For a Class 4 major project estimate, a contingency range of 10% to 30% is typical. This range is applied to cover the high level of uncertainty and potential risks associated with the early stages of project planning and conceptual development. The specific contingency percentage should be based on a detailed risk assessment, considering the project's unique characteristics and potential challenges. Documentation, continuous updating, and risk management are crucial for refining the estimate and ensuring project success.

13.4 Cost Sensitivities

Due to the design maturity of the project and progression with current offtake agreements there are a number of construction sensitivities associated with the HyLine build. At this point we focus on the volume of the offtake and therefore the size of pipeline that may be required and the necessary pipeline size. The following tables detail the potential savings or additions depending upon the scope selected which will ultimately be determined by position of the offtakers prior to commencement of Phase 2: FEED, Planning and Land Rights.

HyLine Pipeline Size Options	12 inch (£m)	16 inch (£m)	24 inch – Baseline (£m)
Total Installed Cost (excl. Risk)	[redacted]	[redacted]	[redacted]
Total Installed Cost	[redacted]	[redacted]	[redacted]
Saving against Baseline	[redacted]	[redacted]	[redacted]

Figure 42 Cost Sensitivities for differing pipeline sizing options

Each of the Above options are set out within the appendices to give a more detailed breakdown of the savings.

13.5 Construction Estimate – Logistics and Welfare Strategy

The logistics plan aims to deliver the correct quality and type of steel pipe to the work-front as needed. Just-in-Time is the minimum standard, but stored contingency may be required due to various risks as described below:

- **Programme**: The risk that steel pipe supply becomes critical, due to simultaneous FID/Award and fabrication commencement or transit delays. The Commercial (CAPEX & Cashflow) and Procurement Plan must address this.
- **Quality**: The risk of off-spec pipe, transit damage, or installation damage necessitates quality control at key stages and redundancy in the logistics plan.
- **Cost**: To control significant project costs, WWU may consider a direct contract with the steel manufacturer.

The flow diagram below shows the steel pipe's journey from factory to work-front:

Overseas Maunfacturing Hub	
Location	To Be confirmed
No.	1
Type	Manufacture Port
Stored capacity (units)	1,778
Welfare	N/A
Quality Control	FAT Testing
Mobile Crane	Yes
Frequency of Shipping	1 per month (12 in total)

Logistics Hub	
Location	UK
No.	1
Type	Port with alongside services
Stored capacity (units)	1,778
Welfare	Yes
QC	Import inspection
Mobile Crane	Yes - Permenant
Total Personnel *1	8
Rationale	1 month stored capacity

Forward Logistics Base (FLB)	
Location	Wales
No.	3
Type	Yard with hardstanding
Stored capacity (units)	1200
Welfare	Yes for team of x 3
QC	No
Mobile Crane	Yes - Permenant
Total Personnel	18
Rationale	5 day workfront Requirement

Workfront	
Location	Mobile
No	6
Type	Reinforced Roadway/Laydown area
Stored capacity	40
Welfare	Yes - Mobile x 6
QC	SAT undertaken
Mobile Crane	Yes - Permenant
Total Personnel	31
Rationale	

Figure 43 Flow diagram for steel pipe procurement

This has been derived based on the following core assumptions:

Assumptions	Quantity
Length of route (km)	128.02
Pipe lengths (m)	6
No of Pipe Units	21,337
Installation day rate per Work-front (m)	~40
Workfront's	6
Installation Rate per day (m)	240
Pipe units per day	40

Note 1; Where 12m lengths can be used, this shall be utilised to reduce the number of final welds.

Note 2; These roles will be filled by the Principal Contractor and are an estimate.

Table 39 Table of core assumptions for pipeline costs

14 Phase 2 Cost Benefit Analysis

14.1 Introduction

A Cost Benefit Analysis (CBA) study has been completed for the HyLine Cymru project. The CBA was completed by developing a life of project discounted cashflow taking a societal perspective. This section presents the assumptions used in the CBA cashflow modelling work, the results & conclusions and aligns fully with the rest of the "Re-opener submission".

14.2 Data and Assumptions

A comprehensive Cost Benefit Analysis (CBA) "Databook" document has been prepared to ensure that all CBA modelling data and assumptions are transparent and fully referenced. The Databook is included in full unabbreviated format as an Appendix to this re-opener document.

14.3 Methodology

14.3.1 Reference Case or "Counterfactual"

It is currently envisaged that the HyLine Cymru project will deliver hydrogen to industrial consumers in the Port Talbot area: Tata Steel (two sites), Heidelberg Materials, LanzaTech, Sofidel, and Vale.

The "counterfactual" or Business As Usual (BAU) or reference case, against which the project cashflow was compared and assessed, was premised upon the 5 organisations (six sites) building their own electrolyser plants to supply hydrogen to the sites as an alternative to current natural gas and coal usage.

For the reference case, it was further assumed that Tata Steel shut their coal fired blast furnace and build an electric arc furnace. Hydrogen thus only displaces natural gas in other areas of the site in the reference case, as for the project case.

An important consequence of this reference case definition is that the HyLine Cymru project does not benefit from the large scale reduction in CO_2 emissions from moving from natural gas to hydrogen when comparing to the assumed Business As Usual (BAU) scenario (since the counterfactual case has already achieved that). The project results in a wholesale reduction in electricity consumption from the grid within the boundaries of the project definition, and instead is premised upon the purchase of Hydrogen.

14.3.2 Project CBA Boundaries

"Upstream" projects that will be responsible for generating hydrogen that will supply the industrial customers in the Port Talbot area via the HyLine Cymru project were excluded from the CBA. It was also assumed that the hydrogen arriving into the project boundary is already dehydrated and compressed, so CAPEX and OPEX associated with dehydration and compression are ignored.

14.3.3 Other CBA Clarifications

The following clarifications are to be noted:

- The CBA was based on a pre-tax cashflow.
- Tariffs paid by the industrial consumers to WWU were ignored as these are effectively "self-to-self" payments within a societal view or a "South Wales plc" view – e.g. if everything were 100% owned.
- Potential subsidies to the HyLine Cymru project and / or to the customer decarbonisation projects are excluded.
- Any costs associated with hydrogen storage or supply flexibility measures are considered to be outside the scope of the HyLine Cymru CBA and are ignored.
- Decommissioning expenditure is ignored.
- Atmospheric emissions from construction are expected to be small and are ignored.
- Savings in electricity network upgrade costs required to support the "counterfactual" case are ignored.

- The capital cost (CAPEX) of converting the industrial consumer sites from natural gas to hydrogen is excluded. The reason it is excluded is because the “counterfactual” scenario proposed is one in which each site has its own electrolyser based hydrogen plant. Thus, in the assumed BAU case, these costs have already been incurred and the incremental cost compared to the project case is therefore zero.
- Air quality impacts are not considered relevant for the HyLine Cymru project since the “counterfactual” case also includes Hydrogen fuel replacing fossil fuels in the Port Talbot area.
- There may in practice be technical and or commercial feasibility constraints preventing the defined “counterfactual” case as assumed and described becoming a reality. These are overlooked for the purpose of the CBA.

14.3.4 Project Schematic

A project schematic overview is shown below, highlighting the primary flows of mass, energy and money.

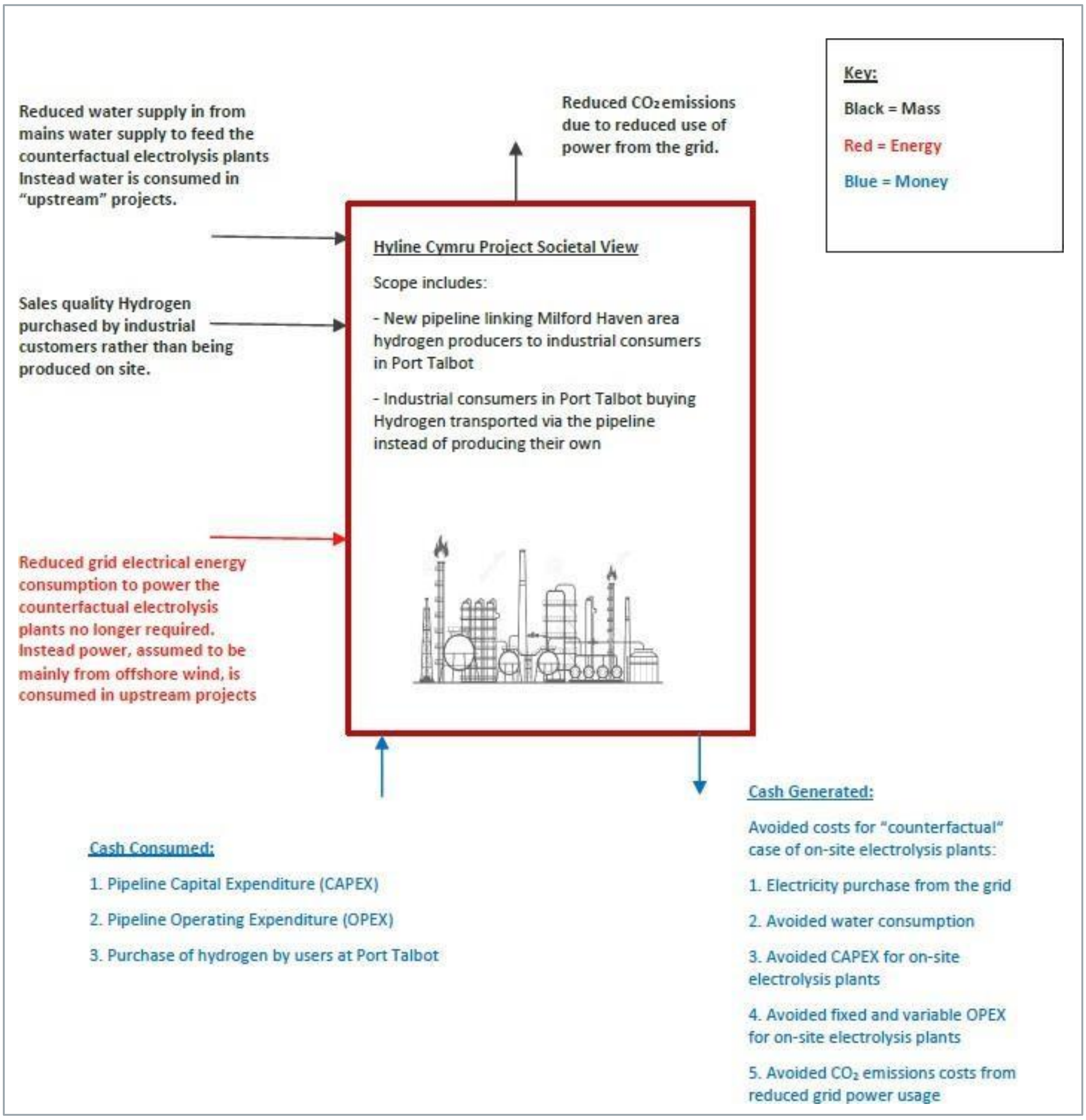


Figure 44 HyLine Cymru CBA Schematic

14.4 Results

A high-level summary of the results of the Cost Benefit Analysis are presented below. A fully comprehensive set of results is shown in Appendix J. The summary results table shown is aligned with HM Treasury Green Book guidance.

The Societal Value is shown with and without inclusion of the avoided on-site Hydrogen costs compared to the “counterfactual” reference case. This enables consistency with Green Book guidance and gives clarity on the fundamental drivers of the societal value proposition offered by the HyLine Cymru project.

In recognition of Green Book guidance to beware of the potential for optimism bias in evaluations and submissions, a scenario with a 50% reduction in demand compared to the low Hydrogen demand case and a 50% increase in CAPEX for the 12 inch case is explored. As can be seen, the Net Present Social Value (NPSV) is calculated at £887mln, a 63% value erosion compared to the assumed low demand smaller pipeline scenario, but nonetheless robustly in positive territory.

In recognition of OFGEM guidance that a “deferral option” or delayed case be studied, the low demand, smaller pipeline case was used as a basis. It was then assumed that the project was delayed by 3 years to a 2036 startup, with the operational life still conservatively assumed to terminate at the end of 2050. For this scenario, the NPSV is estimated to be £1,788 mln, representing a 26% value erosion compared to that calculated for the assumed low demand smaller pipeline scenario with a 2033 start.

Case	**12” Pipeline Low Demand – Do Minimum**	**12” Pipeline Low Demand – Do Minimum Excludes Avoided On-Site H2 Costs of counterfactual**	**24” Pipeline High Demand**	**24” Pipeline High Demand Excludes Avoided On-Site H2 Costs of counterfactual**	**12” Pipeline 3 year delay**	**Optimism Bias Stress Case – 12”, Low Demand, 50% increase in CAPEX, 50% reduction in demand**
Net Present Social Value (NPSV) (£m)	£2,407	£-2,868	£6,973	£-7,243	£1,788	£887
CAPEX (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Switching Values of key variables	Counterfactual LCoH: £**97**/MWh Project Case H_2 price £**173**/MWh Carbon Price £**869**/tonne	-	Counterfactual LCoH: £**91**/MWh Project Case H_2 price £**179**/MWh Carbon Price £**905**/tonne	-	-	-
Assumed Life Span	18 yrs (15+3)	18 yrs (15+3)	18 yrs (15+3)	18 yrs (15+3)	15 yrs	18 yrs (15+3)

Table 40 Cost Benefit Analysis Results Summary Table

Ofgem guidance states that “The calculation of switching values shows by how much a variable would have to fall (if it is a benefit) or rise (if it is a cost) to make it not worth undertaking an option. This should be considered a crucial input into the decision as to whether a proposal should proceed. It therefore needs to be a prominent part of an appraisal.” As can be seen in the table above, several key switching values were established. For the low demand, smaller pipeline case the counterfactual LCoH (Levelized Cost of Hydrogen) switching value was established as needing to drop to £97/MWh. This compares against an assumed mid case of £178.5/MWh and a low-low case of £131.7/MWh. The project case hydrogen price switching value was found to be £173/MWh (against £92/MWh assumed mid case). A range of hydrogen prices were explored based on a gas price assumption range and a carbon price assumption range, with a premise that a reference price in the Contracts for Difference framework would be based on the alternative of gas price plus associated emissions costs. The switching point for Carbon Price was fairly extreme and established at £869/tonne. This is against £386/tonne assumed mid case.

For the high demand, larger (24 inch) pipeline case, the switching values were also calculated. The "counterfactual" case LCoH would need to drop to £91/MWh to give an NPSV of zero (against £178.5/MWh assumed mid case). The project case Hydrogen price would need to increase to £179/MWh (against £92/MWh assumed mid case) to drive the NPSV to zero. Finally, the carbon price would need to climb to £905/tonne (against £386/tonne assumed mid case) to fully erode the NPSV. The carbon price sensitivity is interesting because its effects are twofold and working against each other. On the one hand, a higher carbon price increases the benefit accruing to the project from reducing electrical power use, and hence emissions, from the grid. On the other hand, a higher carbon price serves to increase the hydrogen purchase price in the project case, reducing the value of the project. The last point is only true if the hydrogen price is modelled as a gas price plus an emissions cost for that alternative fuel. This approach was mostly taken in the CBA work. Ultimately, as is strongly indicated by the value washline graph (see below), the latter effect is stronger than the emissions reduction gains, so a high carbon price *reduces* the benefits from this project rather than increases the benefits which may initially seem counter intuitive.

The graph below presents a cost and benefit breakdown, for the example of the 24 inch pipeline, high demand case. The graph, sometimes referred to as a "washline" graph or a "flying bricks" graph is useful for conveying in a highly visual manner the fundamental breakdown of any cashflow evaluation such as this CBA. The graph enables the value proposition to be understood very clearly. There are only five major building block elements to the CBA contributing to the Net Present Social Value (NPSV). Each building block is presented on a discounted basis to enable consistent comparison corrected for Social Time Preference. Note that instead of showing CAPEX, instead the CAPEX financing cost at the WWU Weighted Average Cost of Capital (WACC) is shown as calculated in strict compliance with the Spackman discounting approach. The 12 inch low demand case shows very similar trends albeit with the three major "bars" of avoided on site generation cost, hydrogen purchase and Net Present Value (NPV) each a little less than half of the values shown below for the high demand 24 inch case.

[redacted]

Figure 45 HyLine Cymru Cost and Benefit Breakdown – 24" Pipeline High Demand Case

As per RIIO-GD2 investment decision pack guidance, sensitivity analysis has been carried out beyond that shown in the results summary table above. For more details see Appendix J. A spider plot showing sensitivity analysis for the high demand larger (24 inch) pipeline case is shown below.

[redacted]

Figure 46 HyLine Cymru NPV Sensitivity – 24" Pipeline High Demand Case

As can be seen from the spider plot above, the CAPEX and OPEX play a small part in the CBA which is instead fundamentally driven by hydrogen demand assumptions and closely linked to that, the price of on-site hydrogen generation in the "counterfactual" reference case and the Hydrogen purchase price in the project case. The gradient on the spider plot clearly points to the dominance of these factors in the cashflow. Extrapolation of the plots is also a quick shorthand way to establish switching values discussed above.

14.5 Discussion

As has been explored in the Results section above, the Societal business case (Net Present Social Value) hinges upon avoided costs of onside generation in the "counterfactual case". Consequently, it has been shown that the NPSV calculated is highly sensitive to the assumed hydrogen demand, the assumed costs for onsite generation in the "counterfactual case" and the assumed hydrogen price in the project case. Each of these parameters carries considerable uncertainty at this stage. However, recognising these uncertainties, sensitivity analysis has been carried out and "switching values" have been established. This work has shown considerable business case robustness and provides considerable "value for money" insights on the economic case for investing. The Risk register in Appendix D aids understanding of the threats to the value proposition and will be used as a foundation for driving effective risk management in defence of the business case presented.

As has been stated, a critical incentive for progressing the HyLine Cymru project is to enable a pathway to market for large scale wind power projects in the Pembroke and Milford Haven area. These benefits are not included in the CBA presented above due to the boundaries that have been defined for the evaluation.

14.6 Non-Market Valuation and Unmonetisable Values

These important aspects such as natural capital, air quality, noise, waste, recreation, amenity value, water quality and biodiversity have not been covered in the CBA due to time and information constraints. However, future analysis as the project progresses could include these aspects to gain a fuller understanding of the project's societal benefits.

15 Regulatory Treatment and Bill Impacts

This chapter confirms the eligibility of this project for funding under the Net Zero Pre-Construction Works and Small Net Zero Projects Re-opener (NZASP) mechanism and outlines the range of benefits and reasons to socialise the cost of this project across all gas offtakers. This supplements the funding request and justification presented in Section 5.6.

15.1 Regulatory Funding Justification

Given the uncertainty surrounding hydrogen investment, to support hydrogen project development and other associated innovation, Ofgem has established funding mechanisms within the RIIO-GD2 framework via the Network Innovation Allowance (NIA) and the Net Zero and Re-opener Development 'Use it or Lose it Allowance' (NZARD UIOLI), to fund early-stage development of applicable projects. Both have been used to fund the initial stages of this project.

15.1.1 Network Innovation Allowance (NIA)

The allowance is intended to enable network licensees to undertake innovation projects that have the potential to address customer vulnerability and/or focus on the energy system transition, which would not otherwise be undertaken within the price control. Licensees are also obliged to make a 10% TOTEX contribution towards all NIA funded projects.

This funding mechanism has been used to part fund the regional decarbonisation pathways study as well as early work through the SWIC initiative.

15.1.2 Net Zero and Re-opener Development - Use it or Lose it Allowance

The allowance is intended to enable the necessary development work for net zero projects and promote the progression of low regret net zero facilitation capital projects within the gas sector. The allowance should be predominantly allocated to those net zero projects which may be low in materiality but high in impact and customer value. Network licensees should not use the NZARD UIOLI for net zero facilitation capital projects that are expected to cost more than £2m, and such projects can instead utilise other regulatory mechanisms, such as the Net Zero Pre-Construction and Small Projects Re-opener (NZASP). This funding mechanism was used to fund the Feasibility work for the project.

15.1.3 Strategic Innovation Fund

The Strategic Innovation Fund (SIF) is designed to drive the innovation required to equip gas and electricity networks for a low carbon future. The SIF works as a competition-based mechanism, allowing networks to apply for funding against specific innovation "challenges" issued by Ofgem. Applications are required against three SIF 'phases', with successful applications for earlier stages not guaranteeing success in subsequent stages.

- Discovery Phase: Up to two months and funding capped at £150k
- Alpha Phase: Up to six months and funding capped at £500k
- Beta Stage: Between six months and five years with funding starting at £500k (which may be capped at a certain level).

15.1.4 Net Zero Pre-Construction Work and Small Net Zero Projects Re-opener

The Net Zero Pre-Construction Work and Small Net Zero Projects Re-Opener (NZASP) was created to allow network licensees to undertake early design, development, general pre-construction work, and net zero facilitation capital projects that will enable the achievement of net zero carbon targets. The materiality threshold for the Re-opener is £1m per project and the funding provided per project under the NZASP may not exceed the total of £100m.

The mechanism can only be triggered by Ofgem following a detailed engagement phase to establish the needs case in principle.

15.1.5 Net Zero Re-opener

The Net Zero Re-opener is an Ofgem triggered mechanism designed to support larger scale net zero projects. The terms of the Re-opener are specified in the network's license, and it may be used where a net zero development has occurred or is expected to occur, and the cost is not otherwise provided for in this licence.

15.1.6 Evaluating and Determining the Suitable Regulatory Mechanism

For the HyLine Cymru Phase 2 FEED, Planning and Land Rights work, the NZASP Re-opener is considered the most suitable mechanism in this circumstance as it is designed to cover this type of cost.

Whilst in principle this project can be deemed 'innovative in nature', and WWU will be upholding a 10% contribution across the project, it does not meet the strict definition of an 'innovation project' in place for SIF mechanisms.

The proposed project meets the criteria of the Net Zero and Re-opener Development UIOLI; however, the materiality of the project now exceeds the threshold of £2M. Hence, for the HyLine Cymru Phase 2 work, the NZASP Re-opener is considered the most suitable mechanism in this circumstance as it is designed to cover this type of cost.

Sharing of project costs via the use of the NZASP aligns with the principles established by the Green Gas and Hydrogen Levy and also follows the same principles deployed with other net zero projects and Uncertainty Mechanisms. To meet the requirements of the NZASP Re-opener, there has been extensive pre-engagement undertaken with Ofgem, including the submission of a 'trigger document' covering the criteria of the 'Engagement Step' as outlined in the corresponding governance document. Ofgem have confirmed that they were content that the needs case has been established in principle and that the NZASP Re-opener can be triggered.

15.2 Regulatory Treatment

The NZASP Re-opener is designed to provide the funding for FEED studies for capital projects that will enable the achievement of net zero carbon targets. Therefore, we propose the funding is treated in line with the structure of the NZASP and in the same manner as other similar projects. Our expenditure would be outside of the Business as Usual (BAU) efficiency incentives built into the RIIO-GD2 framework.

It is not appropriate or sustainable for networks to fund a significant proportion of the costs of delivering the UK government's net zero plans. We do recognise, however, the unique opportunity that the development phase of this project represents and are therefore committing a contribution of 10% of the FEED study costs.

This re-opener has a materially worse fast/slow money split than the actual cost incurred across Opex, Capex and Repex and we would welcome consideration on changing the fast/slow split to better align to the actual capitalisation rate of the underlying spend.

15.3 Impacts on Consumers' ills

There are significant geographical, temporal and sectoral differences between different groups of potential hydrogen customers, and therefore uncertainties around charging. Based on current policies at the time of preparing this submission, we expect that an application will be made for a future round of the Hydrogen Transport Business model for future phases of the project. At this point it is not therefore possible to accurately forecast the long-term impact on consumer bills.

When compared with the wider societal progress expected from this project, the incremental consumer cost for the phase proposed for NZASP Reopener funding is in our view well justified. The proposed project will support the realisation of benefits to existing and future gas network offtakers, allow the potential for earlier development of hydrogen transportation at scale for the industrial offtakers, and help understand options for domestic consumers and the existing gas network. It can also act as a blueprint for decarbonisation in other areas of the UK.

16 Customer and Stakeholder Engagement

16.1 Stakeholder Engagement Plan

WWU has prepared a phased Stakeholder Engagement Plan (SEP) to support the successful delivery of the HyLine Cymru project across its three phases including:

- Phase 1: Feasibility and Planning Options
- Phase 2: FEED, Planning and Land Rights
- Phase 3: Detailed Design and Construction

16.1.1 Phase 1: Design Work to Date

Phase 1 is already advanced with early strategic advocacy market insights and intelligence to inform the business case and FEED design in Phase 2. This includes a detailed stakeholder mapping exercise undertaken, the establishment of the HyLine User Group (HUG) and early conversations with public sector stakeholders. It also includes preparation of messaging and approaches to raise public awareness about the role of hydrogen in the transition to net zero. The consenting route is also agreed, helping to inform further engagement and project direction. This summary focuses on Phases 2 and 3 of the Stakeholder Engagement Plan.

16.1.2 Engagement Principles

WWU has a corporate approach to all stakeholder engagement and aligns with the Accountability Standard (AA1000SES). WWU's approach to all engagement activity is underpinned by three guiding principles:

- Inclusivity – encouraging a wide range of diverse customers and stakeholders to co-determine priority issues and engagements, as well as voice opinions on business initiatives.
- Transparency – consistently demonstrate that openness, honesty and accountability guide the organisation's decisions and are embedded within initiatives and outputs.
- Continuous improvement – aiming to identify key stakeholder issues before they arise, proactively resolve issues when they do and ensure that the outcomes are communicated to stakeholders.

The Welsh Government's Pre-application Community Consultation Guidance for developers has also been considered in the project's SEP as well as wider guidance and best practice standards.

16.1.3 Phase 2: Planning (2025 to 2028)

The recommended planning route is via (four) planning applications under the Town and Country Planning Act (TCPA) 1990. An Environmental Impact Assessment (EIA) will also be required under The Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017 ("the 2017 Regulations") which will be wrapped into the planning application.

In line with TCPA and EIA regulations, pre-application consultation will be required during Phase 2. This will inform stakeholders about the Project and invite their feedback which will be considered through the design and EIA process. WWU aims to go beyond compliance and show best practice and innovation throughout. The primary objective of Phase 2 is to provide all stakeholders with access to Project information through timely, reliable, accurate and high-quality information, allowing stakeholder feedback to be considered.

16.1.4 Key Features of Delivery

Potential engagement methods during Phase 2 include three layers of activity ranging from meeting compliance through to innovation and best practice. Proposed approaches are:

Compliance: Meeting statutory requirements under TCPA and EIA

- Raising awareness of the Project and consultations, including site notices, publicity using local communication channels including press outlets.
- In person public consultation events in each local authority area to share details of the Project supporting the TCPA planning application and the EIA.

- Using online digital approaches to share the Project information.
- Engage all consultees including specialist consultees as defined by regulations and advice.
- Formal consultation of statutory consultees as prescribed by the TCPA (Wales) Major Development consenting route.
- Collecting feedback and demonstrating how feedback was considered.
- Adhering to best practice, accessibility standards (including Welsh language) local advice, and relevant legislation and guidance.

Beyond Compliance: Empowering engagement and enhancing community trust

- Establish working groups with key stakeholders to develop joint messaging. Enabling external stakeholders to speak with one voice on their platforms.
- Use existing WWU mechanisms, e.g. WWU Customer Engagement Group (CEG).
- Opportunities for further public consultation to maximise reach into communities which could include pop-ups at existing events, additional engagement events along the route in strategic locations, road shows, or a dedicated hub location.
- Develop media programme with regular drumbeat of engagement with the media and third party social media channels.
- Provide a nominated community liaison officer who will be the first point of contact for the local community and will stay in post through Phase 2 and 3.
- Provide alternative engagement channels for the public to ask questions and give feedback for example, drop-in sessions, a freepost address, an email inbox, a phone line, etc.
- Distribution of additional notices, flyers of information about the project to residents and organisations in an agreed study area.

Innovation and best practice: Securing social licence to operate

- Public commitments to consultation, for example, compliance with Accountability Standards or Welsh language.
- Creative media and content, community art projects and storytelling.
- Roadshow tours to places where communities naturally congregate or planned local events, for example, with pop-ups, giveaways, and materials.
- Online live and interactive webinars, carefully facilitated to ensure effective but managed interaction with attendees.
- Targeted engagement with school groups, colleges or other organised community groups.
- Tech enablement using digital tools which maximise access and engagement and improve quality and reporting. For example, interactive and 3D visualisation of the project.

16.1.5 Phase 3: Construction (2028 to 2032)

Meaningful stakeholder engagement will continue during the Project's construction phase to maintain momentum of community engagement throughout construction and into operation. Key objectives during Phase 3 (Detailed Design and Construction) are:

- To maintain relationships and trust with communities and secure social license to operate.
- Minimise negative impacts for communities by providing appropriate mechanisms for communities to raise grievances, complaints or concerns.
- Maximise opportunities for local communities by sharing information about the Project, being a good neighbour and publicising opportunities for local communities to benefit from the project.

16.1.6 Key Features of Delivery

Potential engagement methods during Phase 3 (Detailed Design and Construction) include:

- Appointment of Community Liaison Officer (and potentially a social value manager).
- Project website with clear contact points (e.g. email, freepost, phone line).
- Clear grievance mechanisms for raising concerns and complaints during construction.
- Align with EIA mitigation plans, e.g. Construction Traffic Management Plan.
- Align with contractors' commitments, e.g. Considerate Constructors Scheme.
- Continued comms via established Project social media and networks.
- Ongoing membership of strategic groups.

- Appoint community connectors who will interface between the Project and community.
- Continue to promote WWUs existing social investments including, for example:
    - Warm Home Assistance Scheme
    - WWU Corporate Giving Scheme

16.2 Government, Regulator and Political Engagement

Throughout the delivery of the project so far, WWU have regularly engaged with Ofgem, DESNZ, and Welsh Government. The following Table 41, Table 42 and Table 43, summarises this engagement.

Engagement	Date/Frequency	Description
Overview of Regional Decarbonisation Pathways	10/05/2022	Introduction and overview of Regional Decarbonisation Pathways. Included discussion on outputs and use as evidence base for new-build hydrogen pipelines.
Overview of HyLine Cymru	27/03/2023	Introduction and overview of HyLine Cymru during Phase 1A Feasibility and the development of preferred options for delivery.
Discussion on NZASP reopener eligibility and process	17/11/2023	General discussion around use of NZASP mechanism and eligibility of FEED studies alongside supportive work. Engagement supported WWU's decision to proceed down this path for Phase 2 of the project.
Discussion on Phase 2 Needs Case submission	22/01/2024	Engagement on expected process for Needs Case submission, expected contents of Needs Case along with timelines for acceptance.
Update on Phase 2 reopener submission	19/07/2024	WWU update on timeline for submission. Discussion held on presentation of Base Case and FEED Lite options, and expectations around DEVEX funding under the developing HTBM.

Table 41 Ofgem engagement to date

Engagement	Date/Frequency	Description
Introduction to HyLine Cymru following HTBM workshops	12/06/2024	Engagement with HTBM team in response to workshops held through Q2 2024 with gas networks. Introduced HyLine Cymru project and provided update on Phase 2 needs case development with Ofgem. Discussed eligibility criteria for future HTBM rounds, including storage options for regional transmission pipelines without access to geological storage.
Update on HyLine Cymru Phase 2 development and funding	17/09/2024	Engagement with HTBM team to provide update on Phase 2 needs case acceptance and NZASP application. Discussed HTBM funding for Phase 2 DEVEX expenditure which may not fall under NZASP (Base Case option), and how this could be funded by the HTBM in the future. Clarity sought on when such decisions would be made.

Table 42 DESNZ engagement to date

Engagement	Date/Frequency	Description
Innovation & Net Zero Meetings	Monthly	Meetings to provide updates on WWU innovation and net zero projects, including industrial cluster and hydrogen developments. Opportunities discussed for collaborative working, including emerging funding mechanisms and enabling policy.
HyLine Cymru	Quarterly	Meetings to provide updates on the HyLine Cymru project, including progress and key developments. Opportunities discussed for collaborative working, including project contribution to Local Area Energy Plans and wider strategic planning.

Table 43 Welsh Government engagement to date

16.3 Industrial Stakeholder Engagement

Previous engagement with the key industrial stakeholders is discussed in Section 7. Letters of support from the stakeholders can be found in Appendix F.

16.4 Linked and Supporting Projects

For linked and supporting projects see Appendix G.

17 Project Assurance

As a part of our assurance requirements required under Ofgem's Re-opener Guidance, this document has been prepared to provide the highest quality information available and to present this in an accurate, unambiguous, complete and concise fashion.

As required, this is written confirmation that the re-opener has been prepared and submitted, in compliance with the three key points below:

- It is accurate and robust, and that the proposed outcomes of the Re-opener are financeable and represent good value for consumers.
- There were quality assurance processes in place to ensure the licensee has provided high-quality information to enable Ofgem to make decisions which are in the interests of consumers.
- The application has been subject to internal governance arrangements and received sign off at an appropriate level within WWU.

The nominated point of contact within WWU for this re-opener applications is shown below, along with the required contact details:

Name: Richard Pomroy

Position: Regulation Manager

Email: richard.pomroy@wwutilities.co.uk

Telephone: 07812 973337

18 Glossary

The following list provides clarification of the acronyms used within this document.

Acronym	Definition
AACE	Association for the Advancement of Cost Engineers
AGI	Above Ground Installation
BAFO	Best and Final Offers round
BAU	Business As Usual
BEIS	Dept for Business, Energy and Industrial Strategy (now DESNZ)
BESS	British Energy Security Strategy
BOE	Basis of Estimate
BPD	Building Proximity Distance
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CCC	Climate Change Committee
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Usage and Storage
CEG	Customer Engagement Group
CEMP	Construction Environmental Management Plan
CFES	Common Future End states
COD	Commercial Operation Date
CPO	Compulsory Purchase Order
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero
DEVEX	Development Expenditure
DMPWO	The Town and Country Planning (Development Management Procedure) (Wales) Order 2012
DNS	Development of National Significance
DRI	Direct Reduction of Iron
EAF	Electric Arc Furnace
ECC	Engineering and Construction Contract
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
EJP	Engineering Justification Paper
EOI	Expression of Interest
ERM	Environmental Resources Management (ERM International Group Ltd)
EU	European Union
EWN	Early Warning Notice
EWR	Early Warning Register
FEED	Front End Engineering Design
FES	Future Energy Scenarios
FGP	FGP Chartered Surveyors
FID	Final Investment Decision
FIDIC	International Federation of Consulting Engineers
FLOW	Floating Offshore Wind
GB	Great Britian
GD	Gas Distribution
GHG	Greenhouse Gases
GIS	Gas Industry Standard
GPDO	General Permitted Development Order
GVA	Gross Value Added
GW	Giga Watt (Unit of Power)
HAR	Hydrogen Allocation Round
HAUC	Highway Authorities and Utilities Committee
HB	Horizontal Boring

HDD	Horizontal Directional Drilling
HGV	Heavy Goods Vehicle
HM	His Majesty
HoT	Heads of Terms (for Transportation Agreement)
HSE	Health and Safety Executive
HTBM	Hydrogen Transport Business Model
HUG	HyLine User Group
IAQM	Institute of Air Quality Management
I&C	Industrial and Commercial
ICC	Industrial Carbon Capture
IGEM	Institution of Gas Engineers and Managers
IPA	Infrastructure Projects Authority
INS	Infrastructure of National Significance
ITT	Invitation to Tender
JV	Joint Venture
KPI	Key Performance Indicator
LAEP	Local Area Energy Plan
LCoH	Levelized Cost of Hydrogen
LDZ	Local Distribution Zone
LLFA	Lead Local Flood Authority
LNG	Liquified Natural gas
LOHC	Liquid Organic Hydrogen Carriers
LPA	Local Planning Authority
LTS	Local Transmission System
MCH	Methylcyclohexane
MHHK	Milford Haven Hydrogen Kingdom
MOU	Memorandum of Understanding
NDA	Non-Disclosure Agreement
NPV	Net Present Value
NPSV	Net Present Social Value
NGN	Northern Gas Networks Ltd
NRW	Natural resources Wales
NZARD	Net Zero and Re-opener Development Fund
NZASP	Net Zero Pre-construction Work and Small Net Zero Projects
NZIW	Net Zero Industry Wales
OPEX	Operational Expenditure
PA	Public Affairs
PAC	Pre-Application Consultation
PADHI	Planning Advice for Developments near Hazardous Installations
PCD	Price Control Deliverable
PD	Permitted Development
PEM	Proton Exchange Membrane
PPA	Planning Performance Agreements
PM	Project Manager
PMI	Project Manager Instruction
PMO	Project Management Office
PMP	Project Management Plan
PNZC	Pembroke Net Zero Centre
PQQ	Pre Qualification Questionnaire
PRS	Pressure Reducing Stations
QS	Quantity Surveyor
RAB	Regulated Asset Base
RAG	Red, Amber, Green (multi-criteria analysis)
RAV	Replacement Asset Value
RESP	Regional Energy Strategic Planner
RFI	Request for Information

RIIO	Revenue = Incentives + Innovation + Outputs
RPA	Relevant Planning Authority
RWE	RWE AG (Multi-national energy company)
SAB	Sustainable Drainage Approving Body
SAF	Sustainable Aviation Fuel
SCH	Pipe Schedule
SEP	Stakeholder Engagement Plan
SIF	Strategic Innovation Fund
SLA	Service Level Agreement
SMR	Steam Methane Reforming
SoCG	Statements of Common Ground
SoS	Secretary of State
SQEP	Suitably Qualified & Experienced Person
SWIC	South Wales Industrial Cluster
SSSI	Site of Special Scientific Interest
TA	Transportation Agreements
T&S	Transport & Storage
TCPA	Town and County Planning Association
TOTEX	Total Expenditure
UCR	Utilities Contract Regulations 2016
UIOLI	Use It Or Lose It
UK	United Kingdom
UKRI	UK Research and Innovation
UVDB	Achilles Utilities Vendor Database
WACC	Weighted Average Cost of Capital
WBS	Work Breakdown Structure
WWU	Wales and West Utilities

Appendix A Cost Spreadsheet

Appendix A is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix B Needs Case (as submitted)

Appendix B is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix C Planning Option Strategy

Appendix C is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix D Risk Register

Appendix D is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix E Feasibility Report

Appendix E is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix F Letters of Support

Appendix F is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix G Linked and Supporting Projects

A list of known related capital projects is summarised in the table below.

Project Name	Description
Celtic Sea – Milford Haven Hydrogen Kingdom (MHHK)	Celtic Sea Power has successfully led a collaborative bid with to secure £877k of funding from Innovate UK's Launchpad: net zero industry, South West Wales program to deliver the £2.1m Milford Haven: Hydrogen Kingdom (MHHK) project. MHHK will test and validate the cost benefit to the customer and savings that could result from the roll out of ultra-low carbon hydrogen-generating floating offshore wind projects in the Celtic Sea. It lays out an end-to-end solution for producing, transporting and delivering hydrogen to industrial customers. Collaborating with Dolphyn Hydrogen, Wales and West Utilities and Offshore Renewable Energy Catapult, our ambition is to accelerate the roll out of the full floating wind and marine energy ambition to deliver industrial decarbonization and net zero, which hydrogen will be key to unlocking. The project outcomes are seeking to support the Celtic Freeport's, £3.5 billion hydrogen industry inward investment target and support the business case and decision timing for the HyLine Cymru project transporting hydrogen from Pembrokeshire to the central and easterly regions of South Wales.
Project Union	Project Union will repurpose existing gas transmission pipelines and build new pipelines to create a hydrogen 'backbone' for the UK. It will enable a low-cost path to net zero, supporting the growth of the UK's hydrogen economy and the decarbonisation of power generation and major industries.
Pembroke Dock Marine	Pembroke Dock Marine will deliver the facilities, services and spaces needed to establish a world-class centre for marine energy and engineering. It will have cross-industry application, but its immediate focus is on the low carbon energy sector. This is a £60m development, funded by the Swansea Bay City Deal through the UK and Welsh Governments, the European Regional Development Fund through the Welsh Government, and through private investment.
SWIC Cluster Plan	A plan for clean growth: Published in 2023, the Cluster Plan demonstrates how HyLine Cymru is central to SWIC and will be a nationally important infrastructure project for South Wales. The full report can be found **here**.
Local Area Energy Plans (LAEPs)	The LAEPs have been driven by national energy planning strategy with a view that Local Authorities take ownership and lead in the delivery of their own plans to reach net zero. WWU's Regional Energy Planning team are contributing closely to these proposals. Further information can be found **here**.
LanzaTech	LanzaTech is planning to build pioneering carbon recycling facilities in and around Port Talbot to convert industrial emissions into sustainable aviation fuel. Further information can be found **here**.
RWE Pembroke Net Zero Centre (PNZC):	will bring together all areas of the company's decarbonisation expertise, including innovation, offshore wind, power engineering, trading and the development/operation of highly technical plants. Further information can be found **here**.

Appendix H Phase 2 Scope of Work

Appendix H is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix I FEED Lite Scope option

Appendix I is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.

Appendix J Cost Benefit Analysis

Appendix J is supplied as a separate attachment alongside this re-opener submission.

Redacted due to confidentiality and commercial sensitivity.