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May 2023

Hydrogen Heating Village Trial Stage 2 Submission: Explanatory Note

This document ("HyPentref – Wales' Hydrogen Village – Hydrogen Heating Village Trial Stage 2 Submission Application") formed a formal application to Ofgem's RIIO-GD2 Net Zero and Small Projects Reopener, to progress a potential hydrogen heating village trial to design and engagement.

After submission, following discussion with other Gas Distribution Networks, Wales and West Utilities (WWU) decided to withdraw this application to focus resources on other potential projects, notably Nothern Gas Networks' Redcar Hydrogen Community.

HyPentref was therefore not progressed, and there are no immediate plans to convert the gas network in this location to hydrogen. Should that change in future, WWU will engage with the local community and stakeholders.

- Items in the submission have been redacted to protect:
  - Commercial sensitivity;
  - Technical sensitivity and intellectual property; and
  - Confidentiality of partners as the project did not move forward.

HyPentref

Wales' Hydrogen Village

Hydrogen Heating Village Trial

Stage 2

Submission Application

WALES&WEST UTILITIES

Department for Business, Energy & Industrial Strategy

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Making a positive difference for energy consumers

Hydrogen Heating Village Trial Stage 2: Submission Application

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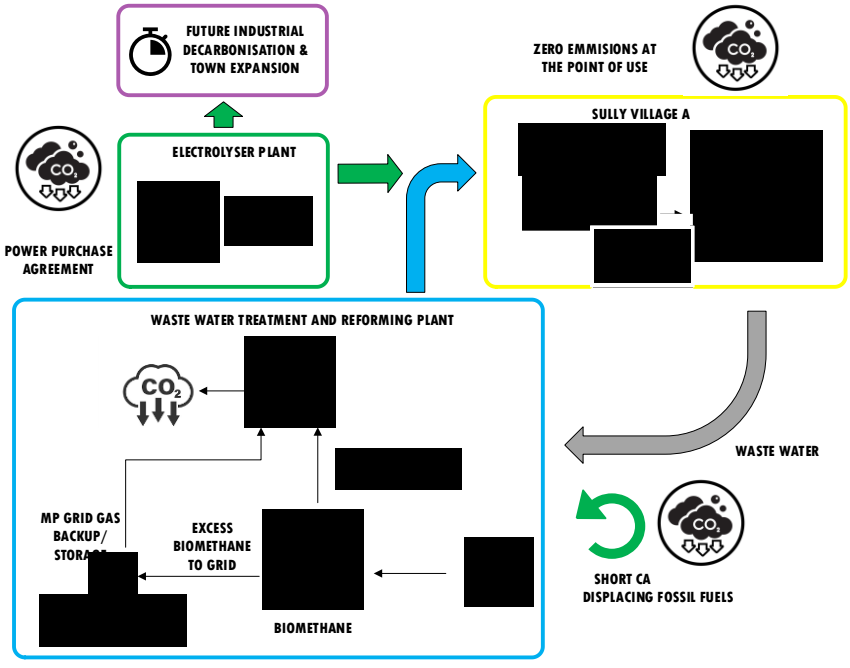
Making a positive difference for energy consumers

1. Project Summary

1.1 Project Title	HyPentref (*Wales' Hydrogen Village)*
1.2 Project Explanation	By 2050, the carbon emissions from our homes need to drop by 95%. Right now, most of those emissions come from burning fossil natural gas in the boilers, cookers, and heaters of the 85% of homes in Great Britain connected to the gas grid. Hydrogen offers a cleaner alternative to natural gas, because it doesn't emit carbon when it is used in the same way. HyPentref is a Village Trial in Sully, South Wales, that will build on learnings from SGN's H100 Fife Neighbourhood Trial and collaborative gas network hydrogen research and development. It aims to demonstrate the conversion of the gas network and its customers to hydrogen, and the operation of an end-to-end hydrogen system, to deliver deep cuts to emissions. The conversion of the village will be co-designed with customers, building knowledge and evidence base to inform policy decisions and future network development, while supporting the most vulnerable in the community. HyPentref will be one of the most sustainable hydrogen projects ever undertaken. It will use biomethane production from wastewater to generate carbon neutral hydrogen via steam methane reformers (SMRs) to supply Sully, while the use of electrolysers gives supply resilience. The combination of technologies will provide in depth learning on hydrogen systems and conversion of infrastructure, with good prospects for future developments. Carbon capture and utilisation from the production process will also benefit other local industries, making HyPentref a truly circular project. 

1.3 Funding Licensee	Wales & West Utilities (WWU)
1.4 Project Description	1.4.1 The Problem(s) it is exploring Networks, policy makers and industry require evidence from a demonstration project to show that hydrogen heating can be delivered in practice through the conversion of existing distribution network infrastructure. HyPentref will build on the H100 Project and provide further key evidence on: - The feasibility of repurposing an existing gas distribution network to transport hydrogen and the associated costs - The impact of converting to hydrogen on a larger scale with around 1,600 homes potentially participating in the trial - The impact to the consumer and the appetite of the consumer to support the switch to hydrogen where no natural gas option is available - The options and processes for switching local businesses and amenities (e.g. schools) to hydrogen 1.4.2 The Method(s) that it will use to solve the Problem(s) Stage 2 of the project (Detailed Design) will review, design, analyse and engage to reach a sufficient level of confidence to take forward the conversion of the gas network and customers in the trial area to run on hydrogen, the development of a decarbonised supply of hydrogen and the operation of the trial. The following will be completed in Stage 2: - Stakeholder and consumer strategies set out, and stakeholder strategy implemented, with initial results obtained - Detailed demand profile modelling and analysis - Detailed network modelling around operation - Development of an overarching case for safety for the trial - Risk analysis and formal workshops HAZID/HAZOPs - Detailed planning(building) and regulatory frameworks - Storyboarding of implementation of the trial and commissioning on the network - Pre-FEED and FEED design to fully define concept to take forward and develop detailed design deliverables Stages 3-5 will implement, build, operate and execute the exit strategy for the Hydrogen Village trial. 1.4.3 The Solution(s) it is looking to reach by applying the Method(s) HyPentref will extend learnings in key areas and provide evidence on the following in stage 2 and all subsequent stages:

	- Ease of repurposing existing infrastructure - Extent and practicability of additional network design, installation, maintenance and repair - Attitudes, behaviours and experience for a range of diverse participants, building types and end user appliances - Consumer acceptability of hydrogen - Cost and requirements involved in roll out methods - Operational learning, including seasonality impacts on hydrogen supply 1.4.4 The Benefit(s) of the proposed Village Trial The following benefits would be realised through the trial to apply to further hydrogen networks: - A consumer and stakeholder assessment to understand consumer needs and wants with a developed engagement strategy - A clear view of hydrogen production, source and quantities and resilience for a village of circa 1,600 homes and learnings that can be applied to larger scale conversions - How to plan and repurpose the existing network - Better understanding of asset and infrastructure requirements - Conversion, repurposing and new infrastructure practicality and associated costs - Clarity and implementation plan for a case for safety

1.5 Stage 2 Funding			
1.5.1. NZASP Funding Request (£k)	[redacted]	1.5.2. Network Licensee Contribution (£k)	[redacted]
1.5.3. External Funding(£k)	[redacted]	1.5.4. Other RIIO-2 funding (£k)	[redacted]
1.5.5. Additional funding required (£k)	[redacted]	1.5.6. Total Stage 2 Costs (£k)	[redacted]

1.6 Whole Life Costs	
1.6.1 Estimated trial Whole Life Costs (£k)	[redacted]
1.6.2 Of which, anticipated private sector contribution (£k)	[redacted]

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1.7 List of Project Partners, External Funders and Project Supporters[1]

Project Partners:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

External Funders:

- [redacted]

Project Supporters:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

1 For definitions see https://www.ofgem.gov.uk/sites/default/files/2021-08/SIF%20Governance%20Document.pdf

- [redacted] - [redacted] - [redacted] - [redacted] - [redacted] - [redacted]	
1.8 Timescale / Project duration	Stage 2: Apr 2022 – Apr 2023 (1 year) Stages 3-5: Apr 2023 – Oct 2027
1.9 Project Manager Contact Details	
1.9.1. Contact Name and Job Title	[redacted] Hydrogen Transformation Manager
1.9.2. Email and Telephone Number	[redacted]
1.9.3. Contact Address	Wales & West House Spooner Close, Celtic Springs Coedkernew Newport NP10 8FZ

1.10 Trial Project Summary

Introduction

WWU's business priorities will support planning and delivery of HyPentref making sure it delivers what customers and stakeholders want and need. These are reflected throughout this submission.

We have identified key themes to deliver a successful project on behalf of BEIS and Ofgem. We refer to them throughout the submission:

- **Deliverability** of the project, a robust solution with appropriate contingency

SAFETY FIRST

- **Consumer centric**
  A positive consumer experience is central to a successful trial

- **Collaboration** with other GDNs and project partners to ensure a successful trial

- **Low carbon**
  Hydrogen produced from short carbon cycle biomethane creating a sustainable village trial (Appendix F)

1.10.1 The population and geographical coverage of the potential trial location

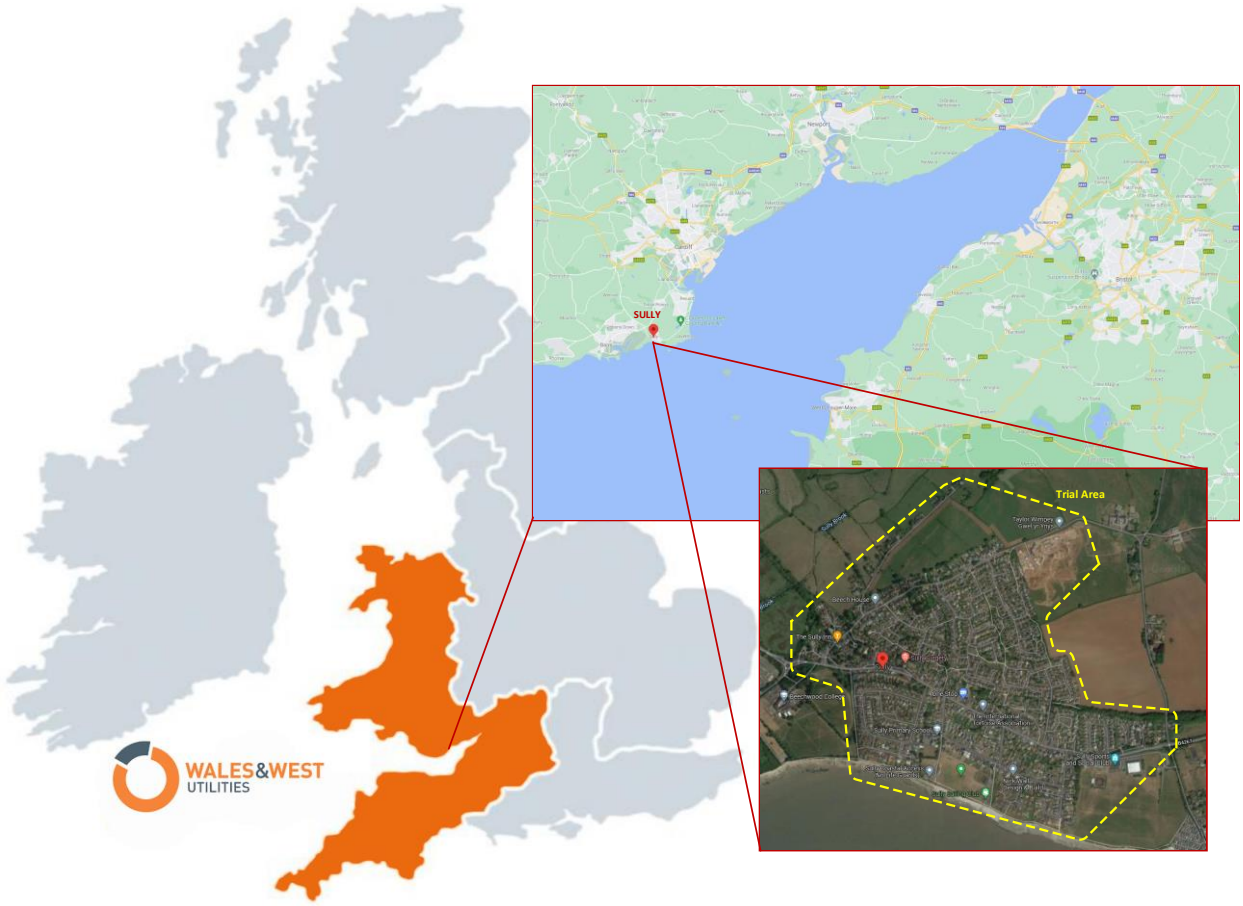
Geography

Sully in the Vale of Glamorgan has been identified as a suitable location for this trial. A coastal village with good transport routes, it is 8 miles south of Cardiff, and 9 miles from the M4.

Sully was chosen because:

- It is a distinct village community with 1,000-2,000 consumers and a balance between residential and light commercial (retail and hospitality) premises
- Low carbon hydrogen can be produced locally
- 94% of the local gas network is PE and ready to transport hydrogen
- The gas network is representative of local networks across the UK
- The layout of the local gas network means Sully can be easily isolated from the wider network
- There is a large industrial estate to the West of the village with current hydrogen users. Although outside the trial, there is further opportunity to build on a successful trial to a wider area and support decarbonisation of local industry

The trial site is outlined below.



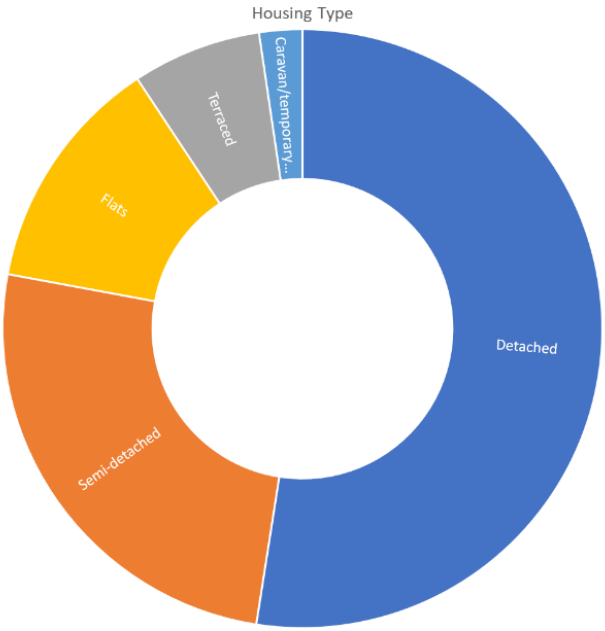
Sully: A Socio-Demographic Profile

- 4,543 residents in the 2011 Census[2], and the Office for National Statistics estimates that this has since risen to 4,901 residents (an annual increase of 0.82%).
- 51.5% female and 48.5% male gender split, broadly in line with country and national statistics
- Mean age of 44.5: above the national average. The highest proportion of population is aged 65 and above (27.6%), followed by 25-49 (26.2%) and 50-64 year olds (21.8%). The 2020 estimates portray an aging demographic, with the number of 65+ year old residents having increased by 5.3% since the 2011 Census.

1.10.2 The number and range of gas consumers in the trial area, and coverage of consumers and building types within the trial

There is a good range of gas consumers in the trial area, including residential and light commercial users. The village has 1,352 connections, with 238 to be added by 2025 as part of the Taylor Wimpey Estate.

The chart below shows housing types in the village.



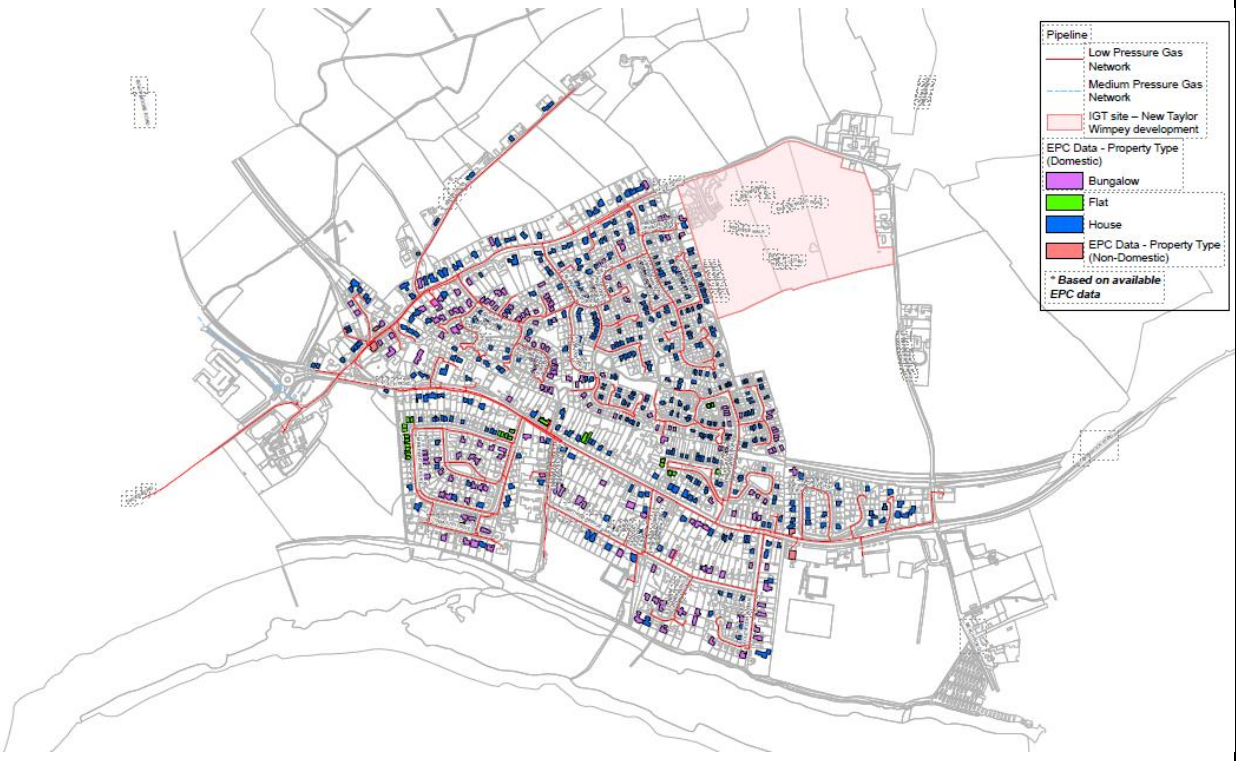
The following maps give information on the makeup of the trial area.

2 Local Area Report – The Ward of Sully 2011 CENSUS - Local Area Report for areas in England and Wales - Nomis https://www.nomisweb.co.uk/reports/localarea?compare=W05000935

Properties on the gas network

Built form of housing stock

Property type



Property tenure

Community Resources

Demand profile

Property heating

1.10.3 The broad strategy for hydrogen supply, new infrastructure and network conversion.

WWU has developed a robust strategy to deliver HyPentref. Partners have been carefully selected to bring world-class expertise in their sectors and have provided letters of support (Appendix A).

Figure 1 depicts the key elements of the supply, infrastructure and network conversion to be delivered collaboratively by the project partners.

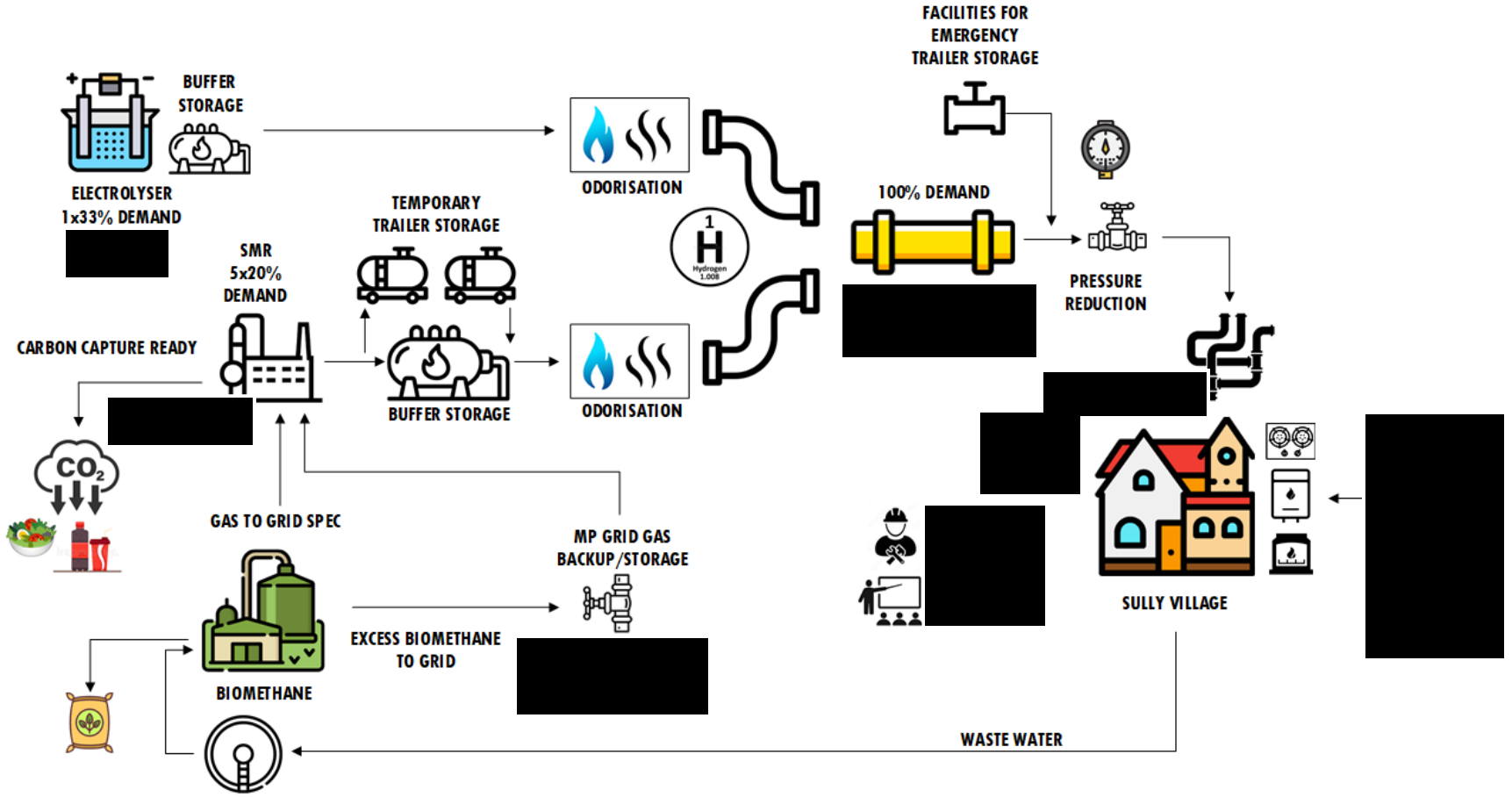


Figure 1 Overview of trial

WWU's collaborative approach to the project with other GDNs and project partners provides world class expertise in key areas:

[redacted]

Project lead and integration, network conversion, gas distribution, storage and conditioning. Coordination of regulatory issues, billing and case for safety.

[redacted]

Biomethane to grid plant upgrade and continued operation of [redacted] ([redacted]), allowing the production and storage of low carbon hydrogen for use in HyPentref and other potential applications.

[redacted]

Design, supply, build, store and operate hydrogen production and storage facilities using electrolysis, with potential for local industrial decarbonisation. [redacted] also supply SMRs and will support [redacted].

[redacted]

Survey, manage, install and maintain all consumer requirements with competent trained engineers using approved appliances. Provide shipper/supplier expertise and billing solutions

W nt scheme is to build and operate a hydrogen production plant at [redacted] WWTW we are exploring the feasibility of siting all hydrogen production on the [redacted] site. Both options are expandable and offer further decarbonisation of local industrial users or expansion of the trial locally into a Hydrogen Town. The experience of customers using hydrogen – homes, businesses, industry or transport – would be the same, irrespective of production location.

Figure 2 outlines the key elements of HyPentref.

2. Evidence Base

2.1 Outline evidence/benefits plan

Overview

Alongside trial-specific information, WWU will lead the collaborative Trials Evidence Framework (TEF) section, performing a gap analysis between all the village trials (see section 2.1, Ref 2, Annex 2).

HyPentref will create an extensive evidence base on the feasibility, costs and convenience of using hydrogen in place of natural gas in the existing gas network and occupied buildings.

2.1.1 Consumer:

Per TEF Ref 4, consumer evidence across the following subsets will be produced:

1. Consumer attitudes and perception
2. Consumer behaviour
3. Consumer expectations
4. Variations in the impact and experience across different segments such as premise-types and demographics

To address each of these subsets, the sources in Table 1 will be leveraged for evidence.

Table 1 Evidence Sources

Evidence Source	Stage
Periodic surveys	All
Housing surveys	Design
Installer surveys	Preparation/conversion/operation
Energy usage data	Operation
Qualitative and quantitative research using a range of methods	All
Call/emergency line	Operation
All media sentiment analysis	All
Analysis of feedback from email/online/face to face/ and other engagement including tailored methods for some groups e.g. vulnerable customers and their representatives/businesses	All
Show home	All

All interactions with consumers will be used to gather evidence, and residents encouraged to participate in all surveys to feedback their experience, while energy usage data will be compiled throughout the trial.

Consumers will also be invited to participate in tailored qualitative research to provide more detailed evidence on recurring themes.

Other sources will be scheduled as part of the Public Engagement Strategy and monitored closely, providing analytics to inform consumer interactions for future hydrogen rollouts. Control villages and historic data will be used to provide relevant benchmark data.

Key evidence generated at each trial stage

- **Stage 2 – Detailed Design:** Demographic data and the building characteristics relevant to each consumer. Data will be maintained throughout the trial, to correlate variations in feedback across demographic groups and different premises types. Consumer attitudes to hydrogen and willingness to participate in the trial will be measured through research, community drop in events and webinars, door to door surveys, and on and offline feedback opportunities. A show home will help provide local people with a reference point for their feedback.
- **Stage 3 – Prepare and Build:** Consumer expectations and experiences of having their premises and the gas network converted to hydrogen, including any disruption. This will be collected through installer surveys, qualitative and quantitative research, drop in events and webinars, and on and offline feedback opportunities.
- **Stage 4 – Go-live and Operate:** A research programme including periodic surveys, qualitative and quantitative research, on and offline feedback opportunities will provide insights into every aspect of the consumer experience. Seasonal impacts will also be monitored and considered. During regular maintenance/survey works, installer surveys will be used to gather information on behaviour relating to hydrogen appliances. This feedback on consumer behaviour will be checked against current/historic energy usage data to understand unusual demand profiles.

As some residents will not choose hydrogen conversion, it will also generate evidence comparing the installation and use of alternative green heating technologies.

Potential limitations in evidence

Sully's demographics are yet to be profiled in full, and the trial may represent certain groups more than others. Additionally, as Sully is semi-urban, it may be less representative of areas at higher/lower levels of population density.

Safety

Alongside collaborative safety work (section 2.2, Ref 2, Annex 2) and in line with the TEF, the trial will evidence the safety of hydrogen for use in buildings. Table 2 gives the intended main evidence sources.

Table 2 List of Safety Evidence Sources

Evidence Source	Relevant Phase
Duty-holder questionnaires	Design/preparation/conversion
Call/emergency line	Operation
Quantitative risk assessment (QRA)	All

Pre-trial safety outputs – Design/preparation/conversion:

Project partners will receive one of three safety frameworks applicable to their role (to be approved by HSE). Duty-holders will be required to complete a questionnaire detailing whether they can meet those requirements without additional work and describing any further

work necessary. Questionnaire data will be summarised as evidence on whether safety requirements pose a barrier to hydrogen in the existing distribution network or buildings.

Live trial safety evidence - Operation:

HyPentref will evidence the effectiveness of safety communications and training given to participants. This will be established by monitoring how frequently and accurately the hydrogen emergency line is contacted. Emergency calls will be evaluated, ultimately evidencing whether consumers accurately follow safety instructions.

Finally, the Quantitative Risk Assessment (QRA) will form a comprehensive basis logging evidence, such as the effectiveness of additional safety equipment and mitigations, safety of WWU operatives undertaking maintenance/repair and additional PPE requirements.

2.1.2 Delivery and learning for town/roll-out:

Per the TEF, the Trial will produce evidence in these subsets:

1. Viability of converting the gas network to hydrogen
2. Design/maintenance/repair requirements of a hydrogen network
3. Time and costs associated with the conversion to hydrogen
4. Emergency response to leaks reported outside of homes etc. field hydrogen detection units

Table 3 List of Evidence Sources for Roll-out

Evidence Source	Relevant Phase
Design/FEED study into network conversion	Design/preparation
Itemised list of equipment needing replacement	Design/preparation/conversion
Housing surveys	Design/preparation/conversion
Maintenance and repair schedule	Operation
Real-time network operation data	Operation
Costed project schedule	All

The project schedule will summarise timescales for every aspect of the trial, by logging the time taken for all work. Where possible, this will include costs. Separate cost evidence will also be collected on a line-by-line basis, including items such as energy usage, network assets, and appliance costs.

- **Detailed Design / Prepare and Build:** The design work necessary and the best approach to the conversion process. The outline stage statement of infrastructure requirements will be furthered in the Design/FEED study. Housing surveys will evidence the nature/proportion of homes already suitable for operation with hydrogen, and which require additional conversion work.
- **Go-live and Operate:** Differences in operating a hydrogen and natural gas grid will be identified by comparing real-time network operations data with natural gas equivalents. WWU will adapt their current maintenance/repair schedules (including time and cost) to reflect the different requirements for a hydrogen network. Flexibility to meet seasonal demand will be evidenced by monitoring the frequency of storage use, and the extent to which pressure at the HP/LP pressure reduction station (the Village PRS) can be increased to boost linepack storage. This pressure reduction station (PRS) is the point at which the hydrogen supply will enter the village.

Potential limitations in evidence

While Sully is broadly representative of gas networks in the UK, there may be challenges to converting other sections of the UK grid which are not experienced in HyPentref. Due to the relatively small-scale of the trial, all time and cost evidence is likely to represent an upper bound for a subsequent regional or national conversion.

2.1.3 Commercial and regulatory:

Per the TEF, evidence will be produced in these categories:

1. Commercial, regulatory and billing considerations for converting to hydrogen
2. Additional training and skills needed
3. Risk associated with converting to hydrogen, including associated mitigations

Table 4 List of Commercial and Regulatory Evidence Sources

Evidence Source	Relevant Phase
Supplier engagement and contracts/questionnaires	Outline/design/preparation/conversion
Regulatory plan	Design/preparation
Consumer	Operation
Energy usage data	Operation
Installer interviews/surveys	Preparation/conversion
Risk register	All

Throughout HyPentref, risks will be collected in the trial Risk Register. This will be updated as new risks are identified. The effectiveness of intended mitigations will be evaluated, including their sufficiency and any necessary additional measures. There is more information on the Risk Register in Section 3.5.

- **Detailed Design / Prepare and Build**: The maturity of the end-to-end hydrogen appliance supply chain and its ability to deliver equipment to schedule will be demonstrated. This will be assessed through further supplier engagement. Any further gaps in the product offering and/or snags in equipment delivery will be recorded. Employed installers will be interviewed/surveyed to understand the retraining/upskilling work necessary, and best practice for overcoming skills gaps.
- **Go-live and Operate:** Consumer evidence sources will be leveraged to indicate the effectiveness of the chosen billing method. Energy usage data will indicate the effectiveness of metering, and for example how billing arrangements can capture shrinkage between production and consumption.

Potential limitations in evidence

The scale of the trial means hydrogen appliances will not be delivered at a scale to fully demonstrate supply chain maturity, or an exhaustive range of end-use cases. The trial will nonetheless cover a diverse range of end-user types, while limiting complexity to ensure deliverability.

2.2 Safety Case Development Strategy

A Safety Dossier will be developed which is a documented 'Case for Safety' to demonstrate that the project will take all measures necessary to prevent a major incident and to mitigate the consequences should a major accident occur. The focus will therefore be on process rather than occupational safety.

To enable re-use (or minor revision) of this document on future hydrogen conversion projects, it is proposed to structure the document in a modular form so that, for example, projects that only involve hydrogen transportation are covered by the transportation section of the Case for Safety.

The project recognises the collaborative work that will be done between GDNs. This collaborative work will cover both Safety Case Framework and Village End User Safety Evidence (see sections 2.2 and 2.3 respectively in Ref 2, Annex 2) in a way that is independent of the trial site location.

HyPentref's safety dossier will be a single reference point for the HSE and pulls together subordinate or related studies & reports prepared by the relevant stakeholder for:

- generation (using the requirements of a Control of Major Accident Hazard (COMAH) regulations Safety Report)
- transportation (using the requirements of a Gas Safety (Management) Regulations (GS(M)R) Safety Case)
- consumption (in accordance with the Gas Safety (Installation and Use) Regulations (GSIUR) regulations) of hydrogen.

The Pressure System Safety Regulations (PSSR) will also apply to any pressure reduction equipment on the generation and the transmission side. All relevant regulations will be considered, and the safety dossier will document appropriate compliance to ensure the safety of the local community, all stakeholders, customers and the general public.

The detailed components of the Safety Dossier will generally be developed in accordance with the principles of the HSE (Competent Authority) Safety Report Assessment Criteria as set out in HSE Safety Report Assessment manual (SRAM) and associated technical criteria.

The dossier provides an overview of how hazards are identified and how risks are assessed, controlled and managed. It will be founded on established risk management principles applied to natural gas transmission systems and will take due consideration of the relevant regulations and documentary evidence appropriate to the generation, transmission and consumption of hydrogen and the obvious and subtle normal and abnormal behaviours of hydrogen and natural gas.

Risks will be avoided wherever possible and will be reduced to the lowest reasonably practicable level by taking appropriate measures. The 'Case for Safety' will be based on the ERIC PD 6 step model:

- Eliminate: impractical to replace hydrogen with a non-flammable alternative
- Reduce: hydrogen inventories & pressures will be as low as operationally practical
- Isolate: primary containment integrity & separation of personnel & plant
- Control: process monitoring, control and protection
- PPE: task specific personal protective clothes and equipment
- Discipline: consideration of human & organisational factors that may influence performance

Hazard identification and risk analysis techniques will be applied proportionately according to the scale and complexity of the process or plant and range from simple checklists early in the project to detailed dispersion & consequence modelling as the design develops.

The analysis will take due account of the potential for both human and hardware failures and recognise the potential for Natural Hazards Triggering Technological Accidents (Natech) due to environmental factors as well as the potential for cyber-attacks.

Both individual and societal risks will be evaluated in accordance with WWU risk tolerability criteria.

The dossier recognises the potential thermal, overpressure and impact effects of hydrogen jet fires, explosions and uncontrolled high-pressure releases and identifies technical and organisational measures to prevent and mitigate a loss of containment.

Bow-tie diagrams (example in Figure 3) will be used where appropriate to help communicate and sustain the protection strategy for each asset or activity and risk controls will be represented as barriers that either prevent the threats (causes) from initiating or creating the top event (uncontrolled release of hydrogen) or mitigate the consequences (effects) from an ignited or unignited gas cloud or jet.

The dossier will reference existing projects, data sources and incident databases to ensure that common good practice is being applied.

The project will employ and engage subject matter experts and use the latest tools with current data to ensure analyses are as accurate as practical.

The dossier lists the most applicable UK regulations – specifically those which relate to Process Safety including, (but not limited to) COMAH, COSHH, DSEAR, GSIUR, GS(M)R, PSR & PSSR as well as the general obligations of the HSWA.

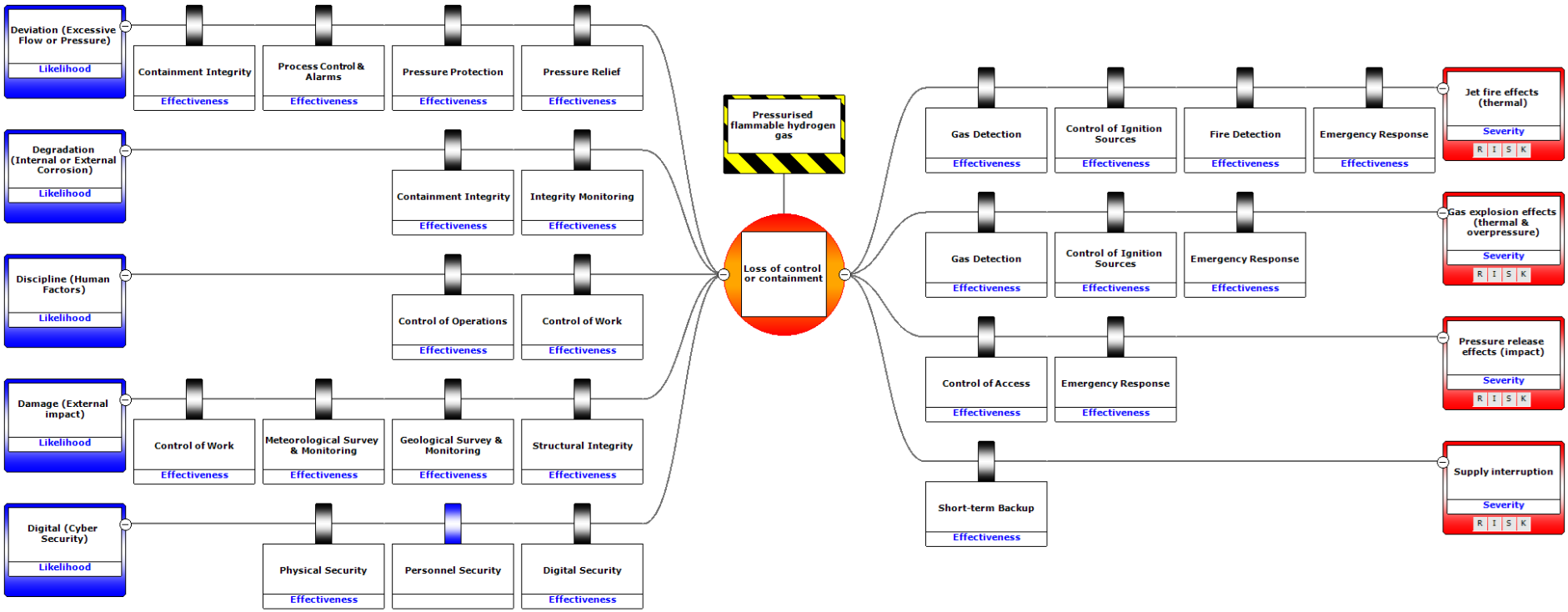


Figure 3 Example bow-tie diagram

3. Planning and Risk Mitigation

3.1 Plan, timetable and scope of work for subsequent stages of the trial

The plan and schedule for HyPentref will provide clear sequencing of events, to avoid delays and identify critical decision points. This will include long lead times for supply, acquisition and construction.

HyPentref has five stages:

1. **Outline Design**: completed as part of this submission
2. **Detailed Design**: Trial FEED and design
3. **Prepare and Build**: Procurement, Construction and Commissioning of the trial
4. **Go-live and Operate**: Operation and maintenance during the trial
5. **Trial Exit**: Extension or abandonment of the trial – More detail in Section 3.4

Project planning is underway for the entire trial, but the focus is on **Stage 2: Detailed Design**, which has been broken down into four phases:

Phase 1: Bridging Report

This will confirm the hydrogen production capability at [redacted] WWTW and determine its reliability and capacity restraints. An Options Study for hydrogen production from the proposed [redacted] electrolyser will also be completed to provide further definition ahead of FEED. The experience of customers using hydrogen – homes, businesses, industry or transport – would be the same, irrespective of production location. There is an optimisation opportunity to explore in siting all the hydrogen generation at [redacted]'s industrial site just to the west of Sully and piping biomethane direct from [redacted]. This could reduce some of the complexity of the project but during Stage 1 it has not been explored in enough detail. Further details can be found in Section 4.1.

Phase 2: FEED

FEED will determine the project cost estimates more accurately than at initial feasibility stage and further evaluate and mitigate project risks. The FEED study will build asset 'Life Cycle Cost', for the future operational business models. A design will be selected based on a reliability, availability, maintainability (RAM) analysis which is typically used to predict the performance of process systems and to provide a basis for the optimisation of such systems. This will confirm the best arrangement of modular SMRs and electrolysers to ensure supply security. Phase 2 will take 5 months to complete.

It will also include:

- Basis of Design, including specification and design criteria for each system component as well as a detailed project execution plan (PEP)
- Full evidence/benefit plan
- Design calculations and modelling of lifecycle operating costs and detail bills of quantity, and CAPEX/OPEX Estimation
- Public Engagement Strategy
- Development of Consumer Engagement Strategy
- Billing Strategy development: A tariff rate design for hydrogen tariffs must be neutral to consumers and not exceed the current natural gas rates

- Design drawings
- Safety studies with subsequent preliminary design enhancement
- QRA for storage options and plant site, pipeline and PRS
- Environmental Impact Study
- Regulatory approvals
- Planning approvals for pipeline route and site/plant plots, including land agent engagement
- Hydrogen enabling activities and additional asset monitoring capabilities
- Exit strategy criteria and plan for decommissioning or make permanent

Phase 3: Detailed Design

This will build on the FEED and develop the design to a level of detail that can be used to procure and construct major assets, including:

- **Hydrogen Production:** Design and verification work to ensure the design of the hydrogen plant meets the requirements of the trial to ensure security of supply. This is the most significant engineering work and will take approx. 7 months to complete.
- **Storage Facility:** Design calculations, PFD, P&ID, mechanical, civil, E&I drawings, layouts, civils for parallel tube high pressure hydrogen storage vessels rated for 24 hours demand.
- **Pressure Reduction Facilities:** Design of two high pressure 'decanting' hydrogen PRS from storage pressure (VHP) to pipeline distribution pressure (HP) with gas odourant.
- **Pipeline:** Detailed design with hydraulic analysis, calculations, stress analysis, layout and profile drawings and cathodic protection provision for carbon steel hydrogen pipeline from production to village.
- **Emergency Storage:** Detailed design for alternative (emergency) high pressure storage with decanting posts for trailers and site arrangement.
- **Pressure Reduction:** Detailed design for Village PRS rated for maximum flow rate of daily peaks including calculations, P&ID, Mechanical Drawings, Plot Layouts, E&I Design.
- **Gas Distribution Network:** Review of existing village gas network with reinforcements and detailed design for installation of strategic isolation valves
- **Isolation:** Physical separation from natural gas source and hydrogen system design

Phase 3 will take 7 months following Phase 2.

Phase 4: Enabling Activities

Other activities will be carried out alongside Phases 1-3 to complete enabling work for Stage 3. As well as collaborative tasks with other GDNs (outlined in Ref 2, Annex 2) these include:

- Site investigation for proposed sites and pipeline.
- Storyboarding, method statements and procedures for Planning and Commissioning.
- Review and confirmation of legal documents/contracts
- Finalisation and delivery of Public and Consumer Engagement Strategies
- Partnerships Workforce training program for hydrogen safe working practices and technical competencies.
- Update of local operating procedures and emergency response procedures
- Project management

Critical Project Milestones

Project milestones have been identified for stage 2 of the trial aligned with the four phases:

- **M 1** – Deliver Bridging Report into feasibility of hydrogen production options
- **M 2** – Deliver FEED Report and supporting material
- **M 3** – Deliver Detailed Design Report and supporting material
- **M 4x** – Various milestones for delivery of Enabling Activities (see above)

High level project schedule

HyPentref will require further detailed planning during the stage 2 to ensure correct phasing of design and construction to support timely delivery of the trial.

The proposed schedule is based on quotes from a number of suppliers and includes lead times for key equipment, site construction work and testing and commissioning.

A critical path has been identified up to end of 2024 for procurement and construction of long lead items like hydrogen plant (SMRs and electrolysers) and install new customer appliances in the second quarter of 2025.

A detailed life cycle plan is provided in Appendix B, summarised in Table 5 and in Figure 4.

Table 5 Key Dates Project Plan (reg years)

Stage 2			
Stage	**Activity**	**Start**	**End**
Stage 2	Phase 1: Bridging study	Jan 22	Mar 22
	Phase 2: FEED Design	Apr 22	Sep 22
	Phase 3: Detailed Design	Sep 22	Mar 23
	Phase 4: Enabling Activities	Apr 22	Mar 23
Stage 3	Construction – prepare and build	Apr 23	Mar 25
Stage 4	Trial Live	Apr 25	Sep 27
Stage 5	Trial Exit	Oct 27	Depends on exit scenario, see section 3.4

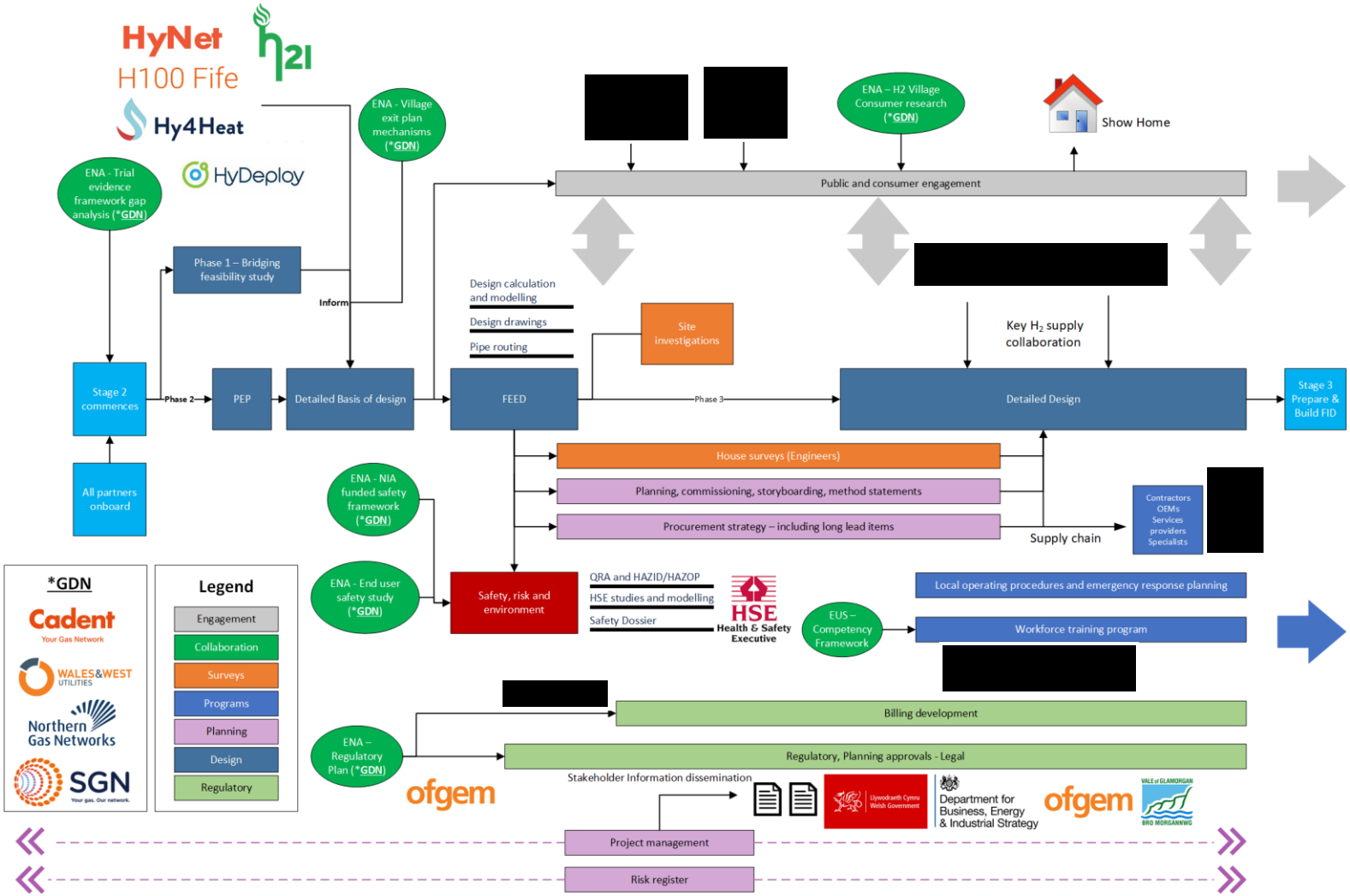


Figure 4 Overview of Stage 2 Detailed Design Plan

3.2 Organisation of responsibilities and liabilities

Trial responsibilities and liabilities[3] are split into three areas:

- Generation
- Distribution
- Consumption

The figures in this section provide an overview of the main responsibilities relating to each area at each Stage of HyPentref.

Generation

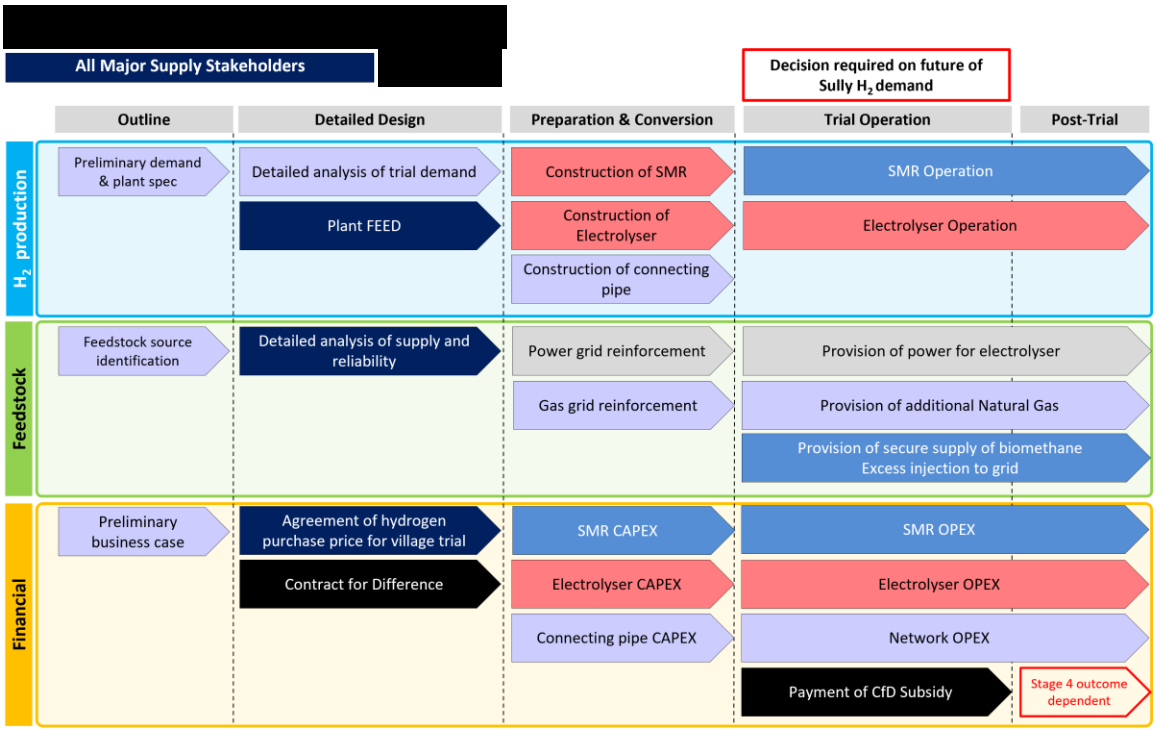


Figure 5 Generation responsibilities

Hydrogen production

- **Design:** Hydrogen production plant specification will be performed by WWU alongside all major generation stakeholders. This will involve a deeper analysis of the village's demand characteristics, including information on hydrogen uptake.
- **Preparation/Conversion:** [redacted] will be responsible for the construction of SMRs and electrolysers at the agreed sites. WWU will be responsible for the design and construction of connecting pipe for the delivery of hydrogen from production sites to Sully.
- **Operation:** [redacted] and [redacted] will be responsible for the delivery of pre-determined quantities of hydrogen from the SMRs and electrolyser respectively.

[3] Please note that the project partners named here are currently not legally bound by the content of this section.

- **Post-Trial:** Should HyPentref not continue after 2025, hydrogen will be supplied to [redacted]'s industrial partners and/or [redacted] may explore producing vehicle-grade hydrogen. This is contingent upon a timely decision regarding the continuation of the project, requiring input from all parties including consumers, to allow the project partners time to make any necessary adjustments.

Feedstock

- **Design:** All generation stakeholders will collaborate on a thorough analysis of the biomethane supply at [redacted] WWTW to inform the design of the SMR plan, electrolyser sizing, and any necessary gas network reinforcements - there must be enough capacity available to provide the full feedstock requirement for the SMRs. Additional work will consider power grid reinforcements to facilitate the electrolyser.
- **Preparation/Conversion:** WPD and WWU will be responsible for reinforcement to the power and gas distribution networks respectively.
- **Operation:** [redacted] will be responsible for the provision of biomethane for the SMRs throughout the trial and beyond.

Financial

- **Design:** All generation stakeholders, BEIS and Ofgem will reach a joint contractual agreement on supply volumes and the price at which hydrogen is sold to the trial. This could form part of a Contract for Difference (CfD), through which price parity with natural gas will be ensured for consumers. Central to a cost-effective solution is low feedstock pricing, replying on the efficient operation of the Anaerobic Digestion (AAD) plant and a favourable power purchase agreement (PPA) for the electrolyser.
- **Preparation/Conversion:** [redacted] and [redacted] will provide the CAPEX for the SMR and electrolyser respectively. WWU will fund connecting pipework.
- **Operation:** OPEX will be met for each asset by the same stakeholders as provided CAPEX.
- **Post-Trial:** [redacted] and [redacted] will retain ownership of and responsibility for the plant irrespective of the continued supply of hydrogen to Sully.

Distribution:

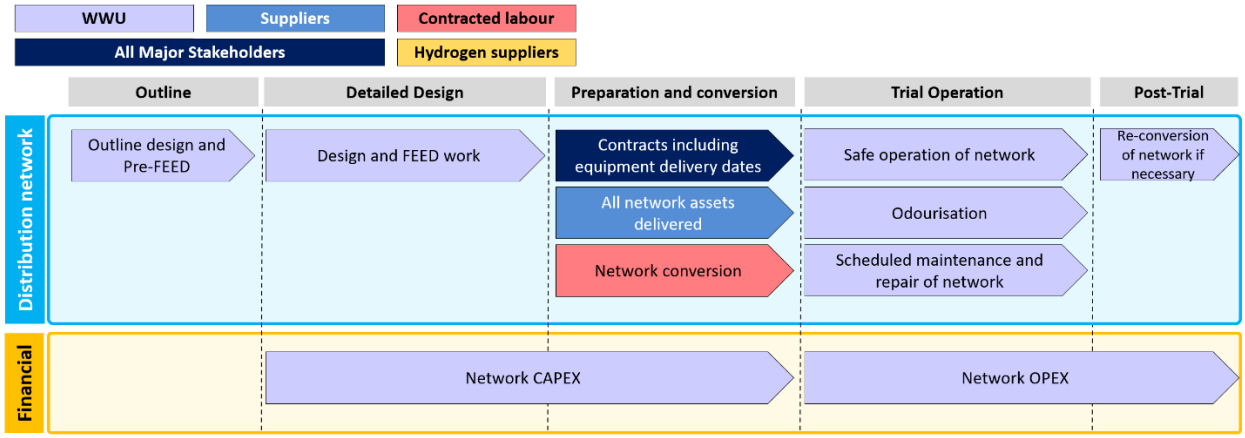


Figure 6 Distribution responsibilities

- **Design:** WWU will be responsible for all necessary design work for the network conversion. This includes a detailed assessment of the infrastructure requirements and ensuring designs meet safety criteria before commissioning.
- **Preparation/Conversion:** WWU will be responsible for funding and procuring the necessary network assets by establishing contracts with suppliers, including delivery dates of assets. WWU will contract engineers to convert the network to specification.
- **Operation:** WWU will own and operate all network assets, including contracting the labour to ensure their appropriate maintenance and repair. WWU will be responsible for the safety of the converted network, including hydrogen odourisation.
- **Post-trial:** Should hydrogen supply to Sully not be continued following the HyPentref trial period, WWU will be responsible for reverting customer's homes and the grid back to natural gas or alternative energy supply. This will be supported by the GDN collaborative work in Ref 2, Annex 2.

Distribution network CAPEX/OPEX at all stages will be covered by WWU.

Consumption:

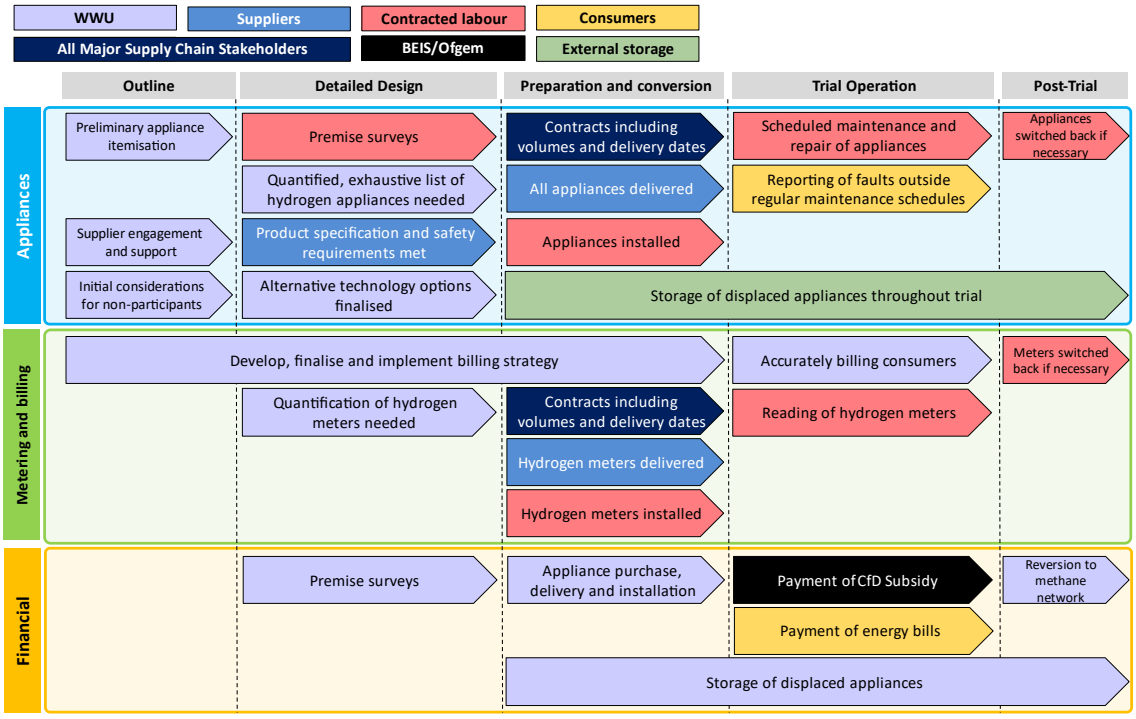


Figure 7 Overview of Consumption responsibilities

Appliances

- **Design:** Appliance suppliers must provide product specifications, including efficiencies, so that demand and other requirements can be fully understood. These products must also meet safety standards for natural gas. WWU will be responsible for quantifying an exhaustive list of appliances needed for the trial, based on the premise surveys, as well as ensuring consumers who opt out of the trial can obtain suitable alternative heating system and other appliances.
- **Preparation/conversion:** Appliance unit costs and volumes will be agreed

contractually between WWU and suppliers. WWU will provide funding to the suppliers, who will then be responsible for the timely provision and delivery of the assets at the agreed scale and cost. WWU will be responsible for identifying an installer base, while an external training provider will be responsible for planning, funding and delivering relevant retraining. Contracted installer [redacted] will then be responsible for competently installing all appliances, including those for consumers who opt out of the trial. WWU/BEIS will be responsible for paying installers, with no funding provided by consumers.

- **Operation:** Suppliers will be responsible for providing appliances which operate as specified, and a project maintenance partner for ensuring continued performance. WWU/BEIS will fund all appliance maintenance/repairs/replacements. Consumers will be advised to report any faults falling outside the regular maintenance/repair schedules.
- **Post-trial:** A storage company will be responsible for the storage of all incumbent natural gas appliances. WWU will be responsible for coordinating the reinstallation of these appliances if necessary.

Metering and billing

- **Design/Preparation/Conversion:** WWU, in partnership with [redacted], will be responsible for establishing a strategy for billing consumers and setting up a special-purpose vehicle (SPV) to collect the payments. This will be in line with the joint GDN work undertaken with Xoserve, as set out in Section 3 of the GDN collaborative supporting evidence (Ref 2, Annex 2). WWU will also be responsible for agreeing procurement contracts for hydrogen meters, with the contracted suppliers then responsible for their timely delivery. WWU will be responsible for contracting the labour required for their installation.
- **Operation:** Consumers will be responsible for energy bills up to the agreed price point, with BEIS/Ofgem to pay the remainder as per the CfD. The shipper/supplier project partners will bill consumers and collect payments via the SPV as per the strategy laid out above. They will also be responsible for reading hydrogen meters at regular intervals.

3.3 Regulatory plan

Introduction

This Section is underpinned by the Safety Case Framework in Section 2.2 and the Regulatory Plan in section 3.3 of Ref 2, Annex 2. The collaborative work will shape the formation of the HyPentref safety case and regulatory plan.

The principles in the collaborative work have been applied to HyPentref and have been broken down into two parts and expanded for Sully in this Section, including reviews of:

- Legislation, licences, regulations and industrial codes to highlight modification/derogations that may be required in order for HyPentref to progress.
- Planning regulations and environmental impact assessments for the current proposed design of the hydrogen network.

Legislation, Licences, Regulations and Industry Code Review

The overall objective of the analysis was to build on the work of H100 by identifying a regulatory framework that would have minimal change on the UNC. The core assumptions that were made when conducting the analysis include:

- Competition in supply must be maintained
- Customers must experience no cost impacts of being supplied hydrogen rather than methane from the network
- Minimum change has ideally no impacts on Shipper and Supplier systems and minimum impact on central systems and transporter systems

Upon completion of this work, WWU is satisfied that the regulatory approach proposed above can be applied to HyPentref. Broadly speaking this involves treating the hydrogen network as if it were part of the gas network, such that hydrogen is treated commercially in the same way as natural gas from a National Balancing Point (NBP) perspective.

The Gas Act (1986) would be directly applicable to HyPentref with only a minor amendment to Section 10 relating to Gas Transporters maintaining a gas connection. In particular, for the purpose of the trial WWU may need to disconnect those end customers who do not agree to be part of the trial. This issue has been identified in BEIS' Hydrogen for Heat consultation, and as can be seen in Section 5.3; WWU intends to provide a customer focused alternative solution for those who will have their heating systems changed.

WWU's current Gas Transporter Licence (GT Licence) enables WWU to transport gas through its network, with the definition of gas encompassing hydrogen. WWU is not intending to undertake any other licensable activities for the trial, therefore the GT Licence still holds and does not require amendments.

For the Suppliers Licence, WWU at this stage have not found any specific modifications / derogations required, however, there are some general points that are worth highlighting:

- Under Condition 21A, Suppliers involved in the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme must submit gas usage for large industrial customers. Hydrogen does not produce carbon when combusted, however, may have a carbon factor associated with it depending on the source. Therefore, for the trial it is worth considering what the associated carbon factor for the trial is, and how Suppliers can declare this.
- Under Condition 33 and 34, Suppliers have the obligation to ensure reasonable steps are introduced to ensure relevant smart metering systems are installed in each Domestic Premises and associated in-home display. Within the timeframe of the trial smart

hydrogen meters may not be available. If this is the case, potential derogations should be considered to exclude hydrogen meters from such Conditions.

- Condition 49 relates to the requirements for Suppliers to ensure that Alternative Home Area Network (HAN) activities are carried out. This is similar to the above point, in that for the trial period there may not be hydrogen smart meters developed. Therefore, if smart hydrogen meters are not ready for the trial period, derogation from this condition should be perused.

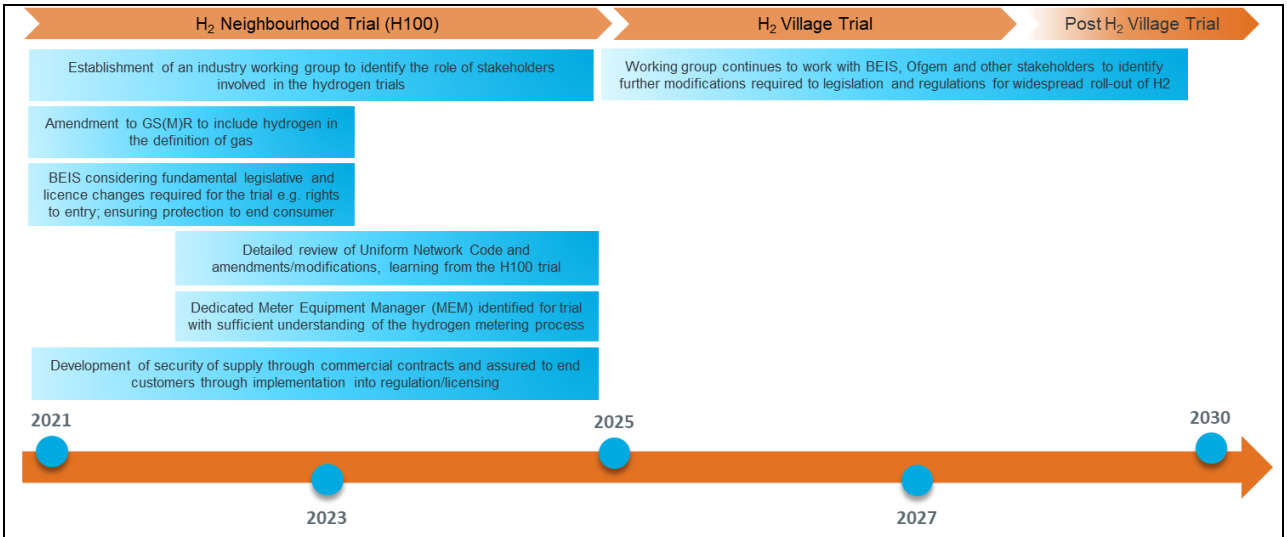
The Gas Safety (Management) Regulations (GS(M)R) (1996) are strictly for natural gas pipelines, therefore they do not apply. However, from a safety perspective, WWU will work with HSE and other GDNs to ensure that for the village trial compliance to GS(M)R is displayed as if they apply. Furthermore, it is worth noting that WWU is aware of IGEM's Gas Quality Working Group which is looking at providing an evidence base to change gas regulations to allow a wider range of gases including hydrogen. There is potential this could involve either amendments to the current GS(M)R or creating a new one for hydrogen specific networks. WWU will continue to monitor outputs from this working group to ensure compliance. This is addressed further in section 4.4.

The Uniform Network Code (UNC) will require potential modification / derogations, with a full outcome of the analysis displayed in Appendix C; however, any changes to the UNC will need to satisfy one or more of the relevant objectives in Standard Condition A11 of the GT licence.

The Retail Energy Code (REC) and Smart Energy Code (SEC) have both been reviewed by WWU and no required changes have been identified, but this is subject to discussions with Suppliers regarding supplier billing processes. A point to highlight, however, is that within the time period of the trial, hydrogen meters are likely to be new to the industry. Therefore, Meter Equipment Managers (MEMs) are unlikely to have a detailed understanding of the technology. WWU believes consideration to identify a dedicated MEM for the time of the village trial which would have a detailed understanding of hydrogen meters would ensure a smooth operation and benefit to the end customer.

Some additional points WWU has identified during this work:

1. Depending on the final commercial framework for HyPentref, commercial pressure should ensure price protection for consumers vs natural gas. However, WWU suggests that to ensure commitment to end consumers this price protection should be included within legislation.
2. Government review of VAT rates for hydrogen to ensure that VAT for hydrogen is charged on the same basis as natural gas for domestic consumption.
3. For thermal energy calculations "The Gas (calculation of thermal energy) Regulations 1996" will be reviewed as part of the collaborative GDN work.
4. GSOP will also be reviewed as part of the collaborative GDN work.
5. To ensure security of supply to end customers the design of the network will be in alignment with current regulatory standards. As HyPentref will be on an isolated network with a maximum of two hydrogen sources, WWU suggests that duties associated with security of supply from the rest of the value chain are clearly set out in the regulatory framework



HyPentref Planning Regulations

Based on the known scope of the project, it is considered that planning permission would be required for at least some elements of the proposals. Parts of the project could be permitted development, and equally the work to upgrade existing equipment within the village and install new equipment at the domestic premises is unlikely to be development, thereby not requiring planning permission.

WWU considers that its Statutory Undertaker (SU) powers under the Gas Act and permitted development as a gas supplier under permitted development rights would apply to hydrogen networks.

A review of the relevant planning legislation has been undertaken based on the information available at this time and planning permission is required for at least some of the project. Whereas other elements may be permitted development. Further assessment of this will be undertaken as the project scope develops.

An in-depth planning analysis is provided in Appendix D to demonstrate the necessary considerations in respect of what consents are required, the consideration of such a planning application and an indicative programme is provided in Appendix E.

3.4 Exit plan

An exit strategy from HyPentref has been devised around two scenarios:

1. Ongoing supply of hydrogen to trial area and potential expansion of the trial.
2. Ending hydrogen use and reinstatement of natural gas or electric heating alternative

In order to get the support of the local community and consumers for the conversion process, it is important to sell hydrogen as a long-term solution and Scenario 1 therefore as the most likely outcome. Although Scenario 2 must be planned for, it should be clear it is not the preferred route – there could be significant resistance to the trial because of the disruption caused for a 1–3-year project.

Scenario 1: Development and expansion of the trial would result in further understanding of the long-term impacts of the use of hydrogen as an energy vector in decarbonisation of the UK through our existing gas infrastructure. It is clear that the development of decarbonised hydrogen production to replace natural gas will take many years, and that the national conversion process will need to be managed iteratively over the coming decades. WWU believe that the best way forward is whole system planning, designing an energy system that makes best use of our existing safe and reliable gas and electricity networks, combining multiple energy vectors on the road to Net Zero by 2050.

It is part of Scenario 1 of the exit strategy (if successful and depending on BEIS roadmap) to explore ways in which the trial can be expanded. HyPentref has the potential to be extended to the nearby town of Barry, with over 50,000 residents, a significant commercial sector and a large industrial zone including existing hydrogen production.

Preliminary discussions have been undertaken with the potential suppliers of hydrogen, [redacted] and [redacted], around their long-term involvement. All three organisations are looking at ways in which the trial can be used as a catalyst in this area to promote both decarbonisation of industry and support of an energy hub.

Figure 8 shows the exit strategy options identified as part of the exit plan. The red hatched cloud demonstrates what would be decommissioned, repurposed or reinstated as part of Scenario 2, ending the project after 1-3 years. The green hatched clouds show how the trial would provide a catalyst for further infrastructure for both continuation and ending the project.

[redacted] have already confirmed that their intention is to ensure that fuel grade hydrogen can be produced should the trial have to finish.

[redacted] have also indicated that they wish to decarbonise their process/existing customer base and HyPentref would provide a stepping stone to accelerate their plans. With either the continuation or ending of the project [redacted] have confirmed that modularisation of their SMRs and Electrolysers will enable them to expand as required and create a hydrogen hub in the region. With this expansion and [redacted]'s continued expansion of biomethane, HyPentref creates the ideal hub to explore further decarbonisation projects to support the ongoing commitment to Net Zero by 2050.

Scenario 1 (Development and expansion of the trial)

Overview

The plan will be to develop and expand HyPentref into a pilot scheme which will continue to provide evidence on the efficient and effect use of hydrogen with the existing gas distribution network. The pilot will evidence scalability, expandability of the network, continuing consumer attitudes and behaviour and operation and supply of a gas distribution network transporting hydrogen. The exit strategy will be reliant on the continued support of BEIS to provide a support mechanism for hydrogen production to ensure that customers in the pilot and expansion areas are not disadvantaged. To achieve this the follow key elements and strategies will be catered for within the design:

Plan

Infrastructure:

- Limited infrastructure requirements are currently envisaged but as per the purpose of the trial the understanding of operation, supply and consumer needs will likely inform any necessary modification

Appliances and installation:

- Continued maintenance and support provided by our partners at [redacted] – Consumer waived of this cost during pilot. This will need further discussion and engagement through stage 2.

Associated cost:

- Continuation of support mechanism met by BEIS (dynamic cost depending on the market conditions and arrangements firmed up within stage 2)
- Recycle of retained consumer appliances
- Potential need to offer post trial electrification option even if hydrogen is retained

Scenario 2 (Ending the project and reinstatement if the natural gas supplies)

Overview

The projects ethos and objective are to make every effort and endeavour to support the continuation of the trial so as not to further disrupt the consumer. However, a plan for returning the area to natural gas or converting participants to electric heating will be catered for within the design:

Plan

Infrastructure:

- Decommissioning of minimal infrastructure with the main aim to repurpose. Cost assurance piece include full decommissioning costs as a baseline and will be confirmed once further commitments are made by project partners

Appliances and installation:

- Replacement of hydrogen only appliances with equivalent natural gas appliances or switchover from hydrogen to natural gas of multifuel appliances. Potential offer of electrical appliances in place of natural gas if preferred by customers.

Associated cost:

- Base case costs are decommissioning of specific trial-based infrastructure highlighted in

the above diagram (red hatched) but include ○ Pipelines ○ Village PRS ○ Temporary trailer storage facilities ○ Odourisation ○ Reconnection of gas network and removal of positive isolation ○ All commissioning cost and reinstatement of consumer appliances, potentially with offer of electric appliances instead - Exit plan cost likely to be [redacted] base

3.5 Risk Register

A Risk Register for HyPentref has been drafted for the project using an Excel template which has been successfully used on a wide variety of projects. This is a live document which, if the trial were to go ahead, would evolve with the project and both form a record of decisions made, but also a high-level plan for outstanding activities. This is provided with this submission in Ref 3, Annex 3.

The register covers all project elements (hydrogen generation, distribution and consumption) across all lifecycle phases (Concept & Design, Construction & Commissioning, Operations & Maintenance and Decommissioning & Deconstruction).

Potential threats to the project objectives are identified as risks with their potential (unmitigated) effects or consequences on target risk receptors (who or what is impacted) recorded.

It is recognised that any threat may have multiple effects therefore the dominant risk is assigned from the following list:

- Health & Safety
- Environmental
- Schedule
- Financial
- Reputation

Risks (threats) which may lead to significant consequences are identified with a High Criticality.

Risks (threats) which require urgent resolution are identified with a High Priority.

Using the filter feature of Excel, the register can be reduced to focus on specific project elements or phases, risk receptors or dominant risks or risks which are significant and/or urgent.

The project team will focus on the risks which are both High Criticality and High Priority to ensure the success of the project from the outset. Based on the current status of the project and the experience of the team, the following risks are considered to be either significant and/or urgent.

Table 6 Significant project risks

Dominant Risk	Risk	Mitigation
Health & Safety	Loss of containment of hydrogen – different material stress regime	Appropriate design, construction, inspection & maintenance.
	Absence of hydrogen colour, flame or smell	Adopting best practice from research and other projects
	Unable to make 'Case for Safety' – challenging regulatory regime	Constant engagement with HSE, collaboration with other networks and early engagement with planners.
Schedule Financial Reputation	Community apathy or resistance e.g. perceived 'greenwashing'	Public Engagement and Consumer Strategies

Environmental	Environmental consent not properly evaluated or demonstrated	Research, surveys and early engagement with planners.
Health & Safety Environmental Reputation	Failure to manage work during construction/deconstruction	Safe systems of work & considerate contractors.
Schedule	Delay in regulatory, political or commercial approval	Close collaboration with other GDNs, government and regulatory bodies
Schedule	Failure to engage and retain project partners	Commercial & contractual commitments as early as practical.
Schedule	Lack of resources including manpower, materials & equipment	Active project management (identify long lead items)
Reputation	Lack of available consumer equipment suitable for hydrogen service	Early engagement with equipment suppliers.

Mitigation measures to either reduce the likelihood of the threats or reduce the impact of the consequences are identified for each risk and the party responsible for these implementing or sustaining these measures is also identified.

A qualitative risk ranking has been used to rank the Hazard Severity (HS) from 1 to 5 (lowest to highest impact) and the Likelihood (LH) from 1 to 5 (lowest to highest frequency). Risks are categorised into the rankings in Table 7.

Table 7 Risk rankings

Ranking	Rating	Mitigation
High	Unacceptable	Design change or special precautions required to be communicated to fabricator/manufacturer/contractor/end user
Medium	Tolerable	Residual risk to be communicated to fabricator/manufacturer/contractor/end user
Low	Acceptable	No further action required

Should HyPentref get the go ahead, the risk matrix will be calibrated to match the WWU corporate risk criteria.

The risk ranking will be used (with the Criticality & Priority columns mentioned above) to prioritise risk mitigation/management.

Risk will be evaluated both unmitigated (without mitigation measures in place) and mitigated (residual risk with mitigation measures in place). The project team will utilise their knowledge and experience to predict the worst foreseeable outcomes.

Where known or predicted, a target date for implementing the mitigation measures will be identified.

If further action is required to investigate, evaluate or address a specific risk then this is recorded as an Action/Record of Residual Risk which will then be categorised as either Open or Closed (by default these will be blank if Open and only Closed when the project team are satisfied that the risk has been or will be addressed).

For each risk, an owner will be assigned who is responsible for either managing or expediting the resolution of the risk.

The risk register will be stored on a shared workspace (currently Microsoft Teams) to ensure it is accessible to all stakeholders thereby maximising visibility, engagement & awareness.

It is currently anticipated that critical, complex or novel risks will be visualised in bowtie format to more clearly communicate and manage risk.

4. Infrastructure and Delivery

4.1 Options identified for meeting requirements for hydrogen supply & resilience

4.1.1 Supply specification

Postcode level gas consumption statistics, Xoserve MPRN data, WWU data, and [redacted] suggest Sully will have 1,590 connections by 2025, with an annual domestic demand of 25.5 GWh. The non-domestic Energy Performance Certificate (EPC) register shows four gas heated properties accounting for an additional 0.5 GWh (the register also contains 53 non-gas heated non-domestic addresses within the trial area). We also expect a number of commercial consumers to be registered as domestic users.

While EPC data may be incomplete, more granular gas consumption data is not readily available for Sully. Further analysis will be undertaken during Stage 2.

Assuming all users convert and hydrogen appliances achieve equal efficiency to incumbent technology, the total demand implies a maximum requirement for approximately 7.7 million standard cubic meters (scm) of hydrogen annually.

Since residential properties dominate, the village's overall demand profile has been assumed to follow a typical domestic profile. By scaling typical diurnal profiles for each month to match the annual volume outlined above, average monthly consumptions were derived.

Sully's natural gas demand for 2020-21, with an addition made to account for the new homes expected by 2025, was converted into an energy equivalent volume of hydrogen, implying a peak daily flow for the modelled period of approximately 57,500 scm/d. The scaled flow is plotted with average monthly values in Figure 1. This figure is 84% of the peak 1 in 20 6-minute demand used by WWU. It is anticipated that not all homes will convert to hydrogen which will provide a design margin and the Public Engagement and Consumer Strategies in stage 2 will validate this.

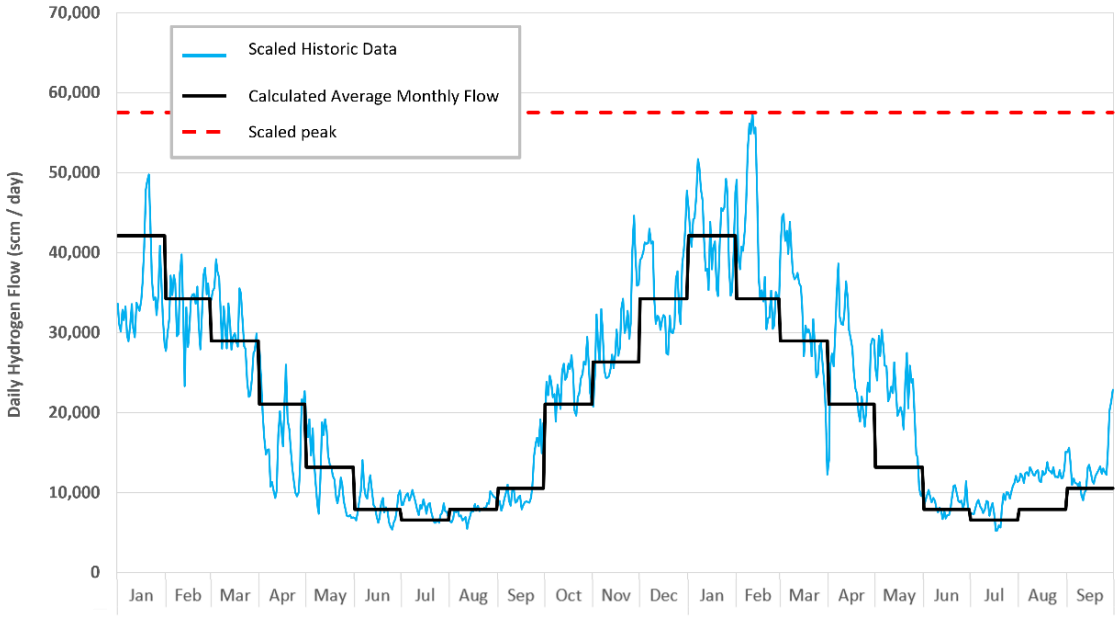


Figure 9 Inferred hydrogen flows for Sully in 2025 calculated by scaling historic natural gas data (Jan 2020- Sep '21) compared with average daily consumption

4.1.2 Project Partners

[redacted]

4.1.3 Estimated Plant Requirements

Table 1 summarises the current understanding of HyPentref's requirements for hydrogen producing assets.

Table 8 Summary of hydrogen production plant requirements

Item	Daily Hydrogen Production Capacity		Quantity (No.)	Total Daily Hydrogen Production Capacity		Proposed Location	Proportion of typical year peak daily demand (%)
	kg	scm		kg	scm		
[redacted]							
[redacted]							
Total				[redacted]	[redacted]		[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

4.1.4 Resilience

Redundancy

For most of the year, the full installed hydrogen production capacity will not be used. This and the two supply modes build redundancy into the design, giving a high availability.

Gas grid

The ability to inject and import natural gas from the grid adds significant resilience to the proposed production layout. If biomethane becomes unavailable, the distribution network will be able to reliably provide feedstock for hydrogen production, given its maturity. As the SMRs can supply over 100% of the typical year peak daily demand, natural gas injection alone would suffice in all except for extreme peak conditions to provide hydrogen in the unprecedented event of simultaneous AAD and electrolyser downtime.

Trailered gas

[redacted] are experienced providers of trailered hydrogen, which could be delivered to supplement the primary sources if needed, whether due to unplanned downtime or an extreme peak in demand.

4.1.5 Carbon Emissions

Generating hydrogen from biomethane means that the SMR hydrogen is low carbon, due to the utilisation of a short carbon cycle. Additionally, there is potential to capture up to 4,500 tonnes per year of CO_2 from the SMRs at an average cost of [redacted] This could be sold into the food and drinks market. See Appendix F for further information.

During times of low hydrogen demand, supplementary biomethane will be injected into the grid, using existing infrastructure at [redacted]. This enables the collection of Renewable Gas

Guarantees of Origin (RGGOs), which can be used to offset any additional natural gas required to meet demand at other times.

The provision of electrolytic hydrogen within the village's energy mix reduces potential emissions. It is essential that renewable power, provided via a renewable power purchase agreement, be utilised for this to avoid multiplying the grid's underlying carbon intensity through the inefficiencies of electrolysis.

4.1.6 Costs

The capital and operational costs of the plant will be subject to additional design work in the next phase of the trial. These will be met by the relevant project delivery partners, while BEIS/WWU will be responsible for purchasing hydrogen from the suppliers at an agreed rate. The financial responsibilities relating to hydrogen generation are detailed in section 3.2.

4.1.7 Alternative

An alternative arrangement retains the same hydrogen mix, however [redacted] would have sole responsibility for the supply of hydrogen through owning and operating all hydrogen producing plant at their Barry site. [redacted] would continue to function as the SMR's primary feedstock supplier, ensuring the trial's environmental credentials.

This has several potential advantages, including the use of an extant industrial location already housing SMRs, and the simplification of contractual arrangements with a single organisation responsible for hydrogen production. Though supported in principle by [redacted], [redacted] and WWU, the details of this arrangement require further exploration in Stage 2.

4.2 A statement of infrastructure requirements

[redacted]

Hydrogen reforming plant:

[redacted]

T[redacted]

Converting gas appliances:

Hydrogen appliances and equipment for domestic and commercial use have been developed. In Stage 2, a detailed survey will be conducted to understand the exact consumer appliances in each home and location, location of the meter, type of meter, ventilation (mechanical and natural), routing of pipework, current boiler and location as well as pipe sizes. This will identify the options for converting appliances on a property basis.

The lead times for each infrastructure component is integrated to a proposed timeline for entire project which is presented in Appendix B with the intention to have the infrastructure components ready for commissioning within the first quarter of 2025.

4.3 Supply chain strategy

Table 9 gives an overview of progress to date in developing the supply chain strategy for HyPentref, including strategies for later stages. Work completed at the outline stage is described in the following sections.

Table 9 Supply Chain Strategy Overview

Stage	Planned/completed tasks
Stage 1 Feasibility Study (tasks completed to date)	Review of building stock to understand the range of hydrogen appliances required.
	Review of network upgrades needed for hydrogen (addressed in Section 4.2).
	Assessment of appliance options for consumers who opt out of the trial, including a prototype method for informing consumers of suitable alternative space heating technologies based on building characteristics. Review of the WPD network capacity map to identify grid constraints if significant electrical heating uptake.
	Engagement with suppliers of hydrogen appliances and securing their support.
Stage 2 Design Activities	Develop an exhaustive list of all necessary domestic/non-domestic appliances following property surveys.
	Finalise alternative heating/other appliance options, and the process for ensuring each consumer is offered a suitable technology. Engage with WPD around any reinforcement needs.
	Revise appliance list based on hydrogen uptake, using consumer input to ensure that each premises' gas appliances will be replaced with a suitable hydrogen (or other) appliance.
	Finalise itemisation of network equipment necessary for grid conversion, including engagement with WWU's existing supply chain.
Stage 3 Prepare and build	Complete procurement process by establishing supply contracts for appliances and network components, including delivery dates.
	Engage with installers, training providers and the existing local gas installer base to ensure appropriate labour and skills are available for the trial.

<u>Review of Sully building stock and associated considerations:</u>

<u>Residential:</u>

There are currently 1,352 MPRN's in Sully. [redacted] Analysis of EPC data indicated a diverse property mix, including detached/semi-detached houses and flats. A wide range of construction types and EPC ratings

are present. Property types and EPC ratings are shown in Figure 10 and Figure 11. Percentages quoted are the proportion of the domestic EPCs available for Sully.

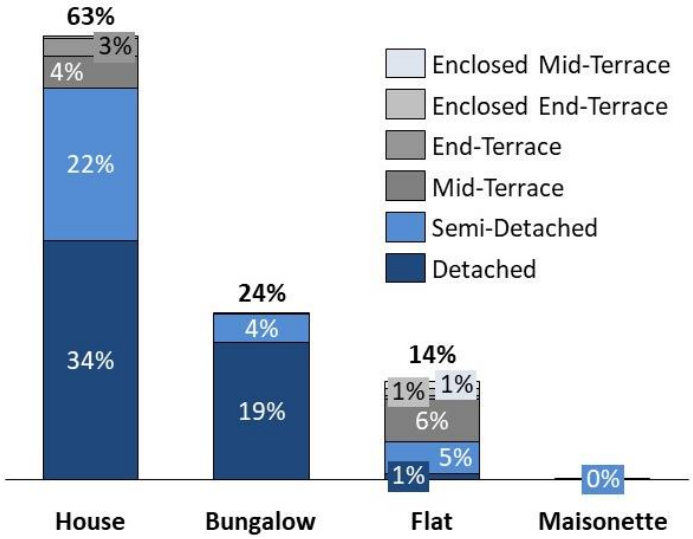


Figure 10 Domestic properties in Sully (% of EPC stock)

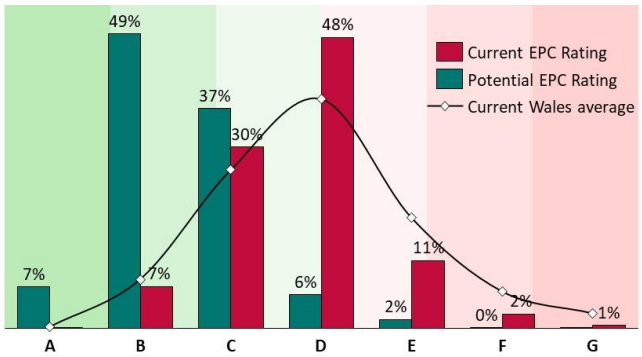


Figure 11 Sully domestic EPC ratings (% of EPC stock)

Heating types across the residences is in Figure 12. However, the type/age of boilers or other existing appliances is not available through the EPC data. Based on available data, hydrogen equivalents have been identified and summarised in Table 10.

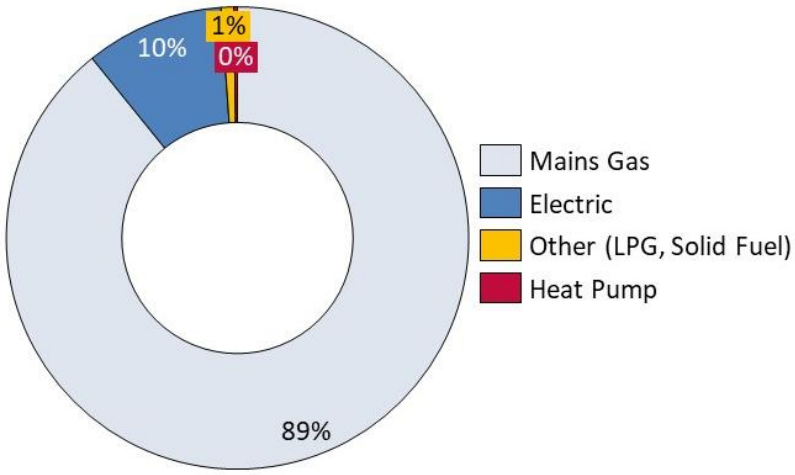


Figure 12 Main heating type in Sully (% of EPC stock)

Where residents opt out of the trial, the supply of alternative appliances has been considered. For non-space heating technologies, electrical equivalents will be supplied for which there is a well-established market. For space/water heating technologies, we have considered the supply of:

- Heat pumps (air/ground source)
- Electric boilers
- Electric resistive heating
- Electric storage heaters
- Biomass boilers
- Liquefied petroleum gas (LPG) boilers

A process assessing the constraints and viability of these technologies has been developed, ranking them depending on a range of specific building properties. Figure 11 shows many homes may need efficiency upgrades to be suitable for heat pumps, or to reduce running costs with direct electric. The potential EPC rating suggests this should be possible in most cases to get to C or better. Associated electricity constraints have also been considered, using WPD's network capacity map. The process will be refined in stage 2, and with consumer input, will ensure all residents are offered suitable alternative appliances should they opt out.

Non-residential:

HyPentref includes several non-domestic premises, including a pub, offices and a primary school. The primary school has the highest known annual thermal demand and has been used as the upper-bound requirement for sizing non-domestic heating appliances. Incumbent appliances at all premises will remain unknown prior to detailed surveying, and the preliminary list of appliances will need refining in stage 2.

Itemising appliances needed for HyPentref:

Based on the building stock review, Table 10 outlines an appliance list. This includes suppliers that have been engaged and expressed support, including their capability to supply the trial.

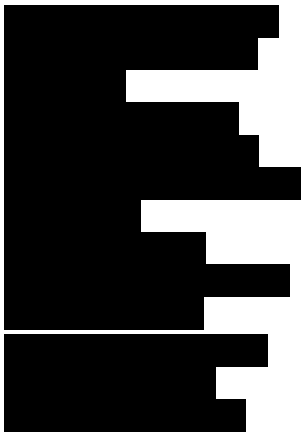
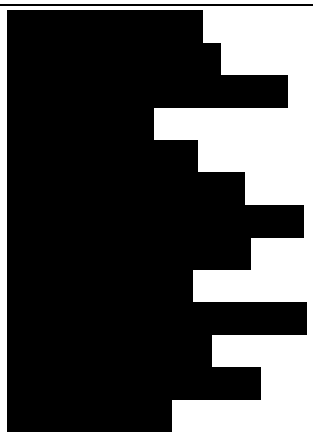
The final column indicates the current confidence level that each appliance will be available before the trial, based on supplier engagement and additional market research. Where this is

not 'high' we will work with supporting suppliers and new entities if necessary, to ensure the final range of appliances available to consumers is as complete as practicable.

Current production costs are of limited relevance, as all manufacturers emphasised this would depend on manufacturing scale by the time of the trial (ultimately reaching prices comparable with natural gas equivalents).

Table 10 Appliance List

Level	Type	Appliance/ equipment	Manufacturers / suppliers Engaged	Support expressed	Availability confidence (High / medium / low)
Building	Domestic	Hydrogen boilers	[redacted]	P	H
			[redacted]	P	H
		Hydrogen cookers	[redacted]	P	H/M
		Hydrogen range cookers (e.g. Aga style)	N/A	N/A	L/M
		Hydrogen fires	[redacted]	P	H
			[redacted]	P	H
		Hydrogen meters	[redacted]	P	H
			[redacted]	P	H/M
		Hydrogen detectors	N/A	N/A	M (Dependent on completion of H2GO domestic hydrogen detector project)
		Hydrogen how-water tap	N/A	N/A	L/M
		Alternative space heating technologies	Multiple	[redacted]	H
		Other electrical appliances (hobs/ovens/fires)	Multiple	N/A	H

Building	Non-domestic	Hydrogen boilers		P	H (cascade of multiple boilers)
				P	M (intention to develop)
		Hydrogen catering appliances		P	H/M (Depends on village requirements)
		Hydrogen meters		P	M (intention to develop)
				P	H/M
		Air heaters		P	H
Network		Pressure reduction assets: Below 7 bar		N/A	H (already supplied as part of NGN trial)
		Pressure reduction assets: Above 7 bar		N/A	H (already supplied as part of NGN trial)
		Polyethylene pipe		N/A	H
		High pressure carbon steel pipe		N/A	H
		Excess flow valves, anacondas, flow regulators		P	H

4.4 Workforce capability, skills and training plan

Workforce training and skills development for HyPentref will be underpinned by the Hydrogen Competence Framework developed by Energy & Utility Skills (EUS) on behalf of BEIS as part of the Hy4Heat program. The framework has been written initially to upskill a small group of current Gas Safe-registered engineers, but will extend to industry and field operatives as hydrogen trials are rolled out across the UK.

Engineers will be required to successfully complete an independent Approved Code of Practice (ACoP) assessment, which will be formally certificated. In turn, this certification will be added to the engineer's Gas Safe record, enabling the engineer to carry out work on hydrogen installations as part of the trials.

Should widespread deployment of hydrogen be approved in future, there will be a need for scaling up of this training/assessment template and the ACoP model will be superseded by the normal assessment methodology, as appropriate.

At the time of writing, the framework is still in development but currently consists of:

- A **Comparative Analysis** of hydrogen and existing hydrocarbon gases
- A **Skills Matrix** that translates the analysis into skills, knowledge and understanding
- An Interim **Hydrogen Technical Standard** that defines acceptable parameters and requirements for hydrogen installation work
- A **Hydrogen Training Specification** that will enable training course consistency and facilitate industry recognition
- An independent **Hydrogen Assessment Module** that will facilitate the addition of a hydrogen competence category on the Gas Safe Register

WWU has been liaising closely with EUS to ensure that the training modules and assessments are fit for a Village trial in Sully and has joined the hydrogen stakeholder group, which will allow WWU to input to development of training and ensure they are fit for purpose for the trial.

For HyPentref, it is proposed to split the training responsibilities in two, with the boundary at the ECV or the doorstep to homes. A brief explanation of the proposed approach is given below:

[redacted] has provided a letter of support to WWU in support of the Sully Village trial. The full letter of support is provided in Appendix A, however the extract below outlines what [redacted] will bring to the trial:

As an experienced consumer facing business, [redacted] will look to support the Wales & West Utilities Hydrogen Village trial by leveraging our expertise in delivering in-home solutions to meet diverse consumer needs. We believe that we could support the trial, and improve the consumer experience through:

a. Ensuring the trial appropriately engages with consumers and delivers for them

b. Ensuring the commercial feasibility of the proposals

c. Ensuring the delivery of the in-home solutions (including the installation and maintenance of heating systems and appliances)

d. Safety considerations (including training and accreditation)

The involvement of [redacted] in the trial will instil significant confidence in the consumers, but their experience in training and accreditation will also be key to the trial. [redacted] will take responsibility for training of all Gas Installation Engineers that will enter consumer homes in the village to fit new hydrogen appliances and all other

work downstream of the Emergency Control Valve (ECV). The size of [redacted] will allow the commissioning and installation work to be undertaken quickly and with minimum disruption to the customer.

[redacted] normally trains personnel at its facilities in Leicester, however, the need for local training is recognised and for the purposes of the trial, it is proposed to use [redacted]

[redacted] has also provided a letter of support to the trial, which can be found in Appendix A. [redacted] is the preferred supplier for all WWU professional and technical training and apprenticeships. Their provision includes a wide range of technical training in the areas of health and safety including general and site-specific provision.

It is proposed that [redacted] will provide:

- Local facilities to undertake all training for the trial (including [redacted] training)
- Training for all Field Engineers, including Maintenance Engineers, Repair Engineers and Emergency / First Call Operatives. In short, [redacted] will provide training for all work undertaken upstream of the ECV.

WWU will stay close to the development of the Hydrogen Competence Framework and will input to the development of training modules, assessments, training centre requirements. This work is yet to be undertaken and we will work collaboratively with EUS and other key stakeholders in the run up to the trial.

5. Public and Local Engagement

5.1 Public engagement evidence

The success of HyPentref depends on the consent of local residents to participate in the project, and WWU's public engagement aims to help the local community make informed decisions on their trial involvement, to maximise learnings the process to convert properties from natural gas to hydrogen in support policy decisions.

In planning public engagement, WWU undertook a comprehensive stakeholder identification and mapping exercise that identified a range of stakeholders, including organisations representing those with specific needs (Figure 13). These organisations have provided – and will continue to provide – insight to shape the public engagement strategy and in some cases will support its delivery.

Figure 13 Strategic Phase 1 Engagement

<u>Stakeholder engagement to-date: Strategic and specialist engagement</u>

A strong and collaborative approach to engagement with a range of stakeholders is essential to make HyPentref a success. Collaborative and partnership working, started in stage 1 and continuing in stage 2, is vital to delivering a consumer focused, fair and just trial, that delivers learning for policymakers.

Planned engagement will build and leverage stakeholder support to deliver HyPentref, including the consumer strategy. In stage 1 WWU identified a number of stakeholders interested in supporting and collaborating on the trial. This included those representing consumers in vulnerable situations and fuel poverty, to understand how best to help all consumers successfully participate in HyPentref. Table 11 is a summary of stakeholders engaged and outcomes sought.

Table 11 Completed Stage One Engagement		
Category	**Stakeholders engaged**	**Projected Outcome**
Government	BEIS	HyPentref aligns with the strategic context, requirements and timing of Government ambitions, policies and priorities.
Devolved Government	Welsh Government Ministers	Ensure HyPentref aligns with the strategic direction of the Welsh Government, aligning expectations and requirements
Local Government	Vale of Glamorgan Council	Raise awareness, secure buy in and ensure HyPentref supports the longer-term energy transition in the area.
Regulatory	Ofgem, Health & Safety Executive	Confirm expectations for trial development, regulatory frameworks and scope health and safety requirements.
Consumer Representatives including Charities and & Not for profit and organisations representing consumers with vulnerabilities	[redacted]	Gain support for the trial and leverage expertise and experiences, particularly around supporting the most vulnerable. Ensure the needs and wants of all consumer groups are understood and appropriate services are co-designed to support.
Academia, Research and trade bodies	[redacted]	Identification of opportunities for collaboration and partnership, particularly relating to consumer behaviours, public perception and developing a fair consumer strategy. Supporting the ongoing development of content and materials which will encourage public acceptance of the trial and wider energy transition.
Energy supply	[redacted]	Understand and plan for deployment of hydrogen to the trial site and lead in times. To share recent experiences of working in Sully.
Appliance Supply Chain	[redacted]	Support the trial to understand issues around hydrogen appliances and technologies, including cost, manufacturing, availability and aesthetics.
Skills and training providers	[redacted]	Support understanding of strategic opportunities around local green skills development to support the widespread deployment of hydrogen.
Political	Members of Parliament, Members of Senedd	Provision of briefing, WWU role, aspirations for alignment of local, regional and national Net Zero aspirations and projects, and invitations to engage.
Other	[redacted]	Collaborative approach to trial development incorporating the Taylor Wimpey Estate.

Carefully timed and well-planned engagement and support for the breadth of the consumer base and wider community is critical to building knowledge, creating trust and gaining buy in for the trial.

Supporting consumer and wider community participation, WWU engaged specialist research organisations including HyCymru, Cynnal Cymru-Sustain Wales and the University of South Wales to understand potential collaboration and to plan development of content on consumer behavioural change which will support the delivery of HyPentref, the consumer strategy development and wider public acceptance of the need for energy transition.

Stakeholder endorsement

HyCymru "We view the project as an important, practical step in providing the platform for the rapid decarbonisation of heating in Wales and the UK…which can be subsequently scaled-up. Skills development and supply chain opportunities will be another key output of the project and how they can be scaled-up for national impact. We are particularly keen on the project's Wales base. As it can provide initial learning and embedding of economic opportunities in Wales."

Stakeholders supporting consumers

Cynnal Cymru Sustain Wales is a sustainable development charity. They wanted to be kept involved in future discussions around community co-design and pulling organisations together to help. They have experience in customer engagement around decarbonisation, are delivering carbon literacy training in Welsh communities and have an understanding of the lessons learned from the Welsh Social Housing Optimised Retrofit Programme.

Care & Repair Cymru is a Welsh Government funded charity supporting older people to live safely in their homes including making adaptations to appliances for people with specific needs. They see a collaborative multi-agency approach as critical to HyPentref's success and are keen to support. They highlighted; the importance of building trust to be able to access people's homes; effective engagement requiring multiple interactions, and the need to consider the impact of disruption on the most vulnerable.

National Energy Action (NEA) is a leading fuel poverty charity working to ensure people are warm and safe at home. They provide independent support and training for people in the energy sector. They told us that 'customers will want to understand their costs and protections post trial, and voluntary sector organisations are well placed to provide independent support to technical surveys and project evaluation.'

Strong platform for Stage Two

Stage 1 engagement has successfully built relationships, collaboration and lines of communication with key stakeholders, as a platform for stage 2 and ongoing engagement with consumers and communities.

5.2 Public engagement strategy

For HyPentref to provide learning on engagement and the conversion process to support policy decisions, it is important consumers' needs and wants are at the heart of the trial. They, alongside other community stakeholders, will help co-design stage 2 and subsequent engagement. To do this, WWU will build on initial stakeholder and consumer insight from stage 1 and experience of running a Citizens' Panel to co-design WWU services.

The tailored and inclusive public engagement strategy (PES) for stage 2 is supported by three guiding principles:

- Transparency
- Inclusivity
- Continuous Improvement

The PES starts engagement with the local community and aligns local consumer and community research, engagement and communication with national activity. It will build trust and gain evidence to develop the most inclusive and appropriate conversion process, tailoring the trial options and understanding concerns, while addressing misinformation to maximise trial acceptability, consumer uptake and learnings.

Preparation & Planning

Socio-demographic profiling of Sully has started and WWU has combined this with local stakeholder insight, site visits, community research, as well as local ambitions and challenges.

Research demonstrates concerns over the cost and disruption associated with decarbonised heating options. WWU will work with representative organisations and local groups to co-design clear and accessible information on hydrogen and other heating options, while committing that consumers will not be financially disadvantaged.

Due to HyPentref's pioneering nature, the strategy and approach will be responsive and agile to challenges arising during the trial.

Inclusivity

Some of the most vulnerable in Sully and those who support them have been identified, including:

- Priority Service Registered consumers
- [redacted]

[redacted]

The PES identifies early engagement with these stakeholders in stage 2 to understand relationships, reliance on energy use, ability to participate in the trial, what a fair consumer offering might be and where dedicated support will be required.

Understanding the needs of local consumers through meaningful and inclusive engagement allows WWU to ensure options for consumers are fair, including mitigating any impact on those already disadvantaged.

Planned methods of communication and engagement

The PES recognises that different segments of the public and community stakeholders will engage differently. WWU have developed a targeted programme to encourage active engagement and build trust, including traditional and digital materials and mechanisms. An overview can be seen at Figure 14.

Preparation of information and materials for different stakeholders will support clarity and consistency of what HyPentref is seeking to achieve. A maintained project website set up alongside offline channels will allow customers to have their say in a convenient way. Virtual engagement has accessibility and flexibility advantages, while WWU will make Welsh and other language provision alongside communication preferences such as braille, sign, audio and large print.

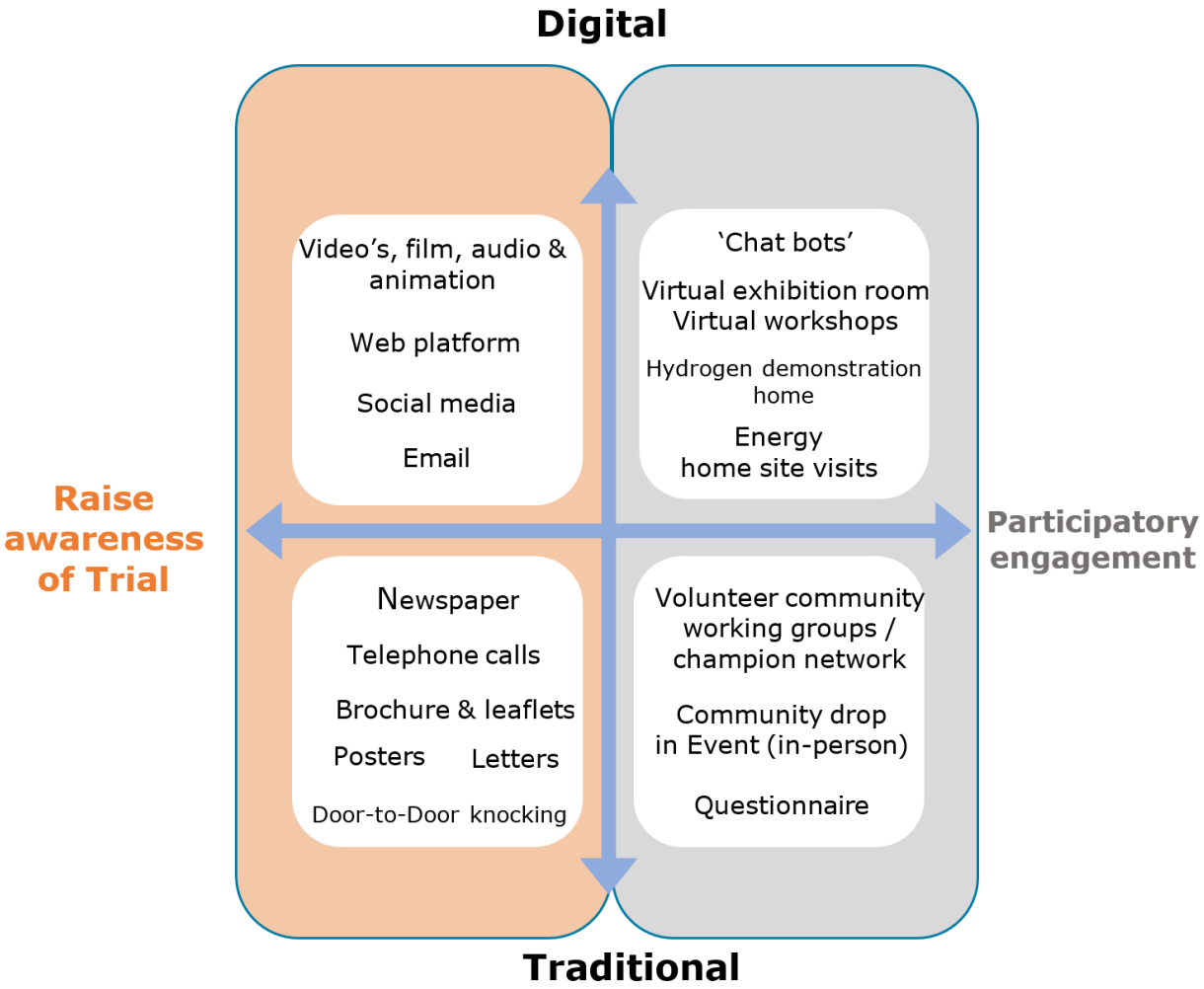


Figure 14 Stage 2 Engagement and Communication methods

With uncertainty around future Covid-19 restrictions, the PES includes both virtual engagement and in person methods, allowing meaningful engagement, irrespective of restrictions.

Phased approach & measuring success

In planning Stage 2, WWU has taken on-board feedback around the strategic approach including review by WWU's CEG to ensure it reflects best practice. This review supported the development of a fair consumer offering and consumer focussed engagement; working with the local community and stakeholders to meet needs.

To meet HyPentref's strategic objectives and key milestones, success criteria for engagement and consumer buy-in have been identified that keep communities and consumers at the heart

of the process. The BEIS Evidence Framework has been considered and key indicators within Table 12 provide a focus for engagement. Success criteria for subsequent stages are in Table 13 and are aligned to the Consumer Strategy.

Table 12 Success criteria for stage 2 Public and Consumer Engagement

Trial stage	Overarching success criteria for Public and Consumer Engagement	Key indicators	End of Stage 2 Output
Stage 2	Awareness of the trial	Regular opportunities and multiple platforms (to support inclusivity) sharing project plans for trial roll out. Progressively improved stakeholder feedback from research feedback over the course of Stage 2 (gauging public awareness and understanding). Active participation from all stakeholder categories within the trial area, including re-occurring attendance and uptake of offers to engage	Database and report providing evidence of all public and consumer engagement, how it has informed the trial's consumer offering including vulnerability register and support plans, ahead of Stage 3
	Building trust to understand the options		
	Willingness to engage & participate through building of trust		

Table 13 Success criteria for subsequent stages of Public / Consumer Engagement

Overarching success criteria for Public and Consumer Engagement	
Stage 3	Acceptance of the offer
	Confidence in the roll out
	Willingness to participate in the trial
Stage 4	Trust in delivery
	Satisfaction in hydrogen
After Trial	Advocacy of hydrogen

An extract of stage 2 Engagement and Communications, building on suggestions from Stage 1 stakeholders is in Appendix G.

Before delivery, WWU will seek additional feedback, insight, learning and buy-in to stage 2 strategy from local representatives, including:

- Political leadership of Vale of Glamorgan Council
- Local councillors and members of Sully & Lavernock Community Council
- Village groups

Awareness of the trial

Insight from research[4] highlights the importance consumers place on pre-trial communication from regulators and policymakers. WWU will work closely with these stakeholders to raise community understanding of the trial and its impact. It will also connect with existing initiatives like the South Wales Industrial Cluster, demonstrating the trial's broader role within Wales' and the UK's evolving hydrogen economy.

Building trust to understand options

Engagement activities will use appropriate methods incorporating an educational tone[4], which will be refined through further research on local demographics and communication preferences. Findings will further shape the consumer offering, inform decisions on incentives and provide consumers with an understanding of options.

Willingness to engage & participate

Engagement will encourage and facilitate active participation and leverage existing community group structures will cut through inertia. Building on Stage 1, WWU will use project supporters/representative local stakeholders from the community to work closely with the engagement team and maintain an agile programme of participatory engagement, tailored to all sections of the community.

[4] a) Joint GDN Village Trial research – Britain Thinks/Savanta – Nov/Dec 2021
b) External Communications Horizon Scan – Sirio Strategies – Nov 2021

5.3 Consumer strategy, ensuring fair treatment for all gas consumers in the trial

Summary

Consumers are at the heart of HyPentref. WWU understands the pride people take in their home and work environment and wants to make sure they have a positive experience from installation of new hydrogen appliances, making a valuable individual contribution to decarbonisation, while contributing to the evidence base supporting a national roll-out of hydrogen for heating and cooking.

HyPentref encompasses a wide range of gas customers. WWU's outline consumer strategy (0) proposes a strong narrative for this village as playing a key role building a zero-carbon future.

WWU proposes multiple engagements to make consumers, not hydrogen, the centre of the trial. Segmentation is key to understanding consumer requirements and developing the offer to give reasons to choose hydrogen. WWU will reassure consumers, guaranteeing no detriment, fair treatment, inclusivity and safeguarding consumers in vulnerable situations.

WWU's consumer strategy raises awareness, acceptance, confidence, support and advocacy for the trial, and delivers key milestones shown in Figure 15.

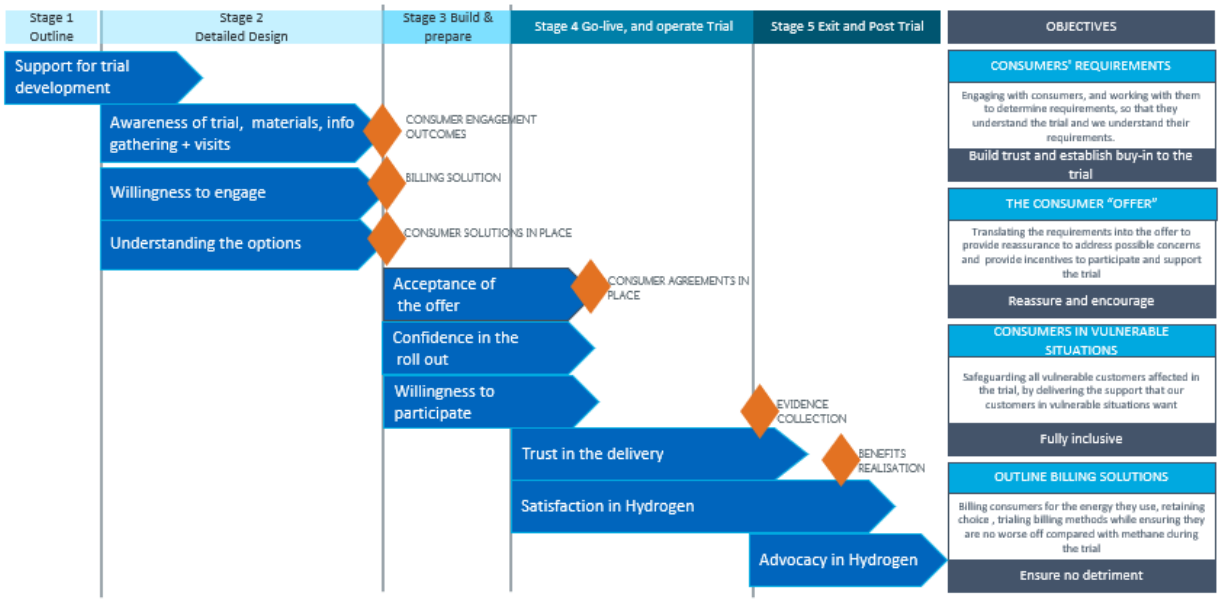


Figure 15 Consumer strategy over the five stages of HyPentref

Consumers' requirements

WWU's public engagement (section 5.2) creates opportunity for consumers to understand the trial and place consumer requirements at the heart of the planning process. Building on well-established processes for consumer engagement WWU's project plan includes creating the delivery team, and co-designing advice and materials.

The team will identify WWU core personnel, advisers, contractors, and trusted third party intermediaries to plan and deliver interactive engagements appropriate to different groups.

WWU will determine requirements through tailored engagements:

- Engaging with non-domestic consumers and determining requirements, both on an individual and on a community level
- Linking individual consumer benefits to the community and wider national context
- Multiple, diverse engagements to accurately gather consumer requirements
- Consumer qualitative research to explore requirements, the offer and build support particularly through hypothetical trial discussions with consumer focus groups

The key milestones include team setup, advice and materials, and creating a database including suggested segmentation by age band, SEG, vulnerability, appropriate Ofgem archetypes, business type, usage, attitudes, appliances, property characteristics as shown below. This will underpin the trial's evidence base.

<u>The consumer "offer"</u>

The offer must be attractive, communicate clear consumer benefits, ease of participation, comprise of several components to build trust, provide reassurance and encourage sign-up:

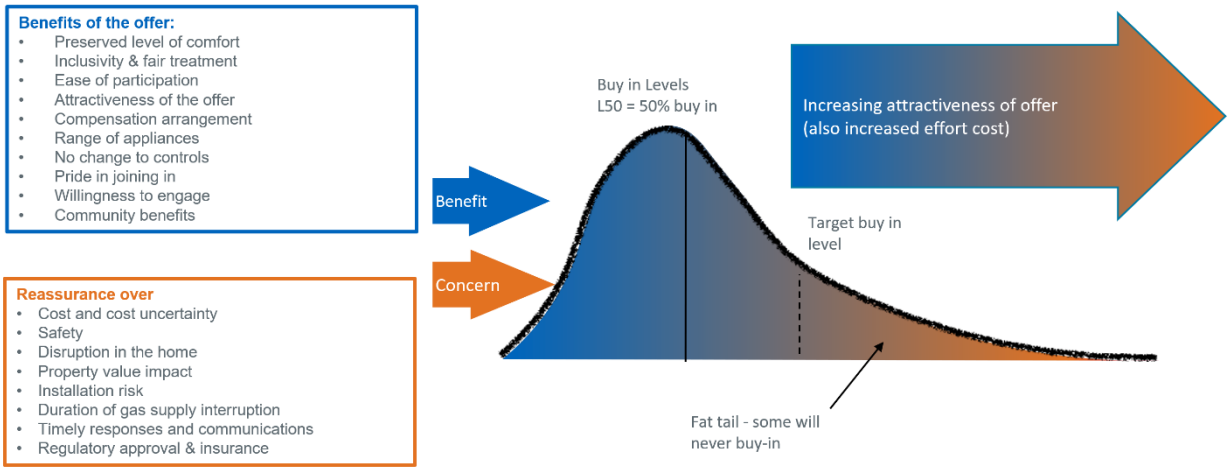


Figure 16 Components of the offer and how they affect the consumer buy in

PROPOSED OFFER: Local residents will be at the heart of HyPentref. Participating households will be amongst the first to fit new hydrogen-powered appliances for heating and cooking. These will be carefully installed and maintained at no cost to participants, with minimum disruption and no significant change at point of use. Running costs will be guaranteed for the trial period to be no more than natural gas, and WWU will maintain communication throughout the trial including on post-trial arrangements. No-one will be compelled to take part in the hydrogen trial, with alternative arrangements offered at no cost to non-participants.

Research and learning from Sully will play a significant role in the decarbonisation of UK home heating, creating a valuable legacy for the UK and future generations while taking direct action to respond to the Climate Emergency

Wording will be finalised in stage 2. Informed by segmentation and engagement, the offer process (below) considers concerns, reassurances and ancillary services (Appendix I) to establish the best match of appliances, systems and support.

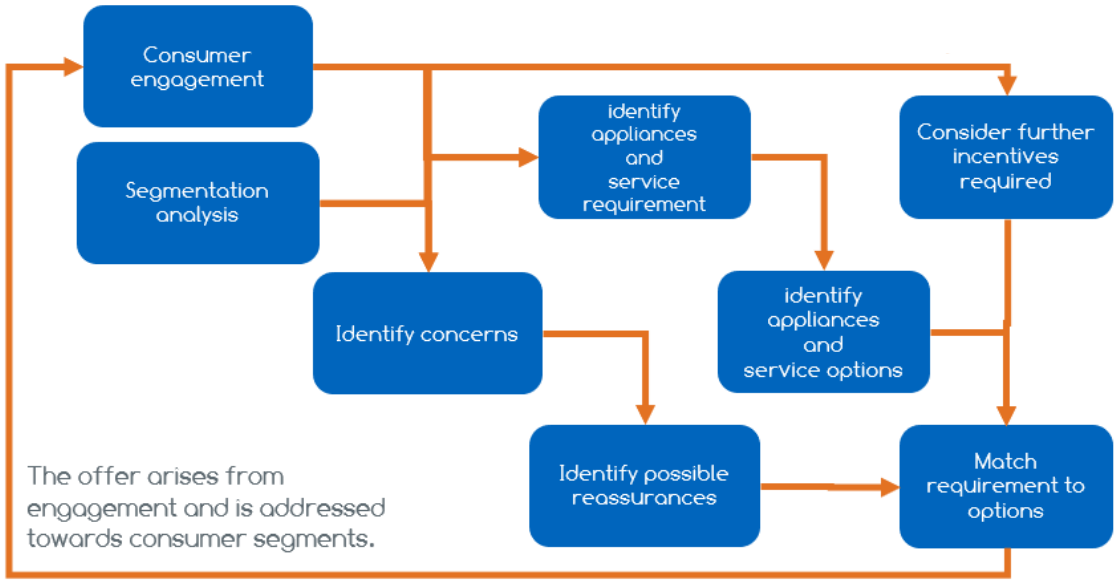


Figure 17 Offer development

While hydrogen should be the least disruptive option for existing gas consumers, fair treatment will be guaranteed for non-participants, with a range of alternatives, noting these may bring more disruption and cost. Where appropriate WWU will seek a contribution towards additional costs from available grants.

To ensure minimal end of trial disruption, WWU proposes participants keep hydrogen ready or alternative appliances. The offer allows consumers to become meaningful actors for clean air and decarbonisation.

Consumers in vulnerable situations

WWU has extensive experience supporting consumers in a wide range of vulnerable situations so the trial will be fully inclusive with enhancements to existing provisions, awareness-raising and encouraging Priority Services Register sign up.

An assessment of risks specially related to vulnerable consumers (Appendix J) includes ineffective communication, anxieties associated with change[5], physical hazards and the need for appliances and services to be 'inclusive by design'. To address risks and learn how to safeguard consumers in any national roll out, WWU will build on its experience, continuing to work with trusted third parties to reach people in vulnerable situations, identify potential hazards and effective mitigations and to reassure and reduce anxiety. WWU is leading an innovation project[6] to further develop the process. This will inform vulnerability plans.

WWU's trial proposal commits to providing backup heating, hot water, cooking, catering, alternative accommodation and communications while maintaining the emergency support required for business as usual

[5] https://wwutilities.co.uk/media/3906/engaging-with-customers-in-vulnerable-situations-a-research-guide.pdf

[6] Switching vulnerable consumers to hydrogen | ENA Innovation Portal (energynetworks.org)

WWU's planned show home will provide an accessible drop-in centre for help and advice. The trial offers opportunities to reduce fuel poverty by offering energy and income maximisation advice to customers in vulnerable situations through partner arrangements.

Outline billing solutions

Costs and the associated billing process will be important to consumers in the trial. WWU propose to build on H100 and NIC Future Billing, with WWU's key design consideration that participants, shippers and suppliers will not be (negatively) financially impacted, and that consumer billing continues with minimal disruption.

WWU propose accurate meter readings underpin billing and to ensure no financial detriment, WWU assume a support mechanism will be established, such as a CfD settled on kWh co-designed with [redacted]. The CfD value would depend on hydrogen and natural gas wholesale prices. The support mechanism will be established in stage 2 through the GDN collaborative work (Section 3.3 of Ref 2, Annex 2).

Additional costs incurred by energy supply companies will need to be accounted for and not passed onto the consumer, and so WWU will establish a project cost accounting and assurance process to support the trial as part of Stage 2.

WWU assumes that VAT differential on hydrogen will be solved, as described in section 3.3.

Overall, WWU's trial includes significant collaboration with national and UK agencies and institutions and Energy Supply companies.

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Making a positive difference for energy consumers

6. Costs and funding requirements

Costs and funding requirements are in Annex 1 to this document (Ref 1) and include stage 2 costs and Whole Life Cycle (WLC) costs. A significant proportion of the required input to the project cost is covered via collaborative GDN work undertaken separately (Ref 2, Annex 2), which will be funded by other mechanisms outside of this NZASP application.

Hydrogen supply and resilience

As outlined in Section 4, hydrogen for HyPentref will be supplied from [redacted] In order to optimise the configuration of hydrogen production facilities, a bridging study is required which will be funded separately through NIA.

The current project base case is:

- [redacted]
- [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Cost build-up methodology:

- Costs for stage 2 have been estimated from a bottom-up approach by assigned engineering and design resource to execute the project components. This is based on past experience of similar natural gas projects with the understanding of the complexity of this project.
- Key resource from across WWU as well as 3rd parties and consultants provided robustness in the cost build-up challenge
- For specific hydrogen components like SMRs, electrolysers and gas to grid technology insight was gained through project partners ([redacted] and [redacted])
- [redacted] provided an OOM CAPEX cost and associated design for a 3MW electrolyser – this was scaled for HyPentref's needs
- [redacted] provided WWU with the output of a previous feasibility study completed for a hydrogen production plant producing 2x1000kg/d of production (circa 25GWh per annum) including a gas to grid facility. They also provided further guidance on the addition of 3x1000kg/d SMR trains for peak demand.
- Typical cost accuracies for the maturity of the current design have been accounted for using a +/- of 10% for stage 2.
- Subsequent phases contain a +/- of 30% and are conservative costings
- Internal WWU cost bases for pipework, equipment have been included as well as market research and vendor engagement

Cost Estimate Review

A review of the detailed cost estimate build up was undertaken by a panel independent to the project team to provide independence on cost certainly, efficiency and assurance.

Cost Summary

Main stage 2 costs:

- Hydrogen production design (externally funded to NZASP): 67% of the total design stage costs (NZASP funding and external funding)
- Public and consumer engagement: 27% of NZASP funding
- Project management and WWU internal costs: 34% of NZASP funding (across all deliverables)
- Safety, regulatory and risk related activities: 15% of NZASP funding
- The remaining covering the engineering design for the network

7. Project deliverables

Reference	Project Deliverable	Deadline	Evidence	Funding requirements
1	Basis of Design, PEP and Full Evidence Plan	June 2022	Fully aligned project with detailed planning and firm basis - documented	3%
2	FEED Package	August 2022	Early design work to ensure optimised project – documented including design drawings	3%
3	End user requirements	Apr 2023	Detailed survey of homes including required modification work and appliances – documented	7%
4	Detailed Design package	Apr 2023	Design package ready for Prepare and Build stage	7%
5	Consumer offer and engagement report	Apr 2023	Documented report	27%
6	Detailed planning, procedures and emergency response	Apr 2023	Documented procedures	2%
7	Case for Safety	Apr 2023	Documented	15%
8	Training program	Apr 2023	Documented	2%
9	Project management and internal function (inc information dissemination)	Apr 2023	Updates and progress report Procurement strategy Cost control Contracts	34%

References

1. Annex 1 – WWU, HyPentref Cost Assurance Template, Dec 2021
2. Annex 2 – ENA, Annex – Collaborative Supporting Evidence, Dec 2021
3. Annex 3 – WWU, HyPentref Project Risk Register, Dec 2021
4. BEIS, Trials Evidence Framework v3, June 2021