UNC 0849R:

Hydrogen Blending: Commercial framework review and amendments

Review Group Four

Wednesday 4th October

Agenda

10:00 – 10:05 Welcome and agenda
10:05 – 10:30 Pressure, Temperature Correction & Compressibility Factor
10:30 – 11:00 Review Actions and Issues Tracker
11:00 – 11:05 Review Assumptions
11:05 – 11:15 Break
11:15 – 12:30 Connections Methodology and Capacity Allocation Discussion
12:30 – 13:00 Lunch Break
13:00 – 13:55 Connections- legislative/framework changes
13:55 – 14:00 AOB, Next Steps

Assumptions and Parameters

There are still some unknown certainties for hydrogen blending which will be answered through separate pieces of work, therefore, to ensure deliverability of this project, a number of assumptions have been defined:

- As the Government are currently set to make a decision in principle for blending into the Distribution Networks by the end of 2023, with a decision for Transmission likely to follow, we assume that changes to GS(M)R for Dx will be implemented before Tx. Having different GS(M)R specifications across networks will therefore need to be considered within this Review Group.
- Both In-network (commingling facility owned by Gas Transporter) and pre-blend (commingling facility owned by Delivery Facility Operator) connections will be considered within this work
- Hydrogen will be available to blend
- Blending hydrogen onto gas networks may be used for the role of "reserve offtaker"; therefore variability in hydrogen volumes to be injected needs to be considered.
- This project will consider onshore networks regulatory frameworks as well as Interconnectors, however we assume that there won't be any direct changes to EID section of UNC as its currently set out. – Megan to review this
- Other projects will be concluding on framework principles (e.g. the "Connections and Capacity Methodology project" and the "Functional Specification project")
- Assume all existing market players and their roles will be included in blending development
- All GB Industrial, Commercial and Domestic users will be assumed to be customers of Hydrogen blend as well as Independent Gas Transporters
- This project is just considering the commercial amendments required, not physical arrangements
- We assume within the project that low levels of blending (C.5%) won't impact physical capability of the networks (due to higher volumes vs energy)

Assumptions and Parameters

The aim of this project is to enable the first roll out of hydrogen blend injections in a timely and efficient manner whereby no amendments to Primary legislation (Gas Act 1986) and Secondary legislation (GCOTER) is required. To achieve this, the below parameters for the first phase of blend connections have been suggested:

- Within this report we assume that GS(M)R will be updated following a HSE safety review in order to accept volumes of up to 20% hydrogen into the networks.

- This project aspires to implement H2 blending by 2025 with least change to existing market framework as possible, it therefore assumes that A CV target will be calculated by the DNO based on a forecast FWACV for the Gas Day and will require to be met at the natural gas/hydrogen gas blend point. The following parameters (a) not exceeding the proposed 20% volume cap in the Transporter's pipe(s) (b) the available volume of natural gas in the pipe at the hydrogen connection point to blend hydrogen with and (c) the CV of the natural gas to be blended with, will influence the prevailing rate of injection of 100% hydrogen by the hydrogen producer across the gas day. These parameters will ensure compliance with GS(M)R (20% volume parameter) and provide data to mitigate against CV Capping (natural gas CV and natural gas flow rate).

- The Connections and Capacity Methodology project will be reviewing suitable connection roll out models that remain in-line with the Gas Act 1986. These models will then be considered within this work.

Do we agree with these assumptions and parameters?
Are there any additional considerations?

Actions and Issues List

Issues and Actions Tracker 0849R (002) (version 1).xlsx

Errors in volume conversion when NG-H_2 blends are conveyed

Presentation to UNC Workgroup 0849R, 4th October 2023

Dave Lander

davelanderconsulting

Overview

- The need for volume conversion
- The volume conversion factor(s) in the G(COTE) regulations
- Errors arising from conveyance of blends
- Summary

The need for volume conversion

- Gas is traded in terms of energy:
  - the product of the quantity of gas and the energy per unit quantity
  - quantity of gas is usually expressed as volume at agreed reference (or base) conditions
    - temperature of 15°C
    - pressure of 1.01325 bar
    - the real gas (non-ideality effects at higher pressure)
- Meters measure the actual volume at ambient conditions, not reference conditions
  - temperatures and pressures vary throughout the day and year
  - need to convert from actual volumes to volumes at reference conditions
  - Volume Conversion Factor is required

Volume Conversion Factor

- Volume conversion factor must take account of
  - ambient temperature
  - ambient pressure
  - the non-ideality of the gas
- How this is done varies, depending on the installation
  - low-pressure, domestic and small commercial meters use a fixed factor of 1.02264, which assumes
    - constant ambient temperature of 12.2°C
    - constant pressure of 1.01325 bar
    - the gas is ideal ($Z_b/Z = 1$)
  - large commercial meters (>732,000 kWh/y)
    - constant temperature conversion factor "T" of 1.0098 (12.2°C)
    - pressure conversion factor "P" (corrects for altitude)
    - compressibility conversion factor "Z" (corrects for non-ideality)
      - "Z" = 1 for pressures below 2 barg
      - "Z" = 0.9978/(1-0.00000226M)

$$V_b = V \times \frac{T_b}{T} \times \frac{P}{P_b} \times \frac{Z_b}{Z}$$

$$V_b = V \times 1.02264$$

$$V_b = \times \text{"}T\text{"} \times \text{"}P\text{"} \times \text{"}Z\text{"}$$

Volume Conversion Factor

- Volume conversion factor must take account of
  - ambient temperature
  - ambient pressure
  - the non-ideality of the gas
- How this is done varies, depending on the installation
  - large, high-pressure installations correct fully for changing temperature, pressure and non-ideality of the gas
  - intermediate-pressure installations correct for changing temperature, pressure and partially correct for non-ideality of the gas
    - IGEM/GM/5 gives guidance on selecting volume convertors

$$V_b = V \times \frac{T_b}{T} \times \frac{P}{P_b} \times \frac{Z_b}{Z}$$

$$V_b = V \times \frac{T_b}{T} \times \frac{P}{P_b} \times \left[\frac{Z_b}{Z}\right]$$

Errors in volume conversion: low-pressure domestic and small commercial

- error in assuming $Z_b/Z = 1$ (21 mbar, 12.2°C)

	Natural gas	20% H_2 blend
Bacton	0.0111%	0.0113%
St Fergus	0.0098%	0.0114%

- (error = measured-true, so -ve error under-estimates volume, favouring consumer)
- changing the 1.02644 factor in the Gas(COTE)R isn't likely to be cost-effective
- these errors are dwarfed by the error in assumptions of the fixed factor regarding temperature and pressure
  - consistent with previous study carried out for Ofgem in 2014* for natural gases

**D.F. Lander "Gas energy measurement in consumer billing" DLC/0059 July 2014*

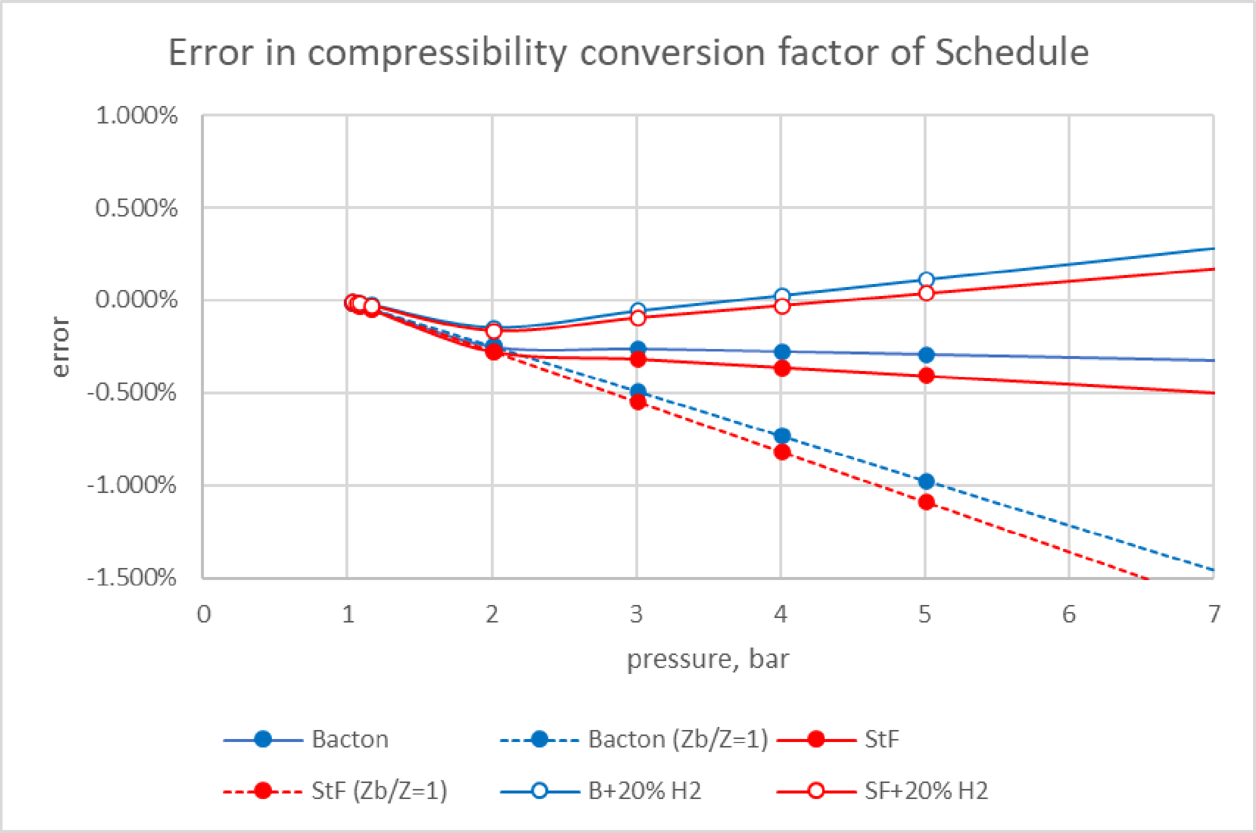
Errors in volume conversion: large commercial

- error in temperature conversion factor unchanged for blend
- error in pressure conversion factor unchanged for blend
- error in compressibility conversion factor of Schedule of Gas(COTE)R

	Bacton	St Fergus	Bacton + 20% H_2	St Fergus + 20% H_2	
75 mbarg	-0.026%	-0.029%	-0.016%	-0.018%	*
1 barg	-0.250%	-0.279%	-0.149%	-0.167%	*
2 barg	-0.259%	-0.317%	-0.059%	-0.096%	
3 barg	-0.275%	-0.362%	+0.025%	-0.031%	
4 barg	-0.291%	-0.408%	+0.109%	+0.035%	
7 barg	-0.340%	-0.547%	+0.368%	+0.238%	

- compressibility conversion factor contains NG errors to no more than ca. -0.3% at 7 barg
- with blends the error is reduced, but at higher pressures contains to no more than ca. +0.3%
- probably leave Schedule unchanged

The complicated explanation…



Errors in volume conversion: high-pressure large industrial

- live calculation of volume conversion factor using flow computer and gas chromatograph
  - upgrade of gas chromatograph to account for hydrogen
  - no significant error (existing equations of state within flow computers are adequate

Errors in volume conversion: intermediate-pressure installations

- typical installations use electronic volume conversion devices
  - correct for temperature and pressure
  - assume a fixed natural gas composition
- IGEM/GM/5 offers guidance over selection and when to use them
- inappropriate choice of the fixed natural gas composition can be as important as correcting for hydrogen content
  - with an appropriate natural gas composition, live correction for hydrogen may reduce error in Z_b/Z
  - with a sub-optimal natural gas composition, live correction for hydrogen content may worsen error in Z_b/Z
- guidance in IGEM/GM/5 needs updating

Summary

- Domestic, small commercial, low-pressure installations
  - no change in fixed factor suggested
- large commercial installations
  - probably no change in Schedule suggested
- Large, high-pressure installations
  - upgrade of gas chromatograph required to account for hydrogen in blend
- Intermediate-pressure installations are less straightforward
  - guidance in IGEM/GM/5 for volume conversion devices needs updating

- Caveat
  - volume conversion considerations only
  - blends have lower calorific value, so volume flowrates are higher – small impact on meter accuracy

Connections Methodology

Assumptions and Parameters

national gas transmission

Hydrogen injection (blend)

- There are both similarities and differences with biomethane, both raise issues of location and capacity rights

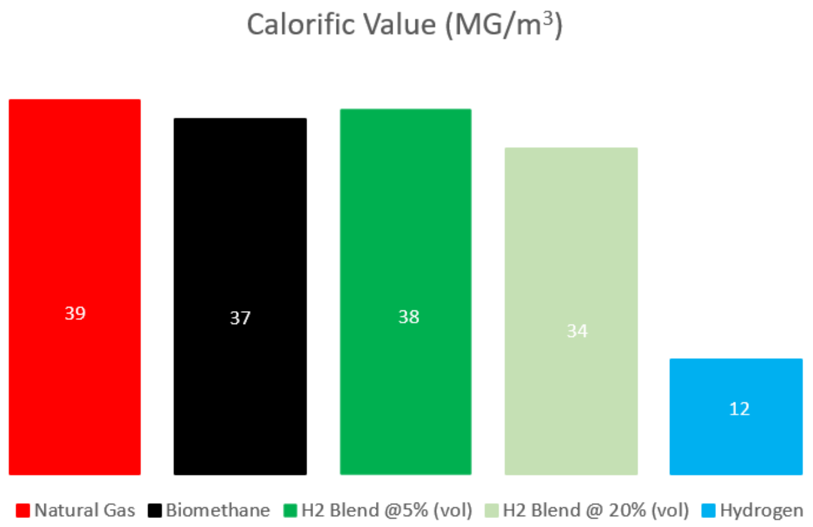
- Biomethane connectees are allowed **to request a connection anywhere;** but there may be prevailing or future limits on the physical capacity available that mean the capacity requested cannot be accommodated (Standard Special Condition D12 requires DNs to offer connectees “Terms that offer the applicant up to the maximum flow rate available from time to time on the pipe-line system”, that is no guarantee of capacity rights)

- On the NTS, Biomethane connectees are also allowed to request a connection anywhere. A desktop capacity assessment is completed as part of the connection application checks and the connectee would be required to book capacity via their Shipper in order to flow gas.

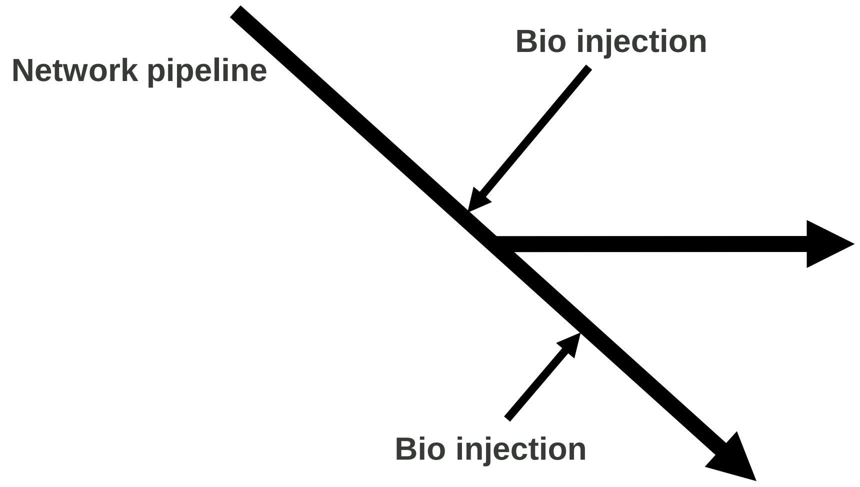
- We are minded to continue this approach for hydrogen because of requirements in D12 but are interested in industry views as to whether a more strategic approach would be worth pursuing and whether the differences between hydrogen and biomethane justify different approaches

The Calorific Value Challenge

- The key issue for hydrogen blending is CV and its impact on settlement and billing where it results in CV capping to 1MJ above the lowest input CV. The figure shows ball-park CVs for the gas network
- The CV of biomethane can be increased to avoid CV capping of this magnitude through the addition of propane or a blending agreement. In both cases biomethane sites have to meet a target CV to prevent CV capping.
- A new biomethane injection site entering into the same network but higher up the system will be allowed if there is enough physical capacity but they have to meet the target CV to avoid CV Capping and subsequently CV shrinkage. There could be an impact on the blending efficiency for the downstream site but propanation would still be an option
- Hydrogen CV is much lower than biomethane and we assume blending with propane to meet target CVs would be uneconomical for hydrogen sites
- To avoid CV Capping and CV shrinkage this means that there is an effective cap on the amount of hydrogen that can be injected into a natural gas network under current thermal energy regulations and UNC Shrinkage rules, in the region of 5% hydrogen content of the gas in the pipe at the entry point.

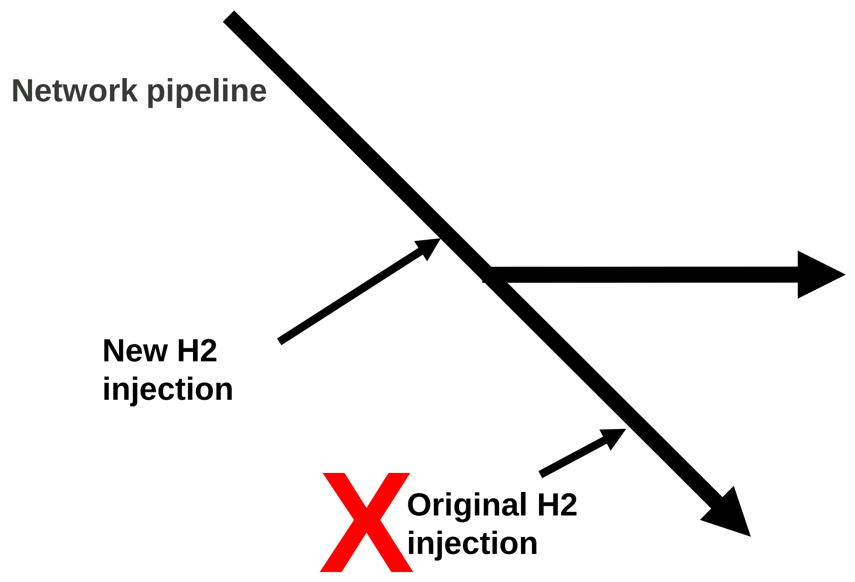


Example 1 – Current arrangements, Biomethane Connections



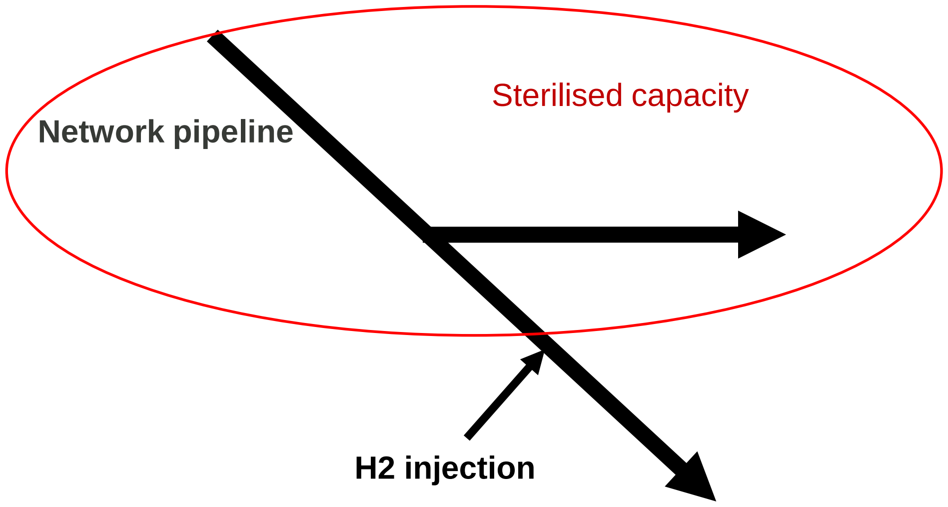
- Biomethane injection allowed subject to:
  - sufficient physical capacity
  - a Network Entry Agreement allowing for CV management to meet target CV.
- Propanation or blending both deemed viable options for meeting target CVs

Example 2 – Hydrogen blending without protection



- New Hydrogen injection allowed subject to:
  - sufficient physical network pipeline capacity
  - a Network Entry Agreement allowing for CV management
  - Not breaching the 20% hydrogen volume cap (GSMR).
  - Not triggering CV Capping (likely to result in no more than 5% hydrogen by volume content in network pipeline).
- In this case gas downstream of the New H2 injection site is likely to be saturated with 5% hydrogen blend and blending cannot then be supported at the original site
- Propanation is not deemed viable for the original site as described previously

Example 2 – Hydrogen blending with protection



- Hydrogen injection allowed subject to:
  - sufficient physical network pipeline capacity
  - a Network Entry Agreement allowing for CV management
  - Not breaching the 20% hydrogen volume cap (GSMR).
  - Not triggering CV Capping (likely to result in no more than 5% hydrogen volume content in network pipeline).
  - No impact on downstream blending at sites already accepted / connected
- In this case the hydrogen blend in gas reaching injection points would need to be agreed and protected
- No upstream connections on the network would be accepted that would result in gas exceeding this blend
- This could result in significant sterilisation of upstream capacity

Free Market vs Strategic blending connection:

1. **Free Market:**

Benefits:

- Continue using existing connection arrangements (4B methodology) for Distribution and the same market frameworks for Transmission.
- Maximises the potential geographical extent of blending

Risks:

- Sterilisation of upstream capacity, including ability to accept blend volumes from Europe
- Prevents maximisation of hydrogen blending volumes – due to the risk that hydrogen injection plants lower down the system would constrain upstream connections
- Increases the need for deblending deployment to manage gas quality

2. **Strategic:**

Benefits:

- ‘Controlling mind’ to maximise hydrogen blend volumes, based upon pre-determined locations and capacity for blending
- Potentially lower infrastructure costs for higher volume injection rates.
- More homogeneous blend rates
- May allow better coordination and management of blend between IGTs, DNOs, Transmission and Interconnectors

Risks:

- Require development of bespoke blending capacity allocation, pricing and location requirements
- H2 production plant located far away from strategic locations

Summary

DESNZ consultation Hydrogen blending into GB gas distribution networks responses due 27th October
[Hydrogen blending into GB gas distribution networks - GOV.UK (www.gov.uk)]

	Capacity rights on connection`	No capacity rights
Location - free market	Sterilisation of upstream capacity	Risk that Hydrogen injection plants lower down the system cannot inject
Location – strategic (network directed)	DESNZ not minded to pursue this approach	

Note a network can only control connections on its network so a DN has no influence on the amount of blended gas coming from the NTS or indirectly through interconnectors.

Next steps for hydrogen injection

DESNZ consultation

- Encourage parties to respond to consultation

Location

- Does industry agree that continuing with a **free-market approach** Networks will not prohibit where connections take place, however prevailing pipeline gas quality (hydrogen content) would effectively limit downstream hydrogen injection rates.

Capacity rights

- Agree a methodology on how to **assign capacity**.

- Industry **consultation**.

- Networks will propose changes to their **Connection Charging Methodology** (4B Statement).

- Ofgem have the power to veto proposed changes.

Hydrogen Blending: Connections (Strategic Market)

Primary Legislation	**Gas Act 1986: Section 9** "Obligation to offer connections if it is economical to do so and avoid any undue preference or discrimination"	**No change** *(in the case of strategic connections, it can be said that it is "uneconomical" to offer a connection in the situations whereby that does not support the strategic ambition*
Regulations	**Gas Safety (Management) Regulations 1996** **The Gas (Calculation of Thermal Energy) Regulations 1996**	**No change**
Licence	**Gas Transporter Standard Condition 4B: Connection Charging Methodology** Charging the connectee the cost of supplying and laying the pipe **Gas Transporter Licence: Standard Special Condition D12** Requirement to offer terms for the provision of gas entry points	**4B Additional:** rules around pre-connection coordination and planning between NTS and DN's to identify strategic locations. **GTL SSC D12 Amend:** Non-absolute condition; inclusion of situations when terms are not offered for a gas entry point in the Strategic Connection scenario. Require commitment from Producer for the connection materialising. Greater requirement for gas networks to share information (ECPG) GT Licence exemption required for pre-blending connection?
Code (UNC)	**Section A: System Classification** **Section V: General** Framework for new connections / modifications (application process, types of connection offer, timescales to offer / accept, application fees)	**Addition:** **Section A:** Definition of a hydrogen entry point as a subset of System Entry Point **Section V:** UNC provision for greater coordination between networks when connecting blend entry point through identification and publication of 'strategic locations' **Amend:** Timescales around providing a connection offer may need to be amended, particularly in the Strategic Connection scenario.
Agreements	**Network Entry Agreement** **Network Exit Agreement** **Delivery Agreement** **Transportation Agreement**	**Amend NEA:** Reference to "Natural Gas" Additional obligation for network operator to notify of expected Natural Gas flows (to enable DFO to know how much can be blended)

Hydrogen Blending: Connections (Free Market)

Primary Legislation	**Gas Act 1986: Section 9** “Obligation to offer connections if it is economical to do so and avoid any undue preference or discrimination”	**No change** *(H2 producers free to connect anywhere on a first come, first serve basis but may be limited injection rates where pipeline has reached blend cap/sterilised)*
Regulations	**Gas Safety (Management) Regulations 1996** **The Gas (Calculation of Thermal Energy) Regulations 1996**	**No change**
Licence	**Gas Transporter Standard Condition 4B: Connection Charging Methodology** Charging the connectee the cost of supplying and laying the pipe **Gas Transporter Licence: Standard Special Condition D12** Requirement to offer terms for the provision of gas entry points	**4B Additional:** rules around pre-connection coordination and planning between NTS and DN’s to manage capacity allocation. **GTL SSC D12: No change** Require commitment from Producer for the connection materialising. Greater requirement for gas networks to share information (ECPG) GT Licence exemption required for pre-blending connection?
Code (UNC)	**Section A: System Classification** **Section V: General** Framework for new connections / modifications (application process, types of connection offer, timescales to offer / accept, application fees)	**Addition:** **Section A:** Definition of a hydrogen entry point as a subset of System Entry Point **Section V: General Amend:** Timescales around providing a connection offer may need to be amended.
Agreements	**Network Entry Agreement** **Network Exit Agreement** **Delivery Agreement** **Transportation Agreement**	**Amend NEA:** Reference to “Natural Gas” Additional obligation for network operator to notify of expected Natural Gas flows (to enable DFO to know how much can be blended)

Thank you

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Appendices

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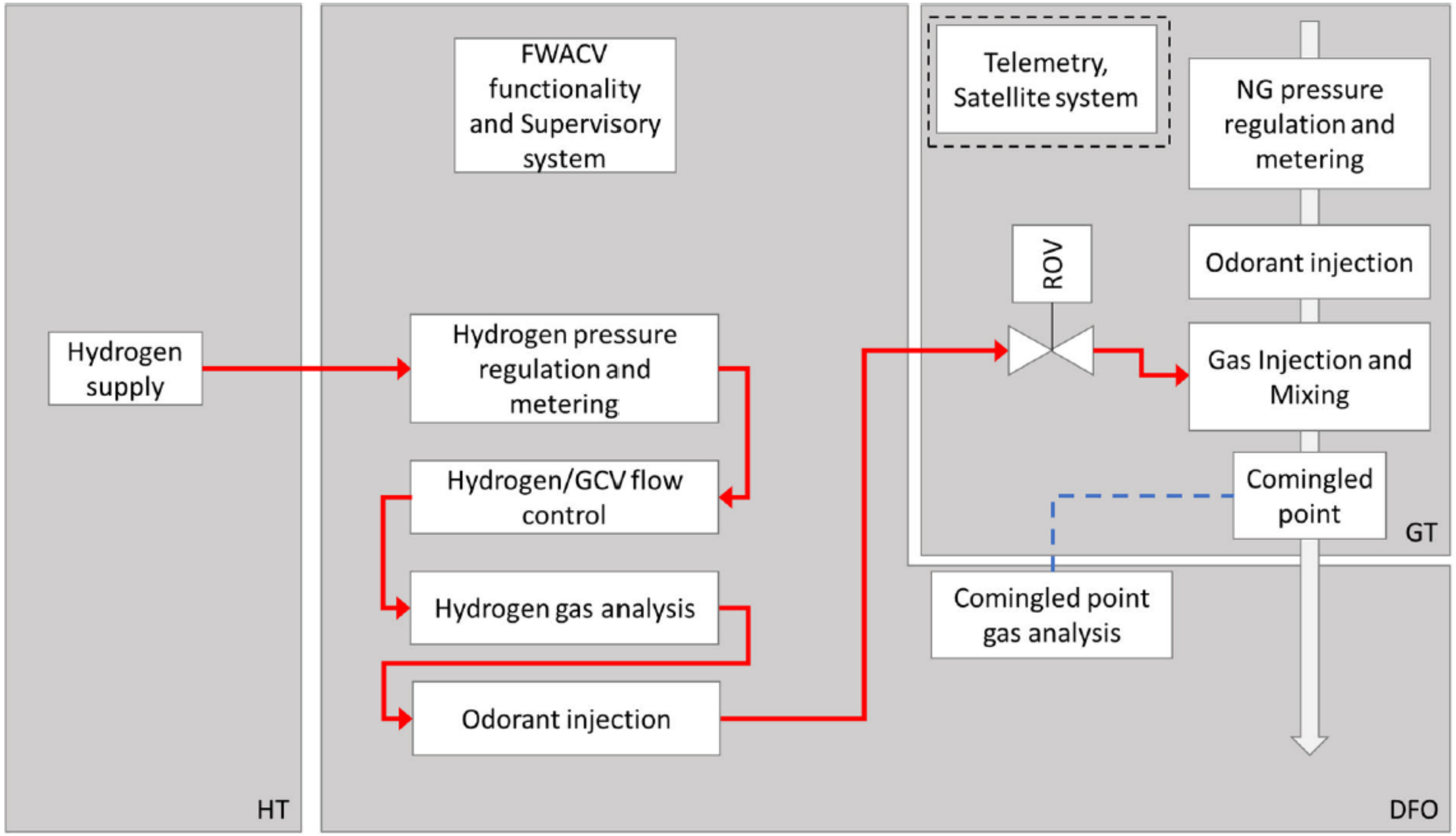
Key Outcomes – Functional Specification

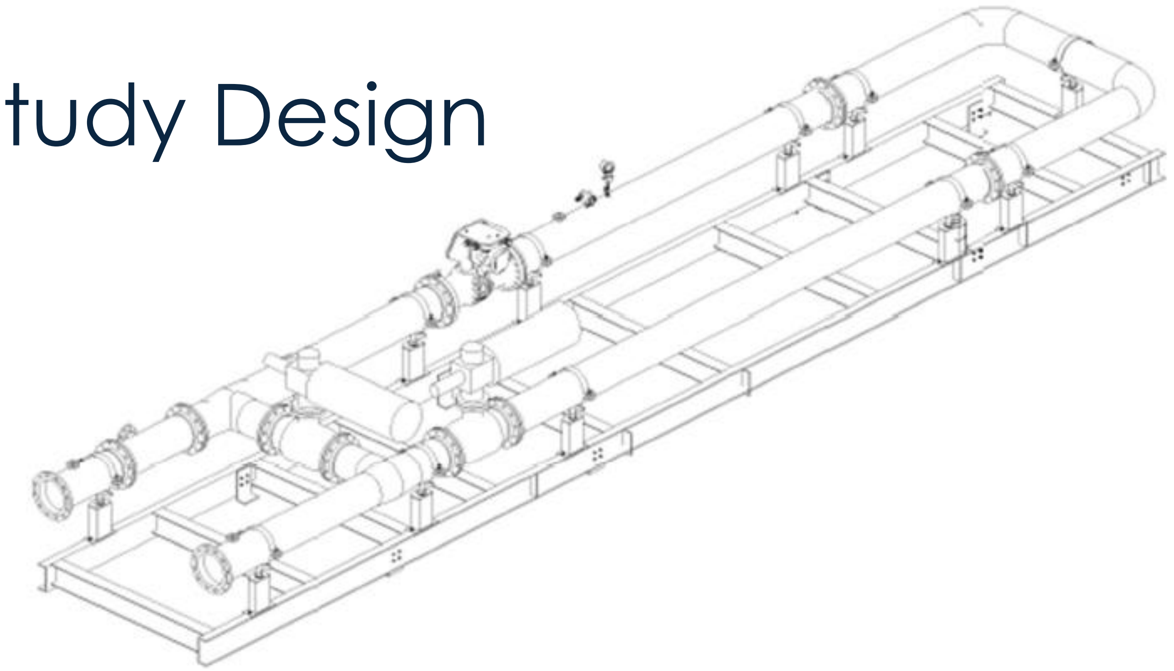
- **GSMR** - A maximum hydrogen content (assume 20%vol.)
- **GCoTER** - Control on a target CV (same as biomethane
- Co-mingling point for GSMR and FWACV compliance
- Direct or Indirect Odorisation

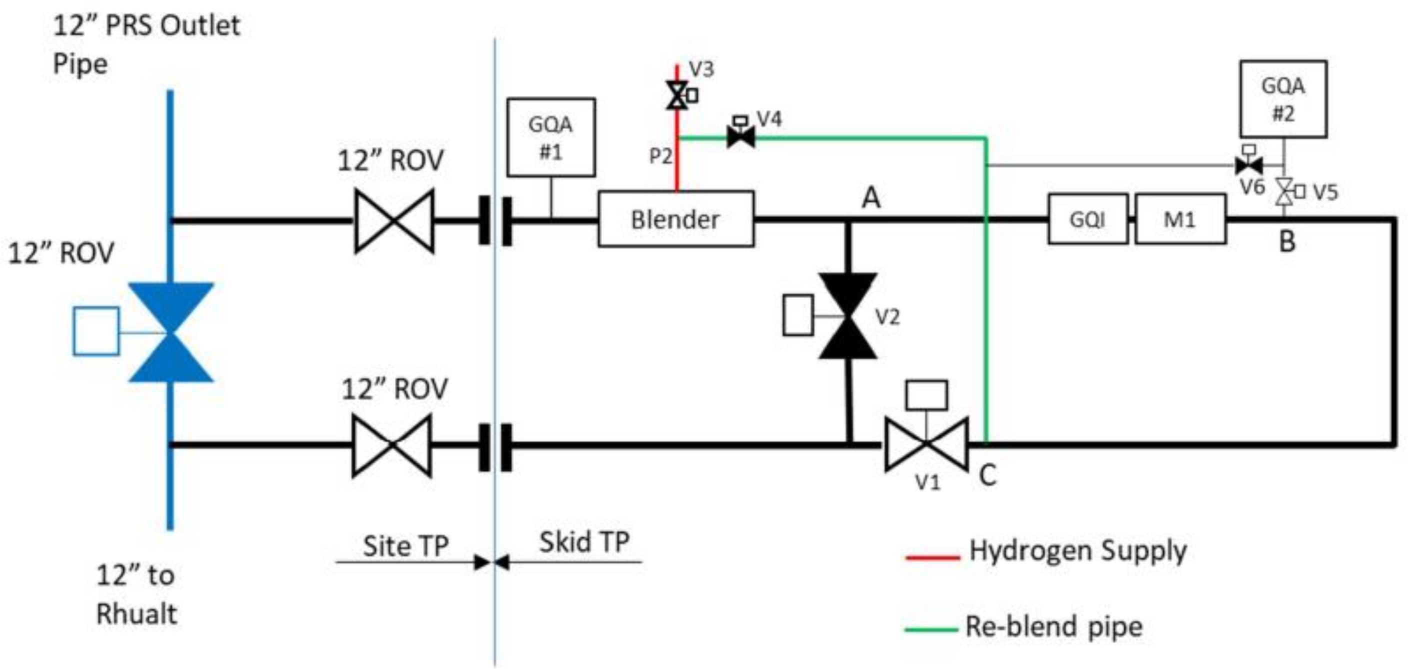
Figure 1: Asset ownership under Model 1 (“Minimum Connection”)



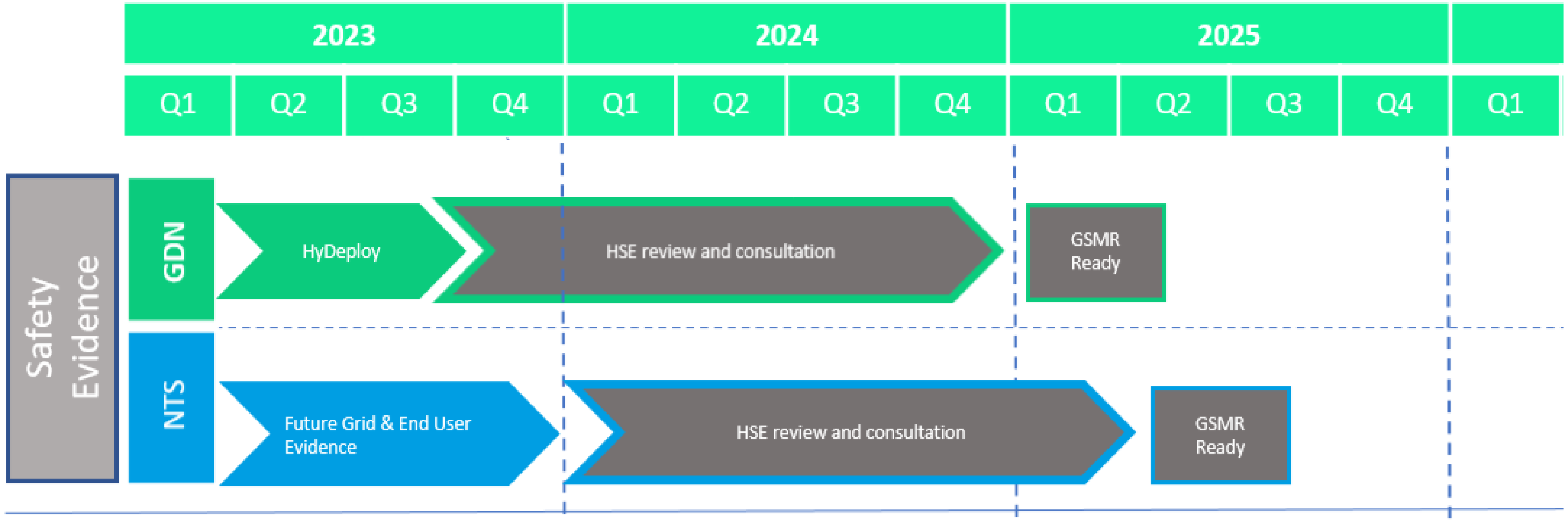
Key Outcomes – Case Study Design

- A compact purpose-built blending facility loop could be built for mixing off the current network
- Ownership of the loop needs consideration
- Software upgrades required (at exiting sites)
- Ofgem Approval of H2 inclusive Calorific Value Determination Device
- Indicative cost of injection skid £1-4m





Expected Policy Timelines



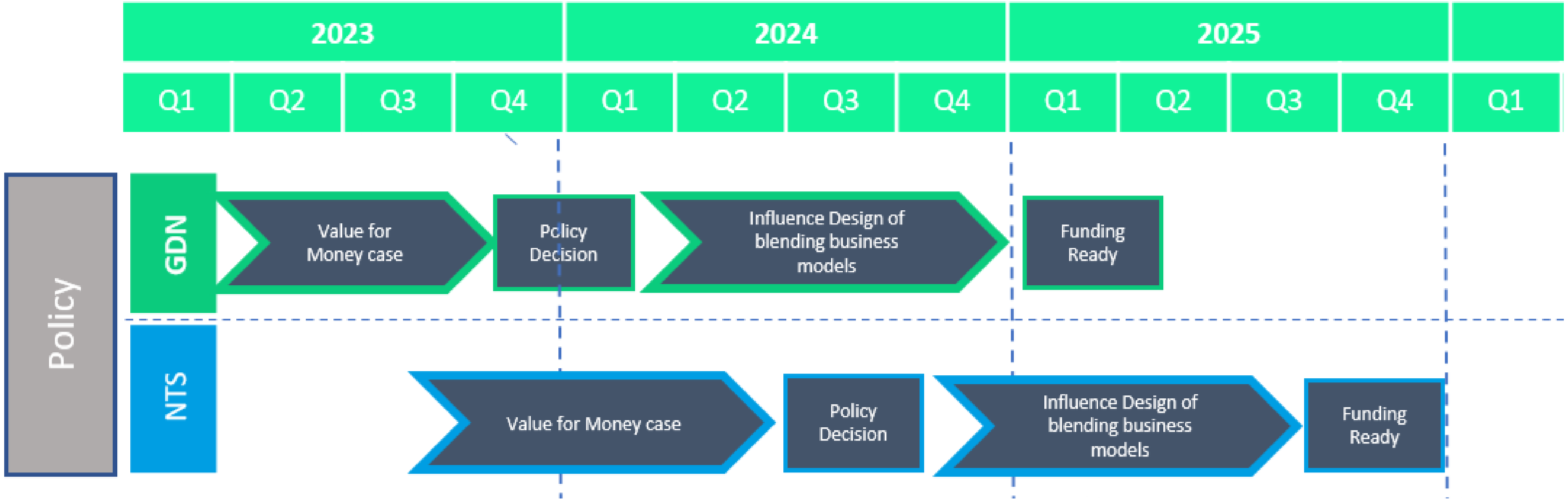
HyDeploy

FutureGrid

Keele University (100 homes & 30 Uni buildings. 18 month trial)
Winlaton (668 homes, 1 school. 10 months)
Tested- network infrastructure/ pipes and home appliances.
Safety data evidence due to be submitted in 2023.

Decommissioned asset test facility located in Cumbria.
Tests for 2%, 10% & 20% blends begin in 2023. Safety data due to be submitted by the end of the year.

Expected Policy Timelines



For the Distribution Networks, the Government have confirmed that a policy decision in principle will be made at the end of 2023. Development into the design of blending business models will then begin whilst the HSE conduct their safety evidence review. The Distribution Networks are therefore aiming to be GS(M)R ready by 2025, with first initial blend injections connecting throughout the year.

Timelines for the NTS is still unclear as this is dependant on the on-going work at Future Grid and the work reviewing impacts to Industrial end users, however current assumption is that this will follow shortly after Distribution.

EU Blending Strategy

Harmonised Rules

The Commission introduced a 5% blending mandate at interconnection points (article 20).
Parliament and the Council proposed to delete this article but agreed on common rules for gas quality for blended volumes comprises between 0 and 3 %, while leaving Member States the decision to apply H2 blending or not.
In the revised article 19, the Council proposes to apply harmonised rules at IPs for hydrogen blends up to **2%.**

Article 52 of the Regulation
The European Commission's initial proposal wanted the Network Codes and guidelines for gas and hydrogen in the EU to "*apply to all interconnection points within the Union and entry points from and exit points to third countries*".
The Parliament is supporting the Commission's proposal.
The Council has proposed to delete this reference to third countries.
The initial proposal of the Commission would means that we would need to comply with EU Network Code and guidelines, should we want to send gas/hydrogen to the EU.

Interconnectors

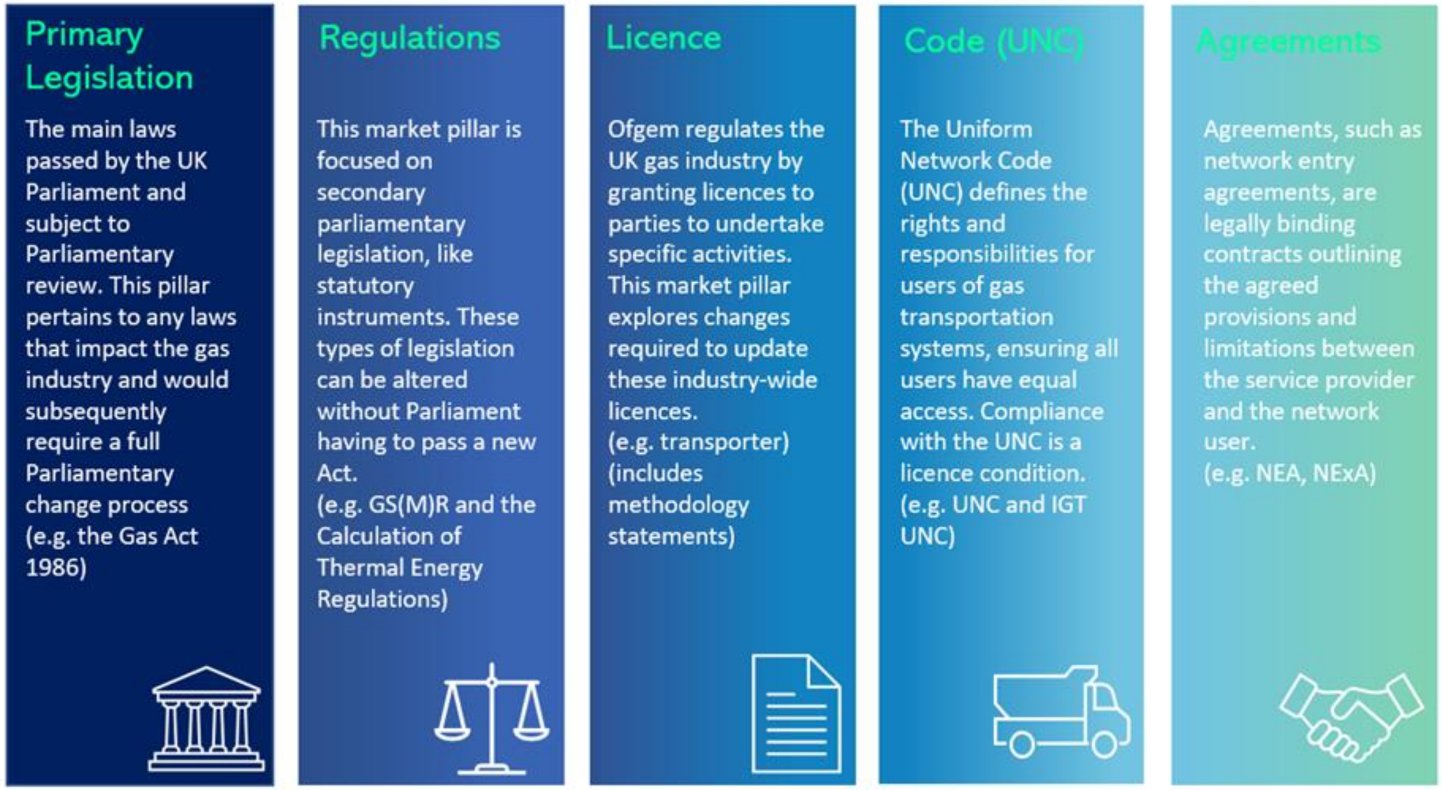
Belgian has amended its Gas Law to allow a 2% hydrogen blend as of July 2023. However, the first concrete injection project will start later, in 2024. Initial Blends will only impact the regional network and won't reach interconnection points. Fluxys has plans to reach a blending level up to 10%. Going beyond this threshold would require changes in the way the network is operated.

The Netherlands Government Strategy on Hydrogen also includes the option of a H2 blending obligation, outlining that "*Physical blending up to 2% is already achievable with minor adjustments, and with further adjustments, the percentage could gradually be increased to approximately 10-20%.*"

Gas Goes Green Proposal

The ENA Gas Goes Green working group have been involved in a number of workshops to develop an initial thought piece on existing commercial framework compatibility and the required amendments necessary.

This Review Group has been proposed for a period of 6 months to review these high-level amendments and further develop solution options with the objective to agree commercial framework changes required with wider industry and raise suitable enabling modifications.



0849R Work Group Objectives:

Work Group 1

-Introduction and overview of H2 blending progress so far.
-Agree Assumptions and Parameters
-Gas Quality Review
-System Operation Review

Work Group 2

-System Operation Review continued..
-Balancing Review

Work Group 3

-Trading Review
-Charging Review (overview of functional specification project outputs)

Work Group 4

-GGG Connections Methodology Solution Options
-Capacity Review
-Connections Review

Work Group 5

-TBC (Progress to be reviewed throughout sessions)

Work Group 6

-Final Considerations
-Pre-mod Review