FutureGrid

Gas Transmission

# FutureGrid

## Role of Gas in the UK

### Gas Demand in the UK today:

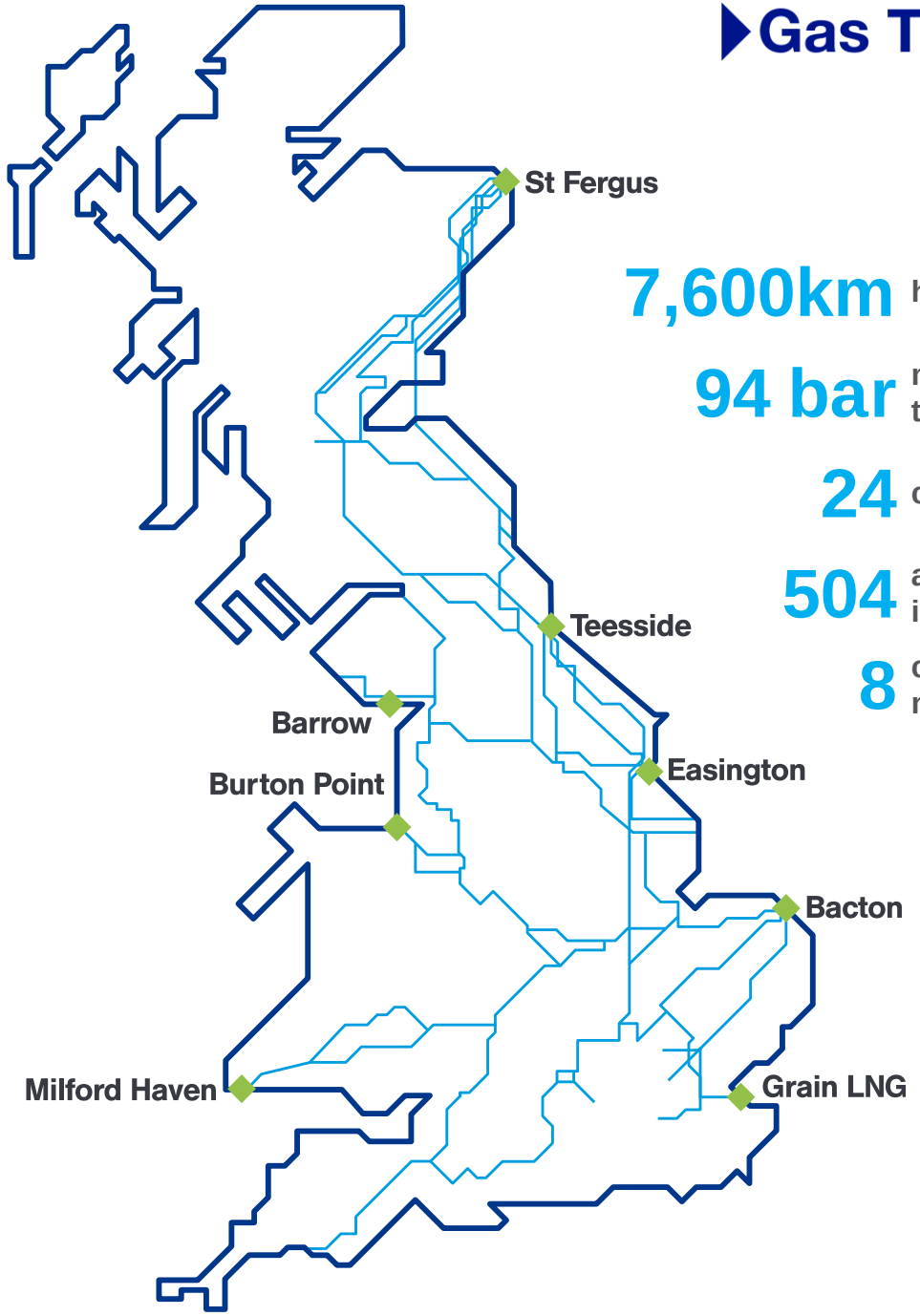
**23m**
gas customers across the UK

**85%**
households are using gas for heat

**881TWh**
of energy is delivered by the NTS

| | |
|---|---|
| 39% | Power Generation |
| 38% | Domestic Use |
| 23% | Industrial & Commercial |

## Gas Transmission




**7,600km** high-pressure pipe

**94 bar** maximum pressure on the network

**24** compressor stations

**504** above-ground installations

**8** connected distribution networks

FutureGrid

Gas Transmission

# Common Goals for the UK & EU

| | UK | EU |
|---|---|---|
| Green House Gas Emissions | **1990 – 2019**<br>800 → 435 million tonnes per year | **1990 – 2017**<br>5 700 → 4 500 million tonnes per year |
| Ambition | **Net Zero by 2050**<br>UK target | **First carbon neutral continent by 2050**<br>EU target |
| Faster Decarbonisation | **37% generation**<br>in 2019 was renewable energy | **50/55% renewable energy target**<br>for 2030 under discussion |
| Key Focus | **Industrial decarbonisation**<br>Followed by transport and heat with a whole systems approach across gas and electricity (with energy efficiency as a core principle) | **Energy efficiency first principle**<br>Focus on electrification (40 – 50 %) with role & benefits of the green gas & green fuels confirmed (SOS, cost-effectiveness, flexibility) |
| Hydrogen | **Clean hydrogen (blue / green)**<br>Starting now & gradually building up from local clusters to a hydrogen backbone, open and competitive hydrogen market (cross border, open access, unbundling principles) | |

FutureGrid

Gas Transmission

# Collaborating to develop our hydrogen knowledge

## Materials considerations

**Pipelines and mechanical assets eg:**
- Hydrogen embrittlement
- Seals & soft parts
- Weld quality

## Safety developments

**Risk assessment and new safety case development including:**
- Hazardous areas
- Electrical equipment
- Plant operations

## Flow characteristics

**How will hydrogen move around our network?**
- Gas velocity
- Pressure drop
- Saltation

## Compression

**What will need to change in our compressor strategy?**
- Turbine compatibility
- Gas compressibility
- Investment cycles

## Network management

**How do we ensure we can maintain security of supply?**
- Storage capacity
- Network inputs
- Deblending

FutureGrid

Gas Transmission

# Transitioning to Hydrogen – Key Steps

**Transitioning to hydrogen requires alignment across production, transmission and demand:**

## Production

**What are the location, timing and volume of production sources?**

Blue hydrogen
Green hydrogen
Natural gas
Imports / exports
Increased interaction with electricity

**Where will storage be available? Intraday and intra-seasonal**

## Transmission

**There are a number of technical considerations:**

Readiness of assets
Conversion vs new build
100% hydrogen or blend
Incremental or pipe by pipe conversion

**Impacts of hydrogen on system operation?**

## Demand

**What are the demand locations, timing and volumes as sectors decline, convert and emerge?**

Power
Heat
Industry
Transport
Increased interaction with electricity

**Market readiness e.g. $H_2$ boilers?**

FutureGrid

Gas Transmission

# Building a Collaborative Pathway to a Greener Future

## Gas National Transmission System (NTS):

**£6.3bn**
value of the existing assets

**7660km**
high pressure pipelines

NTS carries **3/4** of GB energy today

## Collaboration has been key to developing our hydrogen capabilities:

GAS GOES GREEN

Department for Business, Energy & Industrial Strategy

ena energynetworks association

nationalgrid

Northern Gas Networks

Cadent Your Gas Network

SGN Your gas. Our network.

WALES&WEST UTILITIES

**Industry Collaboration – HPDG & Gas Goes Green**

nationalgrid

snam

fluxys

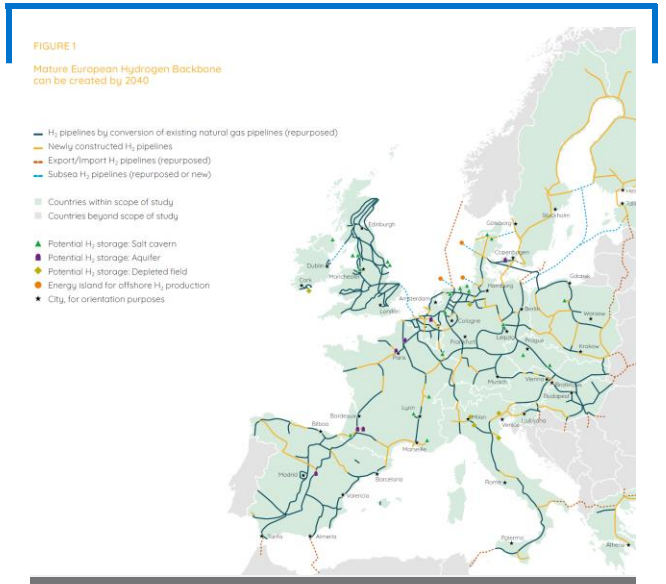
GRTgaz

OGE

gasunie

enagas

**Hydrogen Leader of the TSOs – collaborating with H2GAR**



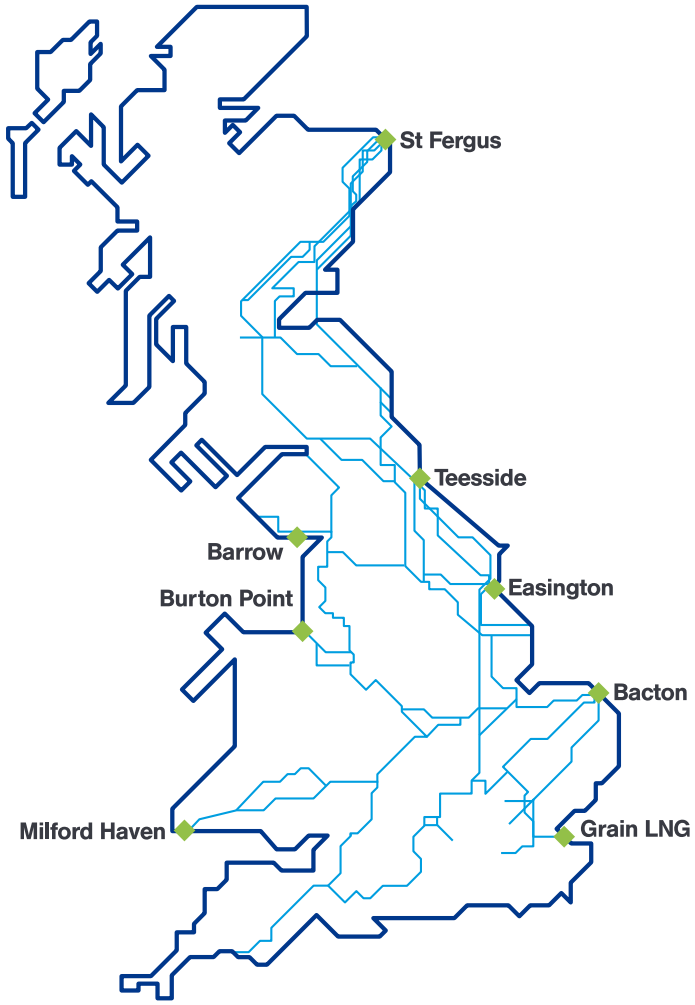

**Developing a European Hydrogen Backbone**

**NTS Pathway to a Net Zero Future**

# FutureGrid

Gas Transmission

## Building a Hydrogen NTS




## Projects Underway in 2021:

### FutureGrid

An ambitious programme to build a hydrogen test facility from decommissioned assets at DNV's facility in Cumbria to demonstrate the National Transmission System (NTS) can transport hydrogen. Testing 2, 20 & 100% hydrogen and developing our hydrogen safety case.

### Project Union

Exploring the development of a UK hydrogen 'backbone', which aims to join together industrial clusters around the UK, potentially creating a 2000km hydrogen network. It's anticipated that the backbone could carry at least a quarter of the gas demand in GB today.

### acorn Hydrogen

This development is preceded by the Acorn CCS Project, which will provide the route to permanently sequester CO2 emissions generated from reformation of natural gas into hydrogen, aiming to blend up to 2% hydrogen into the NTS from 2025.

### East Coast Hydrogen

Working with NGN and Cadent to develop the UK's Hydrogen Network and simultaneously decarbonise a large proportion of the UK's homes and industry. ECH2 includes the entire NGN region, the Cadent Eastern region and a proportion of the NTS.

## Projects in Development:

### Project Centrum

Hydrogen production to unlock the decarbonisation of the Midlands. Concept project identified that Theddlethorpe and Bacton could play a key role in the build out of 'second phase' hydrogen. Strategy project to be launched once Union is underway.

### FutureGrid Phase 2

Expansion of the Phase 1 facility to incorporate Hydrogen Deblending and Compression, H2GO Power Fuel Cells and build demonstrations for ongoing GDN projects such as Cadent's Purification and SGN's LTS Futures projects.

# FutureGrid

Gas Transmission

## Hydrogen – Delivering Net Zero for Gas Transmission

### Our Net Zero Ambition:

**Net Zero 2050**

**Decarbonisation of Gas**

Drive Decarbonisation for:

- Industry
- Heat
- Power
- Transport

### Industry Wide Collaboration

**Government & Regulatory**

Department for Business, Energy & Industrial Strategy; ofgem; HSE Health & Safety Executive

**UK Gas Industry**

ena energynetworks association; GAS GOES GREEN; IGEM

**UK Gas Networks**

Cadent Your Gas Network; Northern Gas Networks; SGN; WALES&WEST UTILITIES

**International Collaboration**

FUTURE FUELS; GERG; PRCI; EPRG

**H2GAR Hydrogen Gas Asset Readiness**

fluxys; enagas; gasunie; snam; GRTgaz; OGE

### Strong Portfolio of Projects

**Key Projects**

FutureGrid; Project Union

**Regional Projects**

Project Centrum; East Coast Hydrogen; acorn Hydrogen

**SIF & NIA**

H2 Eye; HyNTS Compression; EPRG; PRCI; CH4RGE; LEVIDIAN Graphene; H2GO Storage; HyNTS Deblending; CATAPULT 5G Digital; HyNTS Digital Twin

**Academia**

Durham University; University of Edinburgh; University of Chester; Cardiff University; Prifysgol Caerdydd; Cranfield University; WMG University of Warwick; University of Surrey; University of Bristol; University of Cambridge; Newcastle University; Strathclyde University; Imperial College London; Teesside University; Loughborough University

# FutureGrid

An ambitious programme to build a hydrogen test facility from decommissioned assets at DNV's facility in Cumbria to demonstrate the National Transmission System (NTS) can transport hydrogen.

Gas Transmission

DNV HSE Northern Gas Networks

fluxys Durham University The University of Edinburgh

FutureGrid

Gas Transmission

# Key Focus of FutureGrid

## NTS Safety Case

Risk assessment and new safety case development

## Materials Considerations

Pipelines and mechanical assets considering hydrogen embrittlement and welds

## Flow Characteristics

Understanding how hydrogen will move around our network

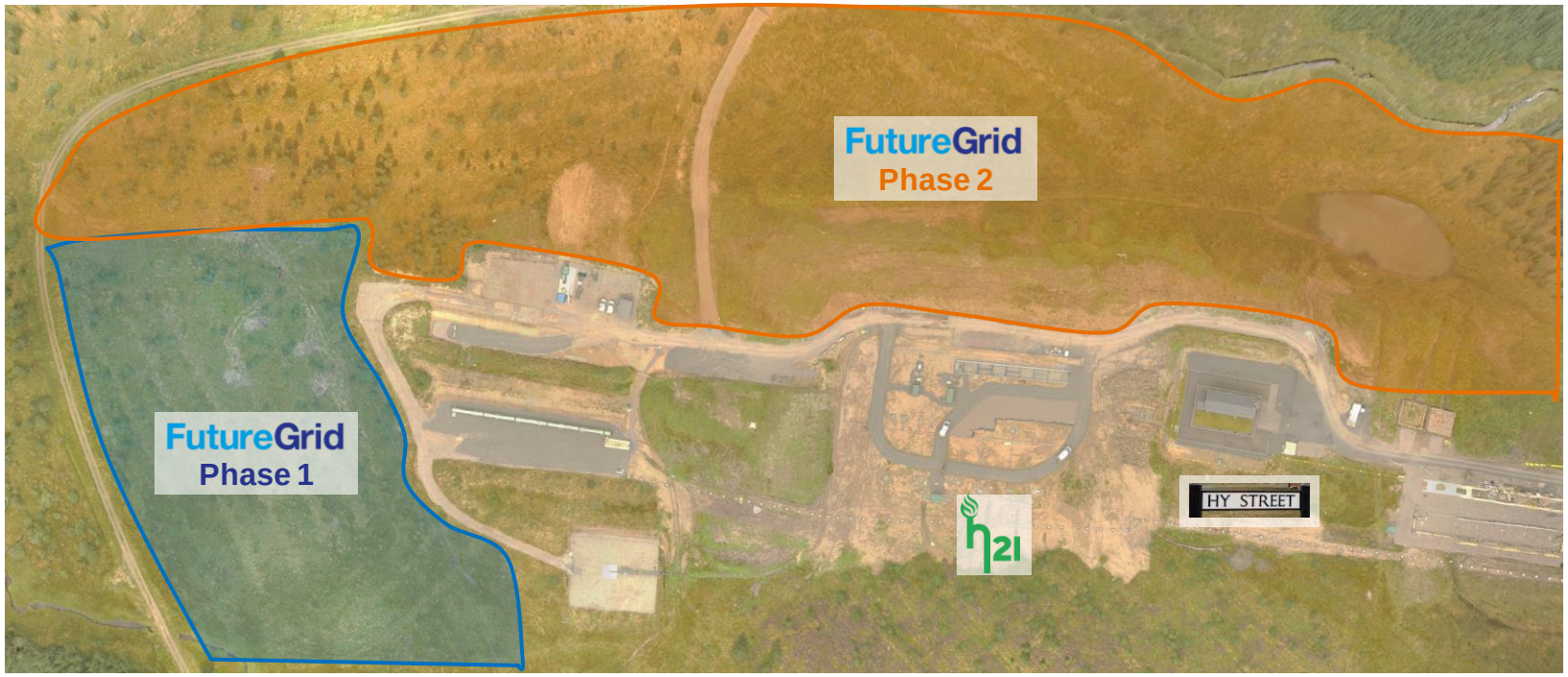
## Network Management

Understanding how we can manage a hydrogen network

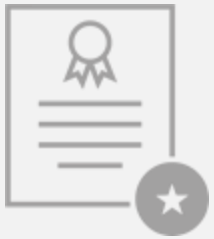
# FutureGrid

Gas Transmission

## Collaborative Hydrogen Test Facility




**Represent the NTS**



**Follow Relevant Standards**

**Platform for Further Innovation**

**Future Expansion & Development**

DNV are our main delivery partner, responsible for building the test facility and developing the comprehensive master test plan across the range of decommissioned assets.

HSE Science Division are supporting the development of the test facility and subsequent master test plan, providing technical assurance and validation across the project.

Northern Gas Networks are collaborating on the project to drive closer links with the H21 project which is building a distribution test facility at DNV GL's Spadeadam Facility.

Fluxys are the equivalent Gas Transmission Operator in Belgium and are contributing a substantial level of hydrogen research, to ensure a internationally collaborative approach.

Durham University will be sponsoring a secondment student to study the NTS asset gaps, focusing on the development skills and training courses along with Phase 2 & 3 of FutureGrid.

Supporting the trials and developing technical papers and research from the project to enable dissemination, linking the H100 activities and FutureGrid/H21 activity to prevent duplication.

# FutureGrid
## Phase 1 Overview

Gas Transmission

**Total Project Cost**
**£12.7m**

**Project Duration**
**2 years**

### Work Package 1A
**Build & Commission**

**Starts:** July 2021
**Completes:** November 2022

### Work Package 1B
**2, 20 & 100% Hydrogen Testing**

**Starts:** December 2022
**Completes:** June 2023

### Work Package 1C
**QRA & Safety Case**

**Starts:** July 2021
**Completes:** August 2023

### Work Package 1D
**Dissemination & Reporting**

**Starts:** July 2021
**Completes:** August 2023

**FutureGrid Phase 1 Delivery & Phase 2 Development**

FutureGrid

Gas Transmission

# Key Focus of FutureGrid

## NTS Safety Case

Risk assessment and new safety case development

## Materials Considerations

Pipelines and mechanical assets considering hydrogen embrittlement and welds

## Flow Characteristics

Understanding how hydrogen will move around our network

## Network Management

Understanding how we can manage a hydrogen network

FutureGrid

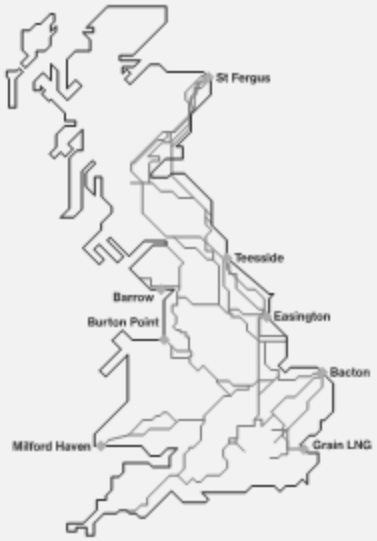
Work Package

# 1A Build & Commission

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 1.0 | Phase 1a – Groundworks & Construction | Construction of the FutureGrid Test Facility at Spadeadam site with the production of the following as evidence:<br>1. As built drawings<br>2. Written scheme of examination<br>3. DNV GL report of build activity & lessons learnt |
| | Deadline: November 2022 | |

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 2.0 | Phase 1a - Testing & Commissioning | 1. Successful completion of testing and commissioning processes with supporting documentation<br>2. Dissemination of facility design and layout to allow detailed development of Phase 2 & 3 interactions |
| | Deadline: December 2022 | |

# Fundamental Principles of the Facility




## Represent the NTS

Utilise decommissioned assets to create an offline test facility that is representative of how the NTS operates. This will ensure results are a true reflection of how hydrogen would impact our assets.

## Follow Relevant Standards

The facility will be built to all relevant standards to ensure safe operation. Where standards may differ to the standards NG uses on the NTS we will ensure we consider these throughout testing.

## Platform for Further Innovation

The facility provides an excellent opportunity for further innovation trials and development. By utilising the facility we can deliver additional innovation projects far more efficiently and maximise outputs.

## Future Expansion & Development

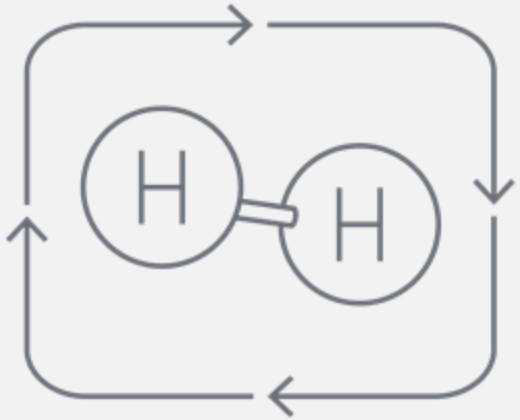
There is significant potential to expand the facility to incorporate a wider range of asset trials. We are focused on futureproofing the facility to allow future collaborative work with GDNs & global partners.

# FutureGrid

Work Package 1A **Build & Commission** | Work Package 1B | Work Package 1C | Work Package 1D

**Gas Transmission**

## Test Facility Set Up

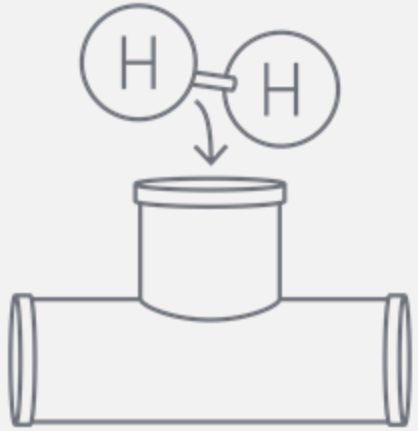



### Offline Hydrogen Test Facility

**A representative range of NTS assets of different types, sizes, and material grades are being supplied from decommissioned assets to build the hydrogen test facility.**

The facility will initially run on 100% natural gas to collect baseline data for the equipment and then move through 2%, 10% and 20% hydrogen / natural gas mixtures and then 100% hydrogen.

The facility will have a maximum flow of 1.76 MSm3/day generated by the use of a gas compressor.




### Standalone Hydrogen Test Modules

**Standalone hydrogen test modules will operate alongside the main test facility, to provide key data required to feed into the main facility including:**

(1) Material Permeation Testing

(2) Pipe Coating & CP Testing

(3) Fatigue Testing

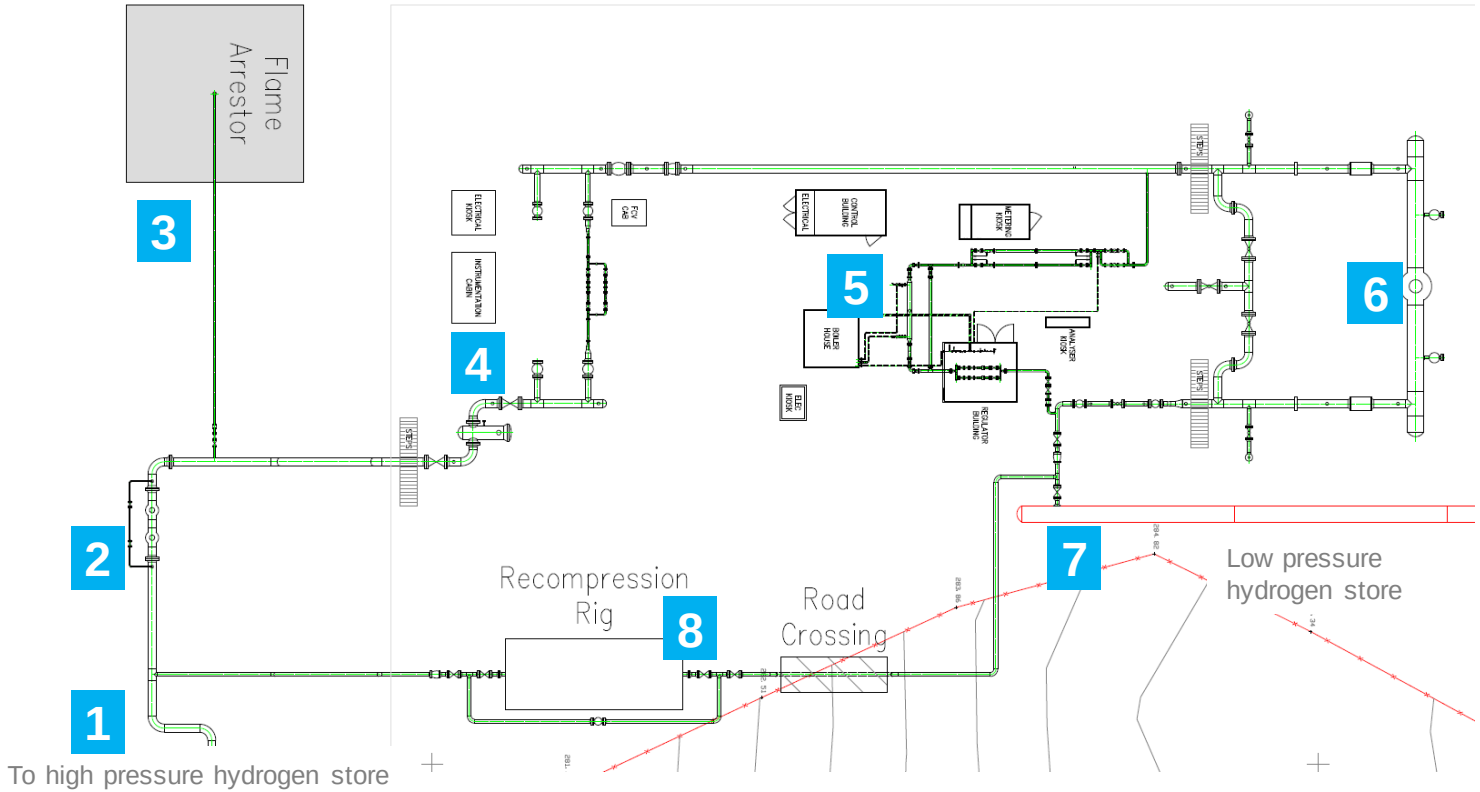
(4) Flange Testing

(5) Asset Leak Testing

(6) Rupture Testing

**FutureGrid Phase 1 Delivery & Phase 2 Development**

# Offline Hydrogen Test Facility




## Key Instrumentation:

- Metering
- Pressure
- Temperature
- Noise
- $H_2$ Flux
- Vibration

## Mechanical Assets:

**Steel Pipeline**
Pipe grades X52, X60, X65
Welds
Bends, tees, flanges

**Filters & Meter Stream**
Orifice Plate Meters
Ultrasonic Meters

**Recompression Unit**
Generate flows of facility

**Valves**
Ball Valves
Plug Valves

**Flow Control Valves**

**Pre-Heater & Regulators**
Pre-Heating at up to 20% blend
Pressure Reduction Equipment

FutureGrid

Work Package

# 1B 2, 20 & 100% Hydrogen Testing

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 3.0 | Phase 1b – Testing 2%-20% hydrogen | 1. Completion of 2% H2 tests identified by the master testing plan inc. launch and close out events<br>2. Completion of 20% H2 tests identified by the master testing plan inc. launch and close out events<br>3. Identification of future test requirements as a result of the findings – test plan evidence<br>4. Results collated, documented and validated for impact on next phases of hydrogen development activities |
| | Deadline: May 2023 | |

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 4.0 | Phase 1b – Testing 100% hydrogen | 1. Completion of 100% H2 tests identified by the master testing plan inc. launch and close out events<br>2. Identification of future test requirements as a result of the findings – test plan evidence<br>3. Results collated, documented and validated for impact on next phases of hydrogen development activities |
| | Deadline: August 2023 | |

# FutureGrid

Work Package 1A | Work Package 1B: 2, 20 & 100% Hydrogen Testing | Work Package 1C | Work Package 1D

Gas Transmission

## Hydrogen Testing Plan

### Three concentrations of hydrogen will be tested:

**2%**
hydrogen in natural gas

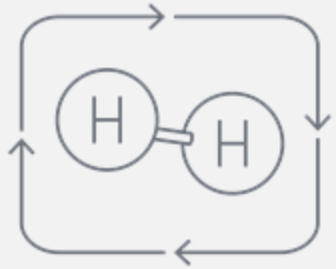
**20%**
hydrogen in natural gas

**100%**
hydrogen

**Operate the offline test facility for 7 months across the 3 $H_2$ concentrations with the standalone test modules running throughout the 2 year period.**

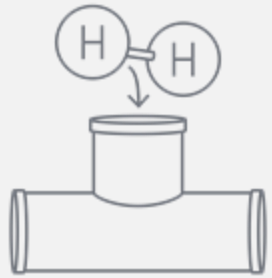
**Review and evaluate the test results utilising the Fluxys Fast Screening Methodology allowing for the extrapolation of results across the NTS.**

**Validate flow parameters such as gas velocities, pressures, energy delivery to understand how we need to operate the NTS with a hydrogen blend (or 100%).**




### Offline Hydrogen Test Facility

A representative range of decommissioned NTS assets of different types, sizes, and material grades will be tested with 2, 20 & 100% hydrogen




### Standalone Hydrogen Test Modules

Standalone hydrogen test modules will operate alongside the main test facility, to provide key data required to feed into the main facility

FutureGrid

Work Package 1A | Work Package 1B: 2, 20 & 100% Hydrogen Testing | Work Package 1C | Work Package 1D

Gas Transmission

# Standalone Hydrogen Test Modules

## Material Permeation Testing

This test will determine the rate at which hydrogen permeates through the pipe wall in a pressurised hydrogen environment. This will inform the soak time required for full saturation on other tests.

## Pipe Coating and CP Testing

These tests will assess the impact of hydrogen on external pipe coatings as well as the cathodic protection system to identify any issues.

## Fatigue Testing

To demonstrate the NTS can endure tens of thousands of pressure cycles in hydrogen service.

## Flange Testing

To assess the effect of hydrogen on RF and RTJ flanged joints.

## Asset Leak Testing

Hydrogen is significantly more prone to leaking than natural gas. We need to understand the extent of this to determine if additional mitigations are required.

## Rupture Testing

Investigate overpressures caused by delayed ignition of ruptures on a buried line containing 100% hydrogen. 36” NB gas storage array to provide the necessary gas flow.

FutureGrid

Work Package

# 1C QRA & Safety Case

**Ref**
**5.0**

**Project Deliverable**
**Phase 1c –QRA & Safety Case**

**Deadline**
**August 2023**

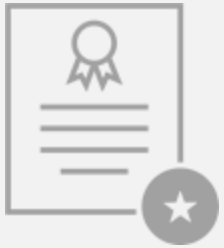
**Evidence:**

1. Overpressure testing on secondary off-line NTS test facility – test report
2. Validation of results into existing QRA model and any mitigations reviewed – updated QRA and mitigation log
3. High level review of NGGT's procedures and standards documented
4. Prepare a commented version of the safety case
5. Updated asset assessment and hydrogen risk review

# Safety and Risk Management

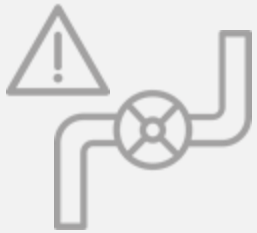
There is a fundamental difference between how natural gas and hydrogen behaves. We must be able to understand the impacts of different concentrations of hydrogen and develop our safety standards:

## Procedure Review



Categorisation of NG procedures as high, medium, low impact with a report detailing the methodology findings and next steps for each.

## Hazard Assessment of the Transmission System (HATS)



Assess impact of hydrogen on MAPD. Provide an updated HATS for the NTS pipelines, based on the network transporting hydrogen instead of Natural Gas.

## Quantitative Risk Assessment (QRA)

Record and update the Hazard Assessment Methodology Manual (HAMM) where deviations are required for assets transporting Hydrogen.

## Hazardous Area Impact

Hazardous Area Drawings will be produced for each asset type at 20% & 100% hydrogen and compared to existing Natural Gas drawings.
IGEM also working on SR/25 update for hydrogen.

## Overpressure Risk (OR)

Identify whether the existing methodology can be adapted for 100% hydrogen. If needed, develop an appropriate methodology for risk analysis and emergency planning purposes.

## NGGT Safety Case

Assess and update the NGGT safety case (policies, procedures and work instructions) depending on the impact of hydrogen. Review will involve SMEs.

FutureGrid

Work Package

# 1D Dissemination & Reporting

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 6.0 | Knowledge dissemination | 1. As per section 5 'Dissemination' of this submission the team will provide a variety of dissemination activities throughout the period of the project which will be completed as per Appendix H stakeholder engagement plan at regular intervals during the project lifecycle and on closure |
| | **Deadline** August 2023 | |

| Ref | Project Deliverable | Evidence: |
|---|---|---|
| 7.0 | Comply with knowledge transfer of the governance document | 1. Annual Project Progress Reports which comply with the requirements of the Governance Document<br>2. Complete Close Down Report which complies with the requirements of the Governance Document<br>3. Evidence of attendance and participation in the Annual conference as described in the Governance Document |
| | **Deadline** August 2023 | |

# Our Engagement Principles


**Digital first approach –** Livestreaming all events with a physical presence where possible.

**Stakeholder led engagement plan –** building our plans to suit how you want to engage with **FutureGrid.**

**Mixed media approach –** using a range of channels to ensure there's something for everyone.

**We want your input –** gives us your ideas on how we can help you to get the most out of the project.

# Key Engagement Points

## Project Milestones

Events to launch the project, showcase the build and update on the testing programme

## Creating Event Opportunities


Such as the UK / EU event and other collaborative opportunities to showcase FutureGrid & partners

## Industry Events

Energy Networks Innovation Conference, Utility Week and other key Hydrogen / Net Zero Events

## Site Tours

Tours for internal promotion and key external stakeholder engagement and promotion

## SME Development & Knowledge

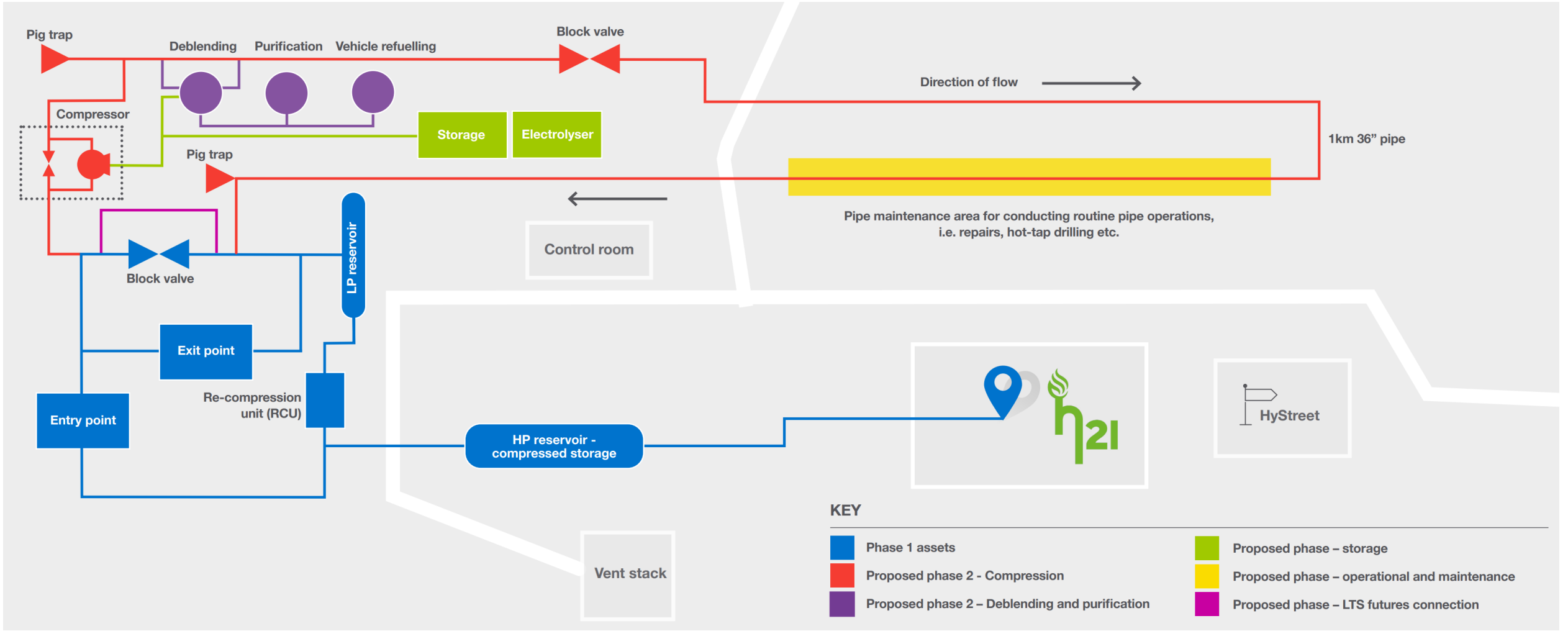
Active programme of activities and workshop / events to engage and update the SMEs (Subject Matter Experts)

## Public Perception & Education

Public facing events and opportunities to educate and promote hydrogen – supporting local events

# FutureGrid — Phase 2 Expansion Potential – SIF Applications

Gas Transmission




## Key SIF Applications

### HyNTS Compression

This project investigates the key challenges associated with compression of hydrogen using existing national transmission system (NTS) assets. This project will also provide the capability for critical operations such as In-Line Inspection (ILI) to be tested at FutureGrid.

### HyNTS Deblending & Purification

This project aims to provide an offline demonstration of gas separation or 'deblending' technology on a gas network scale. The project aims to develop a skid mounted, mobile solution to demonstrate hydrogen fuelling from the NTS for the future transport network.

## Additional SIF's

### Fuel cell gas analyser & data analytics

This project aims to demonstrate a fuel cell gas analyser for blends of hydrogen and natural gas for up to 100% hydrogen in the NTS.

### Hydrogen metering

This project will explore options for gas metering equipment for use with hydrogen. There will be scope for demonstration of new technology potentially at FutureGrid.

### HyNTS pipeline data set

This project will aim to obtain information on the current condition of pipelines for the transition to hydrogen to determine suitability of pipelines for repurposing.

### Hydrogen barrier coatings for gas network assets

This project looks into the potential for deployment of hydrogen barrier coatings via electrodeposition onto the internal surface of a pipelines and other assets.

# thank you!

**You can find out more information and contact us across our media channels:**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nationalgrid.com/FutureGrid


Innovation at National Grid




@NationalGridUK