GAS GOES GREEN

BRITAIN'S HYDROGEN BLENDING DELIVERY PLAN

energynetworks association

CONTENTS

GAS GOES GREEN

ena energynetworks association

ABOUT ENA

We're the voice of the networks. We're the industry body for the companies which run the UK & Ireland's energy networks, keeping the lights on and gas flowing.

Our members own and operate the wires and pipes which carry electricity and gas into your community, supporting our economy. The wires and pipes are the arteries of our economy, delivering energy to over 30 million homes and businesses across the UK and Ireland. To do this safely and reliably, the businesses which run the networks employ 45,000 people and have spent and invested over £60 billion in the last eight years.

We're creating the world's first zero-carbon gas grid by speeding up the switch from natural gas to hydrogen for the 85% of UK households connected to the gas grid.

Gas Goes Green, an ENA programme, is our plan to deliver net zero emissions in the most cost-effective and least disruptive way possible. It is a blueprint for our gas networks to meet the challenges and opportunities of climate change.

OUR MEMBERS AND ASSOCIATES

Membership of Energy Networks Association is open to all owners and operators of energy networks in the UK.

Companies which operate smaller networks or are licence holders in the islands around the UK and Ireland can be associates of ENA too. This gives them access to the expertise and knowledge available through ENA.

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GAS GOES GREEN

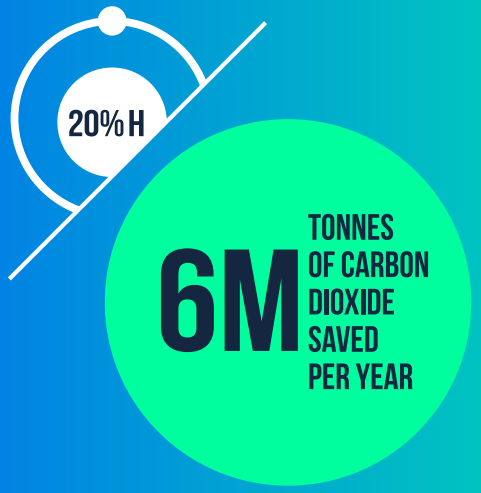
EXECUTIVE SUMMARY

The United Kingdom government has set-out ambitious legally binding obligations to reach net-zero by 2050. If this target is to be met, it will require wide-ranging industry collaboration and a mosaic of innovative solutions to deliver the carbon reduction required. Low-carbon gases such as biomethane and hydrogen are expected to play a vital role in transitioning to a low carbon future. Recent policy documents have begun to define the role of hydrogen, and in particular how blending hydrogen with natural gas in the existing gas infrastructure can support the transition to a net zero future.

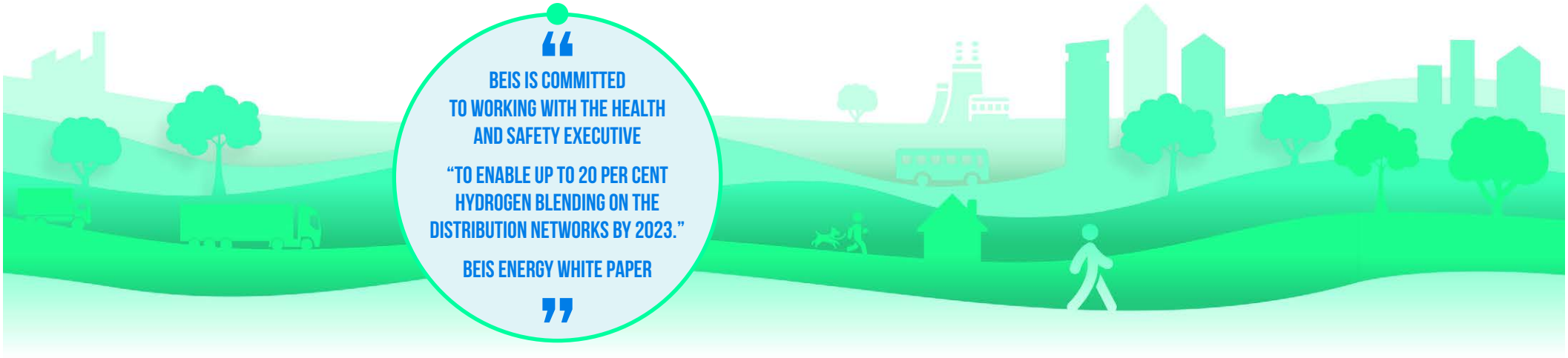
The process of mixing natural gas with up to 20% hydrogen could lead to significant carbon savings. If 20% hydrogen is blended into the gas grid together with existing natural gas, this could save up to 6 million tonnes of carbon dioxide equivalent every year, the equivalent of taking 2.5 million cars off the road[1].

As hydrogen blending would be an intermediate step towards a 100% decarbonised gas future, it is vital that blending delivers the maximum benefit for the minimum outlay. It needs to be delivered quickly, simply, and efficiently to give momentum to the transition towards 100% decarbonised gas.

Ongoing trials and projects are examining the physical, operational, safety and cost-benefit cases for blending hydrogen into the gas networks. In addition to this evidence, the market frameworks governing the duties, rights, and incentives of gas market participants across the value chain must also be compatible with blending. The existing market frameworks assume the conveyance and trading of a relatively homogeneous natural gas. Therefore, existing market frameworks must be reviewed, with any necessary changes made as a matter of urgency in order to ensure that blending can commence once operational trials have demonstrated that it is technically safe and economically efficient to do so.



1. www.energynetworks.org/newsroom/hydrogen-blending-what-is-it-and-why-does-it-matter



> BEIS IS COMMITTED TO WORKING WITH THE HEALTH AND SAFETY EXECUTIVE
>
> "TO ENABLE UP TO 20 PER CENT HYDROGEN BLENDING ON THE DISTRIBUTION NETWORKS BY 2023."
>
> BEIS ENERGY WHITE PAPER

The project has created two timelines to map out how the existing gas market frameworks could be changed to enable blending. For the purposes of this project, the gas market frameworks have been broken down into five market pillars. The market pillars are primary legislation, regulation, licence, code, and safety change

Roll-Out Models

First, the project explored a number of potential physical roll-out models for blending. In order to support the market and regulatory changes required to facilitate hydrogen blending, it was deemed important to understand at a high-level what regime the market rules would be creating. The project investigated a range of potential options for the roll out of hydrogen blending onto the network, two indicative routes were chosen to be explored further based on their differing underlying principles. These were called the Strategic Approach and the Free Market Approach.

The project undertook a high-level assessment of the roll-out models and found benefits and challenges for each approach. Further work is required in this area to define the most suitable approach, to deliver the highest potential carbon reduction savings, whilst taking into consideration the key principles of efficiency, speed, and simplicity.

Engagement and collaboration are needed from the wider gas industry to develop a detailed roll-out model that can deliver the benefits of blending. The project has highlighted the potential development of a methodology to set-out the practicalities and incentives required to deliver an appropriate roll-out model.

STRATEGIC APPROACH

The Strategic Approach would designate connection locations based on the most suitable parts of the network, considering a number of potential factors, including where would maximise hydrogen blending volumes and where on the network would allow efficient control and operation of blends.

FREE MARKET APPROACH

The Free Market Approach mimics the existing arrangements for connections to the gas networks and would let the market decide where to inject hydrogen into the network, with the hydrogen capacity being made available on a "first come, first served" basis.

Timelines

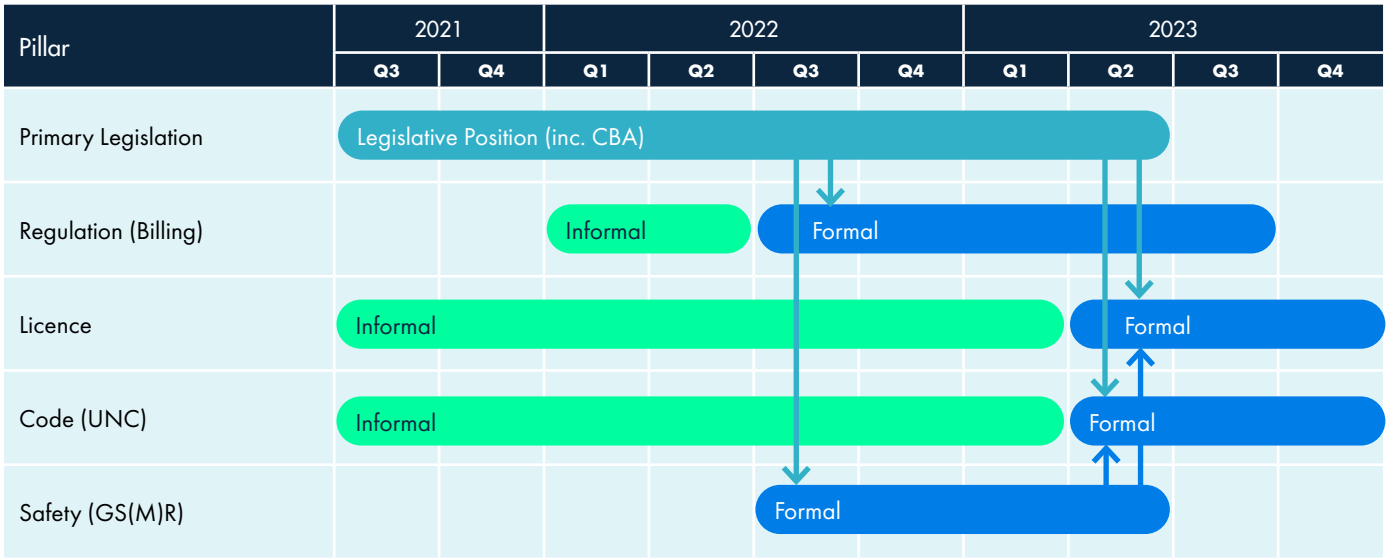
The first timeline the project created was a target driven timeline related to the date set-out in the 2020 BEIS Energy White Paper to enable hydrogen blending by 2023. The 'Target 2023' timeline showcases that whilst there are uncertainties and unknowns, with the right level of collaboration, engagement, and coordination it would be possible to enact gas market change at an accelerated pace to meet the 2023 target. It is important to highlight that this timeline is driven by the government target and there is uncertainty regarding the volume of physical hydrogen production that will be available to be connected to the networks in 2023.

A key reason why the 2023 target could be met was the concept of undertaking informal pre-work before a final policy decision is taken on whether to go forward with network blending. This final policy decision is expected from BEIS in 2023. The Market Pillar timeline below shows how the interaction between the informal and formal processes could deliver accelerated change to meet the government target. The pre-work would need to be undertaken in a collaborative way to build industry consensus to expedite formal process timescales. It should also be noted that the pre-work shown would have to be completed 'at risk' (i.e. before the formal policy decision is taken).This risk could reduce the willingness of industry parties to engage.

In contrast to the target driven nature of the target 2023 timeline, the project also created a second timeline called Sustained Progress. This timeline shows steady progress with pre-work still being undertaken but highlights how the uncertainties related to certain change activities could extend timelines. The Sustained Progress timeline still results in all the market frameworks being updated by the end of 2024 to enable blending, with residual system change being completed in 2025. This timeline still showcases industry engagement and collaboration taking place throughout 2022 and 2023 to deliver the change required.

Both timelines and the details related to each change activity can be found within the full report.

Target 2023 Market Pillar Timeline



Conclusions

The key project conclusions are summed up below and the complete suite of recommendations can be found within the full report.

1 2023 IS AN AMBITIOUS YET ACHIEVABLE TARGET.

The target 2023 timeline showcases how the 2023 date for market framework change can be met, through a route of minimum viable change to deliver blending.

2 EARLY POLICY CLARITY CAN ACCELERATE CHANGE.

With minimal infrastructure changes required to enable blending, the earlier policy clarity can be provided; the more it de-risks industry parties, the more it will drive up engagement and collaboration and the quicker formal change processes can commence.

3 DELIVERY OF THE TIMELINE REQUIRES CENTRALISED COORDINATION OF CHANGE PLANS.

Robust coordination from a centralised body of change plans from across the blending value stream would remove the risk of piecemeal change and ensure the change is delivered in a coherent and structured way. It is vital that change is undertaken in parallel and there is clear communication across the different work streams.

4 NEED FOR INDUSTRY COLLABORATION AND ENGAGEMENT BEFORE FINAL POLICY DECISION IS MADE.

If the industry waits until a formal policy decision is made before starting to try and answer some of the outstanding questions related to blending, it will delay the implementation of network blending. It is vital that those parties who are responsible for leading market change activities undertake collaborative pre-work to ensure the relevant market changes are completed in a clear and ordered way.

5 IMPLEMENT QUICK-WIN SYSTEM SOLUTIONS FIRST.

Central IT systems cannot be a barrier to innovation and change. Engaging with service providers at the earliest opportunity and implementing the quick wins in the first instance would reduce the potential risk of IT system change delaying the rollout of hydrogen network blending. The impacts on third party systems also need to be considered when developing quick-win system solutions to ensure the industry has time to complete their necessary changes.

STAKEHOLDERS' VIEWS ARE VERY IMPORTANT TO THE GAS GOES GREEN PROGRAMME AS THEY CAN HELP SHAPE AND ENHANCE FUTURE DELIVERABLES. IF YOU WOULD LIKE TO DISCUSS ANY ASPECT OF THIS PROJECT OR FIND OUT HOW YOU CAN GET INVOLVED IN THE WIDER GAS GOES GREEN PROGRAMME, PLEASE CONTACT ENA AT GASGOESGREEN@ENERGYNETWORKS.ORG.

2 CASE FOR BLENDING

GAS GOES GREEN

Gas Goes Green (GGG) is an Energy Networks Association programme within which all five of Great Britain's gas network companies collaborate on meeting the challenges of climate change. The programme will research, coordinate and implement the changes that are needed to convert Britain's world-leading 284,000km of gas network infrastructure to transport hydrogen and biomethane, providing consumers with the energy they need. To do this, the Gas Goes Green Pathway to Net Zero has been developed, this sets out the actions that need to be taken to deliver the world's first zero carbon gas grid by 2050. The 'Planning and Research' step is the first on the Gas Goes Green Pathway to Net Zero. This stage will undertake preparatory activities to manage the transition away from natural gas.

This step has six related workstreams:

1. Investing in Net Zero
2. Gas Quality and Safety
3. Consumer Options
4. System Enhancement
5. Hydrogen Transformation
6. External Affairs and Stakeholder Engagement

Gas Markets Plan
In collaboration with gas industry stakeholders and policymakers, the Gas Market Plan (GMaP) programme has been initiated to help prepare the gas markets for potential future transformations. The GMaP programme is currently undertaking a range of market-based research projects in specific areas of industry interest, such as gas quality, hydrogen, and gas balancing.

GGG2.1 Blending Timeline Pathway

This report concludes phase 1 of the GGG gas quality and safety workstream 2.1 deliverable, the Blending Timeline Pathway project, in collaboration with the GMaP programme.

The project has mapped out possible timelines of legislative and regulatory changes, to allow blending of low-carbon and renewable gases into the gas networks as part of the targets outlined in the Prime Minister's Ten Point Plan (5GW of installed hydrogen production capacity, or 42TWh of hydrogen, per year by 2030). It has also:

- Undertaken a high-level assessment on a range of potential physical roll-out models to deliver hydrogen blending into the gas systems and provided next step recommendations.
- It has included primary legislation, regulation, and safety change in the timeline alongside more traditional areas of market change like licence and code change.
- It has highlighted a number of key recommendations to provide a future pathway of work to enable the market frameworks to be ready to meet the government 2023 target.
- Included the secondary impacts that will need to be addressed from potential market framework changes like central IT system change and connected downstream system change.

A key aspect of the project has been the identification of the market framework change activities and the challenges and risks associated with those activities. The project has been co-led by National Grid Gas Transmission and SGN delivering the research, engagement, and outputs, with the support of ENA and Britain's other gas network companies. The project has also engaged with a wide range of industry stakeholders and experts throughout its life cycle.

DECARBONISATION POLICY AND LOW-CARBON GAS

If the UK's ambitious legal obligation to reach net-zero is to be met, it will require wide-ranging industry collaboration and a mosaic of innovative solutions to deliver the carbon reduction required. Low-carbon gases such as biomethane and hydrogen are expected to play a vital role in supporting the UK's drive to achieve net zero. Recent policy documents have defined the role of hydrogen, in particular how blending hydrogen with natural gas in the existing gas infrastructure could support the transition to a net zero future.

The government's November 2020 Ten Point Plan set a national target of 5GW of low-carbon hydrogen production capacity by 2030 and an indicative target of 1GW by 2025. It noted that blending offers "lower carbon heating and cooking with no change in experience for domestic consumers... reducing the emissions of gas used by up to 7%".

The subsequent Energy White Paper announced several hydrogen heating trials planned to take place in the 2020s. BEIS committed to working with the Health and Safety Executive "to enable up to 20 per cent hydrogen blending on the Distribution Networks by 2023."

The UK Hydrogen Strategy reaffirmed these targets and set out a roadmap for the development of a UK hydrogen economy over the 2020s. It restated the intention to conduct Hydrogen Neighbourhood (2023), Village (2025) and Town (2030) trials and confirmed an indicative value-for-money case for blending by Q3 2022, with a final policy decision on blending likely to take place in 2023. It also detailed several consultations and calls for evidence on areas such as hydrogen-ready appliances, hydrogen production subsidies and a UK-wide low-carbon hydrogen standard. It showcased projects such as HyDeploy[2], FutureGrid[3] and LTS Futures[4] that are already underway to test the compatibility of hydrogen with existing gas network assets and appliances.

> BLENDING OFFERS
>
> "LOWER CARBON HEATING AND COOKING WITH NO CHANGE IN EXPERIENCE FOR DOMESTIC CONSUMERS...REDUCING THE EMISSIONS OF GAS USED BY UP TO 7% "
>
> THE PRIME MINISTER'S TEN POINT PLAN

2 hydeploy.co.uk
3 www.nationalgrid.com/uk/gas-transmission/insight-and-innovation/transmission-innovation/futuregrid
4 www.sgn.co.uk/about-us/future-of-gas/hydrogen/lts-futures

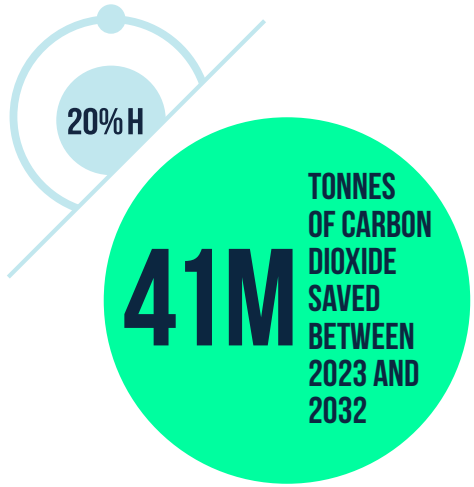
THE CASE FOR BLENDING

Front-loading emission reductions leaves more time and resources to solve the more difficult decarbonisation problems ahead. 'Blending', the process of mixing natural gas with up to 20% hydrogen, could lead to significant carbon savings. If 20% hydrogen is blended into the gas grid together with existing natural gas, this could save up to 6 million tonnes of carbon dioxide equivalent every year, the equivalent of taking 2.5 million cars off the road[5]; or a total of around 41 million tonnes of carbon dioxide equivalent between 2023 and 2032[6].

Blending is a transitional step from the current natural gas economy to a future hydrogen economy. Its purpose is to kickstart the UK's hydrogen economy. As blending is an intermediate step, it is vital that it delivers the maximum benefit for the minimum outlay. It needs to be delivered quickly, simply, and efficiently to give momentum to the transition towards 100% decarbonised gas.

Meeting the existing hydrogen production targets of the Ten-Point Plan and Energy White Paper means creating a favourable market environment to give investors and producers the confidence that installing hydrogen production capacity will be a profitable enterprise. The foundation of a favourable market environment is therefore certainty of demand for hydrogen.

Meeting national targets and nurturing a mature low-carbon gas economy will require different parts of the value chain to move in parallel. Where renewable electricity sources produce the same product as legacy generators and can readily compete for existing electricity demand, hydrogen (and, to a lesser extent, biomethane) is a different physical commodity and can only compete with methane to a limited extent under current market frameworks.



'BLENDING', THE PROCESS OF MIXING NATURAL GAS WITH UP TO 20% HYDROGEN, COULD LEAD TO SIGNIFICANT CARBON SAVINGS.

5 www.energynetworks.org/newsroom/hydrogen-blending-what-is-it-and-why-does-it-matter
6 assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Blending at Industrial Clusters

Blending improves the investment case for hydrogen production at industrial clusters[7] by adding a new source of demand. Hydrogen producers at clusters can sell excess hydrogen into the grid, giving more demand certainty, reducing production curtailment, raising load factors, and reducing production costs, ultimately encouraging more investment in hydrogen production capacity, and yielding cheaper hydrogen.

Blending Upstream Non-Clusters

The potential to install electrolysers associated with renewable electricity generation could enable higher load factors for renewable electricity generation which would otherwise have to be constrained. The potential to store hydrogen and utilise the existing gas network could reduce the need to build additional electricity infrastructure. This could deliver an economically efficient outcome which should reduce electricity network congestion, curtailment of renewables and electricity network reinforcement costs. This could also improve hydrogen production economics and ultimately lower hydrogen cost to consumers by minimising the impact on the electricity grid and making the most efficient use of existing gas and electricity infrastructure.

Blending for Non-Cluster Consumers

Beyond the promising but finite potential of industrial clusters as sources of hydrogen demand, blending is the next step to unlocking greater demand for hydrogen. Ongoing projects are exploring the potential for existing consumer appliances to function safely with no user behaviour change with up to 20% hydrogen in Gas Distribution Networks and up to 2% in the National Transmission Network (NTS). Unlocking this demand would create a sizable market for hydrogen, and projects such as HyDeploy are well along the path to proving that hydrogen is safe in these appliances. From a production perspective, it is assumed the work BEIS are undertaking on hydrogen business models will provide the right incentives, which would likely bring significant production capacity online.

Efficient Deployment of Hydrogen Production and Consumption Technology

Hydrogen gas production technologies are not yet fully mature. Blending would phase them in gradually, fostering the learning of early lessons and cost reductions before larger capacity additions are made. The majority of planned production capacity would therefore be installed when technology is more mature, and costs are consequently lower.

Likewise, hydrogen-ready end-user appliances are in the early stages of roll-out. It is clearly more economically viable to replace appliances at the end of their natural life cycle to avoid scrappage. Blending would allow user appliances to be replaced with 100%-hydrogen-capable appliances gradually, while establishing a hydrogen economy capable of providing the volumes required for a later switch to 100% hydrogen. Bringing significant hydrogen production capacity online before demand has materialised would likewise be challenging.

Location of Blending

There are still unanswered questions about the most suitable place on the networks for hydrogen blends to be injected. Blending into the Gas Distribution Networks may bring some extra complexity with regard to customer billing which would not exist if there were a consistent hydrogen blend in the NTS. This is due to the existing billing arrangements, where different compositions of gas (blended and non-blended) entering a Gas Distribution Network could lead to increase volumes of shrinkage. Existing projects, such as the Future Billing Methodology project are exploring solutions to this complexity. Blending in the transmission network could avoid this issue if the NTS contained a consistent homogenous hydrogen blend. A careful choice of blending location, in both the NTS and Gas Distribution Networks, may also reduce the need for adding propane at biomethane entry points.

7 Please see Chapter 5 "Industrial Energy" of the BEIS EWP for more information on "Clusters"

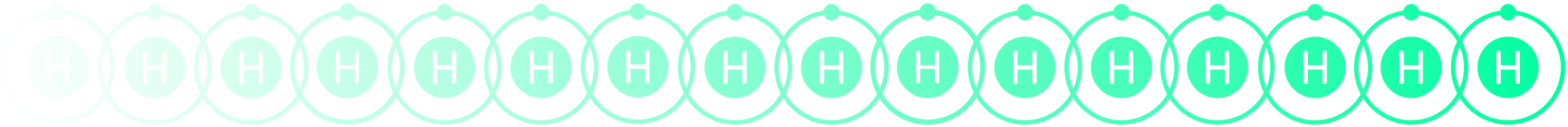
CURRENT PROGRESS OF BLENDING

The existing gas market frameworks do not currently allow hydrogen above 0.1% by volume to enter the UK's gas networks. However, there is an existing process where the HSE may provide exemptions to the 0.1% limit (and other gas quality parameters) if it is satisfied that the health and safety of persons likely to be affected by the exemption will not be impacted as a consequence of any change. Several key projects that are underway to identify and address changes needed to facilitate blending have utilised this exemption process.

- The HyDeploy project successfully trialled a blend of up to 20% into a representative gas network at Keele University and is currently embarking on a larger trial of blending into NGN's network in Winlaton, Gateshead.
- Prior to the start of HyDeploy Phase 3 in 2023 and using the body of evidence gathered in phases 1 and 2, the project is also seeking a class exemption from the HSE which would support individual applications for exemptions from the Gas Safety (Management) Regulation (GS(M)R) for hydrogen blending into Gas Distribution Networks up to 20%.
- The first phase of the National Grid FutureGrid project is trialling hydrogen blending of NTS assets at 2%, 20% and 100% concentration levels. This will be followed by further phases looking at impacts on compressors and testing de-blending technologies.
- SGN's LTS Futures project will also complete a variety of off-site and live tests to understand the viability of Local Transmission System (LTS) infrastructure for both 100% hydrogen and natural gas and hydrogen blends.
- The H21[8] suite of projects addresses further technical and operational challenges.
- The Future Billing Methodology[9] project is examining a range of different future options for the gas billing framework.
- Wales & West Utilities has received approval from the HSE to allow 1% hydrogen into the network from late 2021.

8 h21.green/projects
9 futurebillingmethodology.co.uk

While the HSE examines evidence on the safety case for hydrogen blending, BEIS plans to launch a blending cost-benefit analysis study in autumn 2021 to explore the economic and distributional effects of blending. This is planned to conclude in 2023 to align with the end of phase 2 of the HyDeploy project. While these key policy and safety questions are answered, there is a need to assess the current gas market frameworks to identify the changes that could be required to facilitate blending. It is vital the existing gas market frameworks do not become a blocker to the potential implementation of blending, allowing the full benefits to be realised at the earliest opportunity.

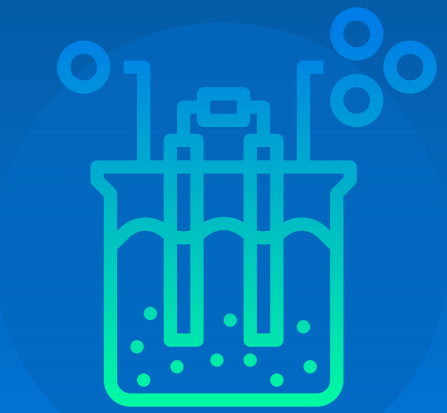


3 THE ROLE OF MARKET FRAMEWORKS

PROJECT RATIONALE AND DESIGN

Ongoing trials and projects are examining the physical, operational, safety and cost-benefit cases for blending hydrogen gases into the gas networks. In addition to this evidence, the market frameworks governing the duties, rights, and incentives of gas market participants across the value chain must also be compatible with blending. The existing market frameworks assume the conveyance and trading of a relatively homogeneous natural gas. Therefore, market frameworks must be reviewed, with any necessary changes made as a matter of urgency in order to ensure that blending can commence once operational trials have demonstrated that it is technically safe and economically efficient to do so. It is essential to the success and value proposition of blending that market frameworks do not delay the roll-out of blending once the technical, safety and cost-benefit cases are clear.

This project builds on existing work on potential changes needed to market frameworks, such as the Network Innovation Allowance study commissioned by Cadent on gas commercial frameworks and blending by Frontier Economics[10]. The purpose of this project was to assess current work, identify the potential gaps in planned work and present high-level timelines based on various possible change scenarios. For the purposes of this project, the 'gas market frameworks' have been broken down into five market pillars. The market pillars are primary legislation, regulations, licence, code, and safety. Breaking down the market frameworks into these pillars facilitates an output which provides maximum value.



10 Economics, F. (2020). HYDROGEN BLENDING AND THE GAS COMMERCIAL FRAMEWORK. Report on conclusions of NIA study.

Within each market pillar, a number of high-level change activities have been defined. These change activities have been researched and mapped onto timelines before being validated.

The project has created two potential timelines, which show how the market frameworks could be changed.
The project has then developed a range of recommendations and key conclusions.

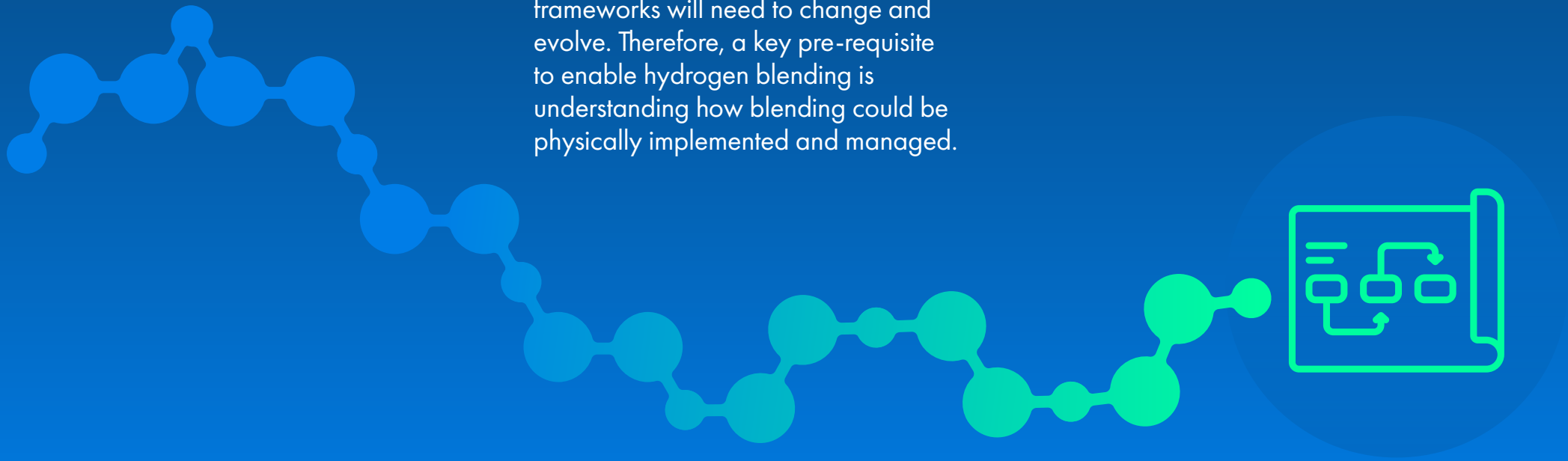
It is important to reiterate that the project is showcasing how change could be enacted under certain circumstances. The project recognises that there are many different routes for how future market change could be delivered as well as numerous uncertainties to manage.

4 PHYSICAL ROLL-OUT MODEL EXPLORATION

The key underlying principles when connecting to the existing gas network is ensuring that all parties have efficient, fair, and transparent access to the gas system. These principles should continue to be adhered to in a potential future blending world whilst also recognising that a different methodology may be required if government targets are to be met.

The current connections process is operated on a first-come, first-served approach. However, as hydrogen is a different compound compared to natural gas, it is important to understand how blending could actually work in practice, especially considering its transitional nature and where it needs to differ from the existing connections regime. The introduction of hydrogen into the GB gas networks will lead to new challenges, and the existing market structures and connection frameworks will need to change and evolve. Therefore, a key pre-requisite to enable hydrogen blending is understanding how blending could be physically implemented and managed.

The project undertook an exploration of potential physical roll-out models in order to support the market and regulatory changes required to facilitate hydrogen blending. The project investigated a range of potential options for the roll out of hydrogen blending onto the network; two indicative routes were chosen to be explored further based on their differing underlying principles. These were called:



Strategic Approach

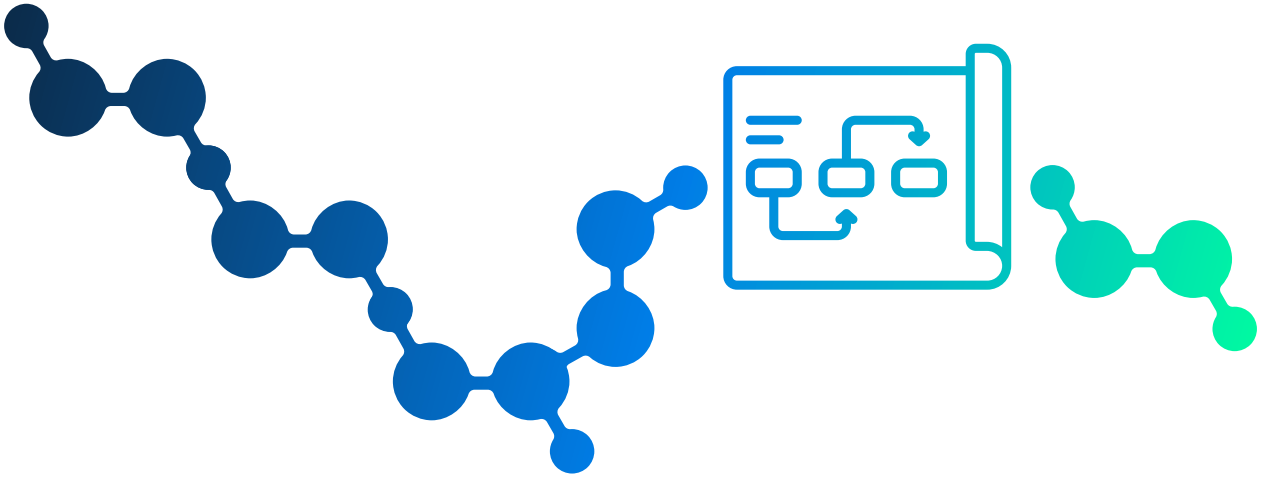
The Strategic Approach would designate connection locations based on the most suitable parts of the network, considering a number of potential factors. For example: the ability to maximise volumes of hydrogen blend and other green gasses, where it links into the broader hydrogen strategy and where on the network would allow efficient control and operation of blends whilst remaining reflective of market forces.

In a Strategic Approach, potential producers may have their connections rejected or relocated if they contradict the overarching hydrogen strategy.

Free Market Approach

This approach mimics the existing arrangements for connections to the gas networks and would let the market decide where to inject hydrogen into the network, with the hydrogen capacity being made available on a "first-come, first-served" basis. Blending would therefore occur wherever producers apply to connect, wherever hydrogen production is most likely to be profitable for them, irrespective of the wider decarbonisation picture. In a Free Market Approach the network may develop in such a way as to make achieving government targets prohibitively expensive and the network overly complex to operate.

The project completed a high-level assessment of the opportunities and challenges for the two approaches.



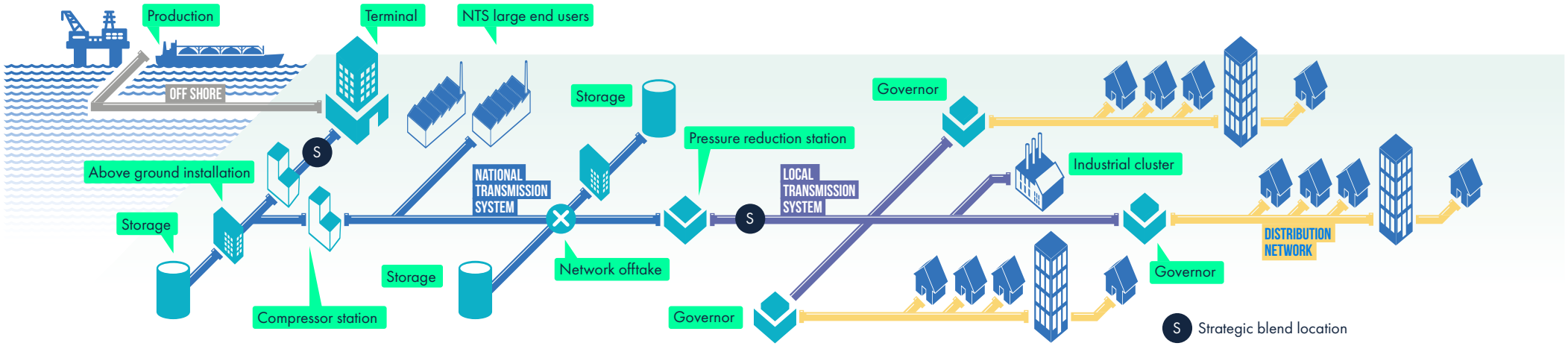
HIGH LEVEL ASSESSMENT

Strategic Approach

Figure 1 illustrates a strategic blending network configuration with blending at industrial clusters, in addition to potential blending points that could be at both NTS and Gas Distribution Network level. The overarching aim of the model is to maximise the capacity of hydrogen in the network, providing the largest abatement in carbon emissions.

The Strategic Approach for the injection of hydrogen onto the network offers a number of benefits, one of the main being the ability to ensure the most efficient release of injection capacity. A strategic location would be selected due to its zone of influence. The example in Figure 1 shows a strategic blending location positioned on the LTS after the Pressure Reduction Station. The LTS networks are largely volume controlled meaning they can accept a constant volume of gas throughout the day. In comparison, the below 7 bar Gas Distribution Network is predominantly pressure controlled, with flows in and out of the network triggered by diurnal change in consumer demand. As there is a limit on the acceptable percentage of hydrogen blend for domestic appliances (expected to be up to 20%), the maximum hydrogen injection into below 7 bar networks would be constrained so it does not breach the 20% limit. This may occur when flows within the network are at their lowest due to low demand →

Figure 1:
Strategic Approach

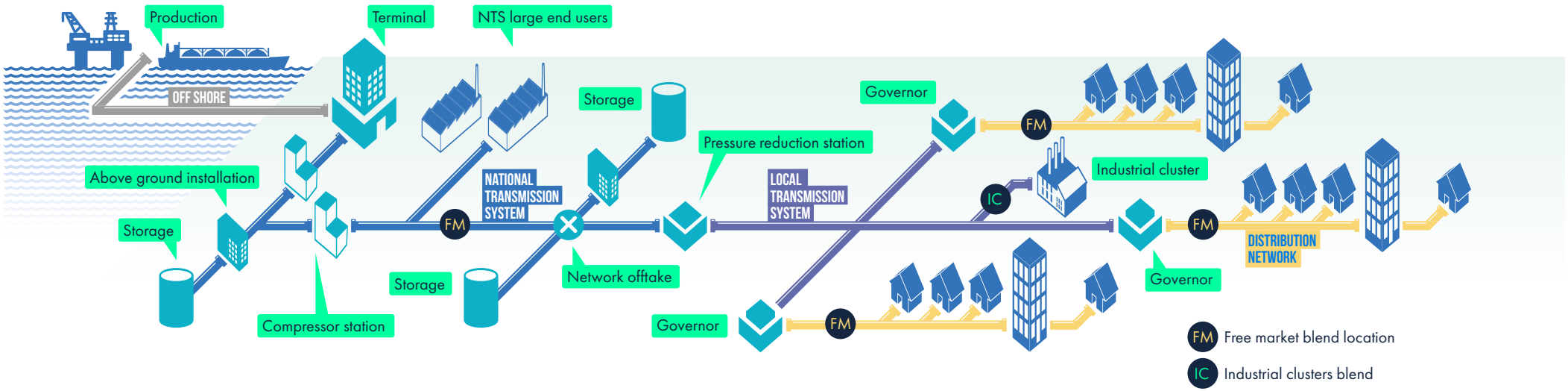


such as overnight or in the summer months. The Strategic Approach to blending, connecting higher up the network pressure tiers allows an efficient management of the network providing a greater hydrogen capacity due to larger zones of influence with the lowest network management implications.

The strategic blending approach could mitigate the risk of network sterilisation. Network sterilisation could occur if multiple hydrogen blend facilities connected within the same zone of influence. This would require more complex and costly solutions to be developed to ensure sites could inject into the network, whilst ensuring the blend limit is not breached. Developing a methodology for the selection of a number of strategic locations to blend onto the network would ensure the maximum hydrogen blending potential and minimise sterilisation risk.

The Strategic Approach differs from the existing arrangements for connecting onto the network. One of the main challenges identified with this blending roll-out model is the associated regime change that would be required to control future connections onto the network in an effort to optimise capacity in the most efficient way possible. This will involve new processes to be developed with differing arrangements required to the existing regime; for example, there would need to be a new process for granting or rejecting future connections to maintain efficiency and network operability. Another potential challenge with a Strategic Approach to blending is the transport of hydrogen from a production facility to a strategic point on the network. For small-scale producers of hydrogen located large distances from strategic points, the transportation of hydrogen via pipeline or road tanker may not be the most efficient option.

Figure 2:
Free Market Approach



Free Market Approach

A Free Market Approach to blending is illustrated in Figure 2, which shows the ability for developers to connect to any part of the network. It also shows blending at industrial clusters. The model mirrors the process for existing biomethane connections that have been embedded into the network currently both on the NTS and Gas Distribution Network.

There are a number of potential benefits to the Free Market Approach, if incorporated with the right market-based regime. One potential advantage of a Free Market Approach could be in the speed for sites to connect to the network. Smaller connections within lower pressure tiers of the network would require less financing and may be able to be streamlined from a planning perspective in comparison to larger strategic blending locations with higher risk on the final investment decision. The Free Market Approach could also take any learnings from the introduction of biomethane, recognising these aren't completely like for like. A similar regulatory regime could translate potential injection constraints into economic signals to market participants, identifying where the most optimal injection points are located on the network, with maximising hydrogen injection considered.

There are also challenges with a Free Market Approach for blending. The main challenge relates to overall network efficiency and the potential for investment and network sterilisation. Operationally, implementing a true Free Market Approach would be very difficult as the requirement to maintain a blend within predefined limits, the risks of new production curtailing existing production and the expected volumes that could be delivered would place a significant burden of risk on investors and gas networks. To mitigate these risks, considerable metering, monitoring and overall control would be required, therefore reducing the overall efficiency of the approach.

ASSESSMENT CONCLUSIONS

The above assessment of both physical roll-out model approaches show that they exhibit a range of contrasting benefits and challenges. Further engagement and collaboration is needed from the wider gas industry to develop a detailed roll-out model that can deliver the benefits of blending. Ultimately the decision lies with BEIS on how to proceed, but industry collaboration and engagement can support that decision-making process.

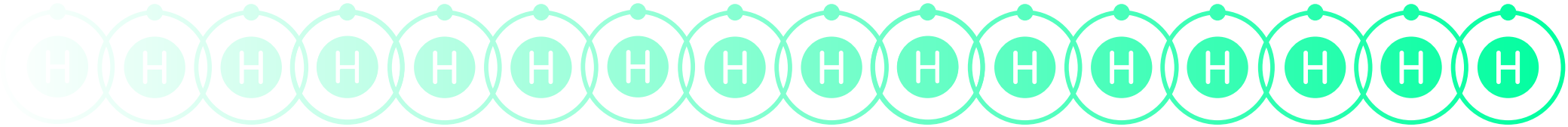
> "FURTHER ENGAGEMENT AND COLLABORATION IS NEEDED FROM THE WIDER GAS INDUSTRY TO DEVELOP A DETAILED ROLL-OUT MODEL THAT CAN DELIVER THE BENEFITS OF BLENDING"

NEXT STEPS

As highlighted in the assessment, one of the main complications that exists with hydrogen blending but not with biomethane is how multiple injection locations within the same sphere of influence interact with each other. Hydrogen may not exceed a set limit (expected to be 20%) of the blend by volume at any point at any time as breaching this limit would have implications for downstream appliances. Therefore, any hydrogen already in the gas arriving at a blending location will reduce the amount that can be injected at this location. The interaction between these injection points will bring increased complexity and cost to the operation of the networks to maintain this 20% instantaneous blend and any investment in hydrogen production will be at risk of another producer connecting upstream of them. The risk of investment sterilisation needs to be managed to support the continued development of Acorn, Cavendish, HyDeploy and HyNET blending schemes. It is likely that investors will require confidence that long-term returns can be made, without a risk of sterilisation.

Whilst there will be new challenges and risks that need mitigating, it should also be clear that any final solution on the locations of blending points will need to take into consideration market enquiries and signals. Therefore, in order to determine the most optimal solution for the roll out of hydrogen blending onto the network, the project recommends an industry-wide consultation is completed on the creation of a connection methodology for blending.

The methodology needs to work in practice and not be overengineered from a conceptual perspective. It is better to create a process that works taking into consideration those key principles of simplicity, effectiveness, and speed. There also needs to be a balance between actual hydrogen production projects that want to connect to the network versus theoretical "better" options that don't exist. The methodology should also align with the outputs from the BEIS Hydrogen Business Model work to ensure both concepts work together in practice.



We recommend:

That a new Gas Goes Green programme is undertaken to define the optimal blending operating model. We recommend that the project:

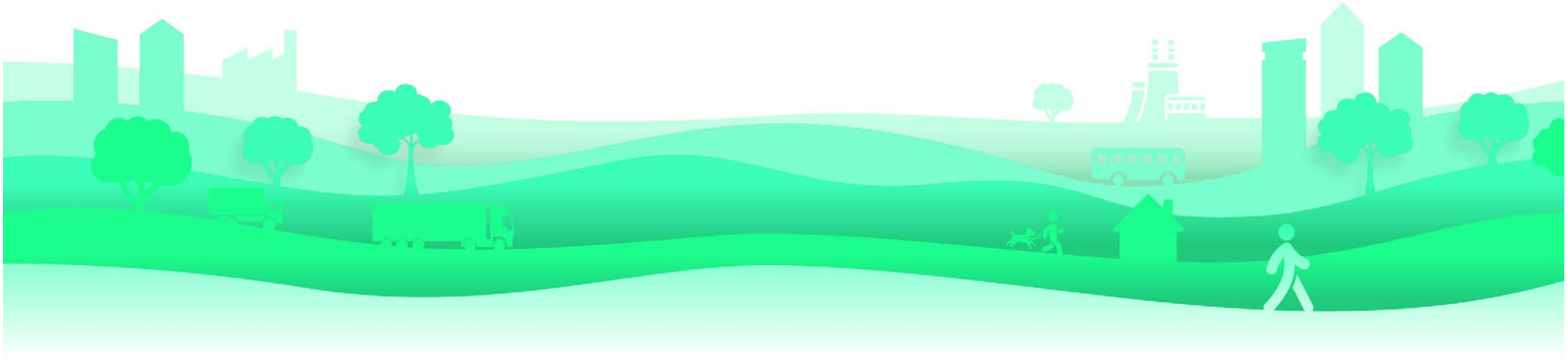
Develops a blending connection methodology which considers long and short-term market signals.

Explores network topology to maximise efficient use whilst also focussing on exploiting the release of injection capacity in the locations where it is most likely to be needed.

Should include an industry consultation developed jointly by the gas networks on the production of a methodology. The aim of the methodology is to define how to control future hydrogen blend connections, taking into consideration market and economic signals.

Align closely with the work being carried out on a future market framework to ensure the roll-out model can be implemented efficiently, minimising impacts on the central system as well as IT systems for transporters, shippers, and suppliers.

GAS GOES GREEN



5 TARGET 2023 TIMELINE MEETING THE GOVERNMENT'S AMBITION

The government has set-out ambitious targets in relation to when they expect to see network blending enabled, as referenced in the UK Hydrogen Strategy.

> "THE TEN POINT PLAN SET COMMITMENTS TO COMPLETE NECESSARY TESTING OF BLENDING UP TO 20 PER CENT HYDROGEN INTO THE GAS GRID BY 2023. SIMILARLY, THE ENERGY WHITE PAPER NOTES AMBITIOUS INTENTIONS TO ENABLE UP TO 20 PER CENT HYDROGEN BLENDING ON THE NETWORKS BY 2023 (SUBJECT TO TRIALS AND TESTING)."

The existing gas market frameworks do not currently allow any hydrogen above 0.1% to enter the UK's gas networks. Along with this the commercial rules and systems are not yet in place to deliver a seamless transition from a homogeneous natural gas product to a blended product. Therefore, the existing gas market frameworks need to be updated in a coordinated and collaborative way to ensure they facilitate network blending and do not become a blocker to realising the environmental and economic benefits of blending.

The project has created two timelines to show at a high level how the gas market frameworks could change to enable hydrogen network blending. The 'Target 2023' timeline is a target driven timeline that meets the government's 2023 target for enabling network blending. It is important to highlight that this timeline is driven by the government target and there is uncertainty regarding the volume of hydrogen production that will be available to be connected to the networks in 2023. The second timeline created, the 'Sustained Progress' timeline shows steady and sustained market framework change progress. The uncertainties related to certain key change activities result in the completion of market and system change by 2025. It is recognised that there are areas of high uncertainty which could impact delivery timescales. Far from trying to predict the future, the timelines show different pathways to change and the interdependencies of key change activities.

There are different strands of the gas market that need to be considered to ensure a fully joined-up approach is taken. The project has categorised the existing gas market frameworks into five pillars:

PRIMARY LEGISLATION

The main laws passed by the UK Parliament and subject to Parliamentary review. This pillar pertains to any laws that impact the gas industry and would subsequently require a full Parliamentary change process (e.g. the Gas Act 1986).

REGULATION

This market pillar is focused on secondary parliamentary legislation, like Statutory Instruments. These types of legislation can be altered without Parliament having to pass a new Act. This pillar is focused on the secondary legislation change linked to the billing regime (e.g. the Calculation of Thermal Energy Regulations).

LICENCE CHANGE

Ofgem regulates the UK gas industry by granting licences to parties to undertake specific activities. This market pillar explores changes required to update these industry-wide licences (e.g. transporter licence).

CODE CHANGE [UNC]

The Uniform Network Code [UNC] defines the rights and responsibilities for users of gas transportation systems, ensuring all users have equal access to transportation services. Compliance with the UNC is a licence condition (e.g. UNC & IGT UNC).

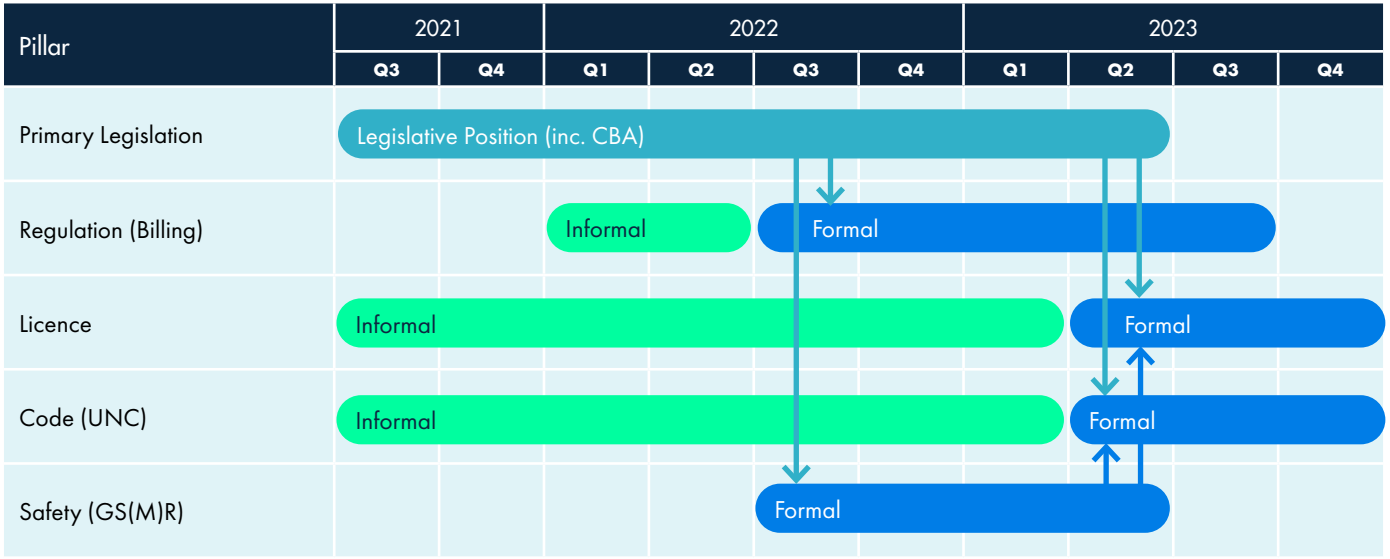
SAFETY CHANGE [G(S)MR]

To ensure safe operation, the delivery of gas to networks must be within certain pre-determined limits as set out in legislation. The current gas quality limits are set out in the [GS(M)R]. Therefore, this market pillar is focused on safety related change, predominantly in relation to how GS(M)R could change to expand the allowable hydrogen range up to a 20% limit.

By taking a broad approach, highlighting areas on the timeline which fall outside the remit of gas networks, the project aims to show the full breadth of potential market change required in a holistic yet simple way.

The following high-level timeline shows each market pillar and when the informal and formal processes could begin and end. Informal processes in this instance are processes undertaken before the defined change process for each market pillar (i.e. pre-work). Such processes would determine the draft solutions to be taken forward with the aim to expedite the formal process timelines by having robust and valid solutions ready to go. The informal pre-work processes are of the utmost importance to deliver shorter formal process timescales. There are a number of formal processes that cannot begin until there is policy and safety certainty. However, the pre-work can accelerate the normal timelines if completed in collaboration with the wider industry. The individual change activities are discussed in greater detail in the next chapter.

Target 2023 Market Pillar Timeline



DETAILED TARGET 2023 TIMELINE

The following Target 2023 timeline breaks down each market pillar into the different 'change activities' required to enable blending, including recommendations for further work. From left to right, the columns of the timeline show the five market pillars (primary legislation, regulation, licence, code, and safety), their related change activities and the duration of those activities. The timeline also includes the key policy decision activity in grey. The red arrows indicate the main interdependencies, that is the linkage between policy, safety decisions and the commencement of formal activities. Finally, the timeline has been colour coded to articulate who the proposed owners of the change activities are, highlighting the cross-industry approach required to change the frameworks to deliver hydrogen blending.

Activity Key

- Inflight / Proposed
- BEIS
- Ofgem
- BEIS & Ofgem
- Network Operators
- Industry / Others

Target 2023 Market Pillar Timeline

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In Flight	BEIS Blending CBA	●	●	●	●	●	●	●	●		
Primary Legislation	BEIS Gas Act Call for Evidence	●	●								
	Network Operator Regime Review	●	●								
	Legislative Review			●	●						
	Legislative Review only (no change to Primary Legislation)				●						
Regulation	FBM/COTER Decision Making Process		●	●	●	●					
	No COTER Change (UNC Billing Change only)						●	●	●	●	
	"Enabling" Billing System Change						●	●	●	●	●
	Upfront System Feasibility				●	●					
Licence	Network Operator Licence Review	●	●								
	Ofgem Led Licence Change Pre-work			●	●	●	●	●			
	Formal Licence Change Process								●	●	
Code	Network Operator Code Review	●	●								
	UNC Modification Pre-work			●	●	●	●	●			
	Targeted UNC Modifications								●	●	●
	"Enabling" System Change								●	●	●
	Upfront System Feasibility						●	●			
Safety (GS(M)R)	HyTechical Programme	●									
	Review of standards managed outside of IGEM		●	●	●	●					
	HSE Approvals Process/IGEM standard process				●	●	●	●	●		
	Updating HSE Safety Case for Hydrogen Blending								●	●	
	Update Existing Contracts (Existing Connections Only)								●	●	●
	Development of Connection Agreements			●	●	●	●				

6 TARGET 2023 TIMELINE KEY CHANGE ACTIVITIES

PRIMARY LEGISLATION PILLAR OVERVIEW

The primary legislation referenced in this section relates to laws that impact the gas industry. Primary legislation is an important component to facilitate hydrogen blending primarily as it defines and limits the powers that Ofgem, BEIS, the HSE and other key actors have to create and modify the substantive rules of the GB gas market framework, such as licence conditions, safety regulations, and code. Depending on the nature of change required, primary legislation change may need to be completed before significant change can commence in other market pillars.

It is not yet known if primary legislation will need to change to enable hydrogen blending to occur. As highlighted earlier in this report, there is still optionality on the different physical roll-out models that could be used to execute blending. These different roll-out models could require different changes to primary legislation.

Primary legislation has the greatest sensitivity on the blending delivery timeline. As the highest element in the UK legal order, all other market pillars are directly or indirectly subordinate to the primary legislation pillar. The timescales of changing UK primary legislation are lengthy compared to the other market pillars and also highly unpredictable, given the multitude of political and practical variables at play. A strategy which minimises change to primary legislation is advisable.

Whilst the need to minimise primary legislation change is advisable, it should also be noted that if blending forms a key part of an investor's business case then having explicit primary legislation rules could provide investors with additional confidence (e.g. removing risk of investment sterilisation).

CHANGE ACTIVITIES

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Primary Legislation	BEIS Gas Act Call for Evidence	●	●								
	Gas network Regime Review	●	●								
	Legislative Review			●	●						
	Legislative review only (no change to Primary Legislation)				●						

> BEIS WILL THEREFORE REVIEW THE OVERARCHING MARKET FRAMEWORK SET OUT IN THE GAS ACT TO ENSURE THE APPROPRIATE POWERS AND RESPONSIBILITIES ARE IN PLACE TO FACILITATE A DECARBONISED GAS FUTURE

BEIS Gas Act Call for Evidence and Consultations

The BEIS Energy White Paper published in December 2020 states that BEIS "will therefore review the overarching market framework set out in the Gas Act to ensure the appropriate powers and responsibilities are in place to facilitate a decarbonised gas future". A BEIS Call for Evidence on the Future of Gas Systems is planned for 2021 which will inform the content and scope of any future consultation and is a chance to get industry feedback on a wide range of topics including network blending. There is a high degree of confidence this will take place as planned. BEIS have also released 'the Hydrogen for heat: facilitating a grid conversion hydrogen heating trial' consultation which seeks views on proposals to legislate in order to allow Gas Distribution Networks Operators to carry out the activities needed to deliver a grid conversion hydrogen trial.

Gas Network Regime Review (Primary Legislation Due Diligence)

As part of the next stage of the Gas Goes Green programme, gas networks are planning to complete a market regime review, to assess the minimum viable change required to enable blending. It is important that this work includes a due diligence assessment on the impact on primary legislation from potential changes to code and licence arrangements. The scope of this work will include both the Gas Act and other legislation. Early visibility of this information could allow market proposals to be modified to reduce the impact on primary legislation and therefore deliver change without the need for legislative procedures.

Legislative Review

Once the Call for Evidence (CfE) is complete, there is a need to determine the potential impact on primary legislation. BEIS will analyse the CfE responses and consider the potential impacts on all primary legislation (not just the Gas Act) required to enable hydrogen blending. Gas network due diligence work could feed into this review process. An output of the review process could be a formal consultation. If primary legislation change is deemed to be required, this review process could take longer and could be undertaken in parallel with other framework change activities.

Legislative Review Only

In the target 2023 timeline, no primary legislation change is needed to deliver hydrogen blending. This shows a potential timeline of change if blending is deemed to be compatible with the existing legislation. Due to outstanding questions that need answering in relation to how blending could be implemented, it should be noted that there is a low degree of confidence that the existing legislative framework could enable blending.

CHALLENGES

Preparing legislative amendments and parliamentary processes are highly variable, depending on the content, political sensitivity, and Parliamentary logistics.

Changing such a fundamental pillar of the GB energy market as the Gas Act, or at the worst multiple Acts, would require significant evidence-gathering, political debate, and scrutiny. Assuming that no legislation change is required is an optimistic but uncertain assumption.

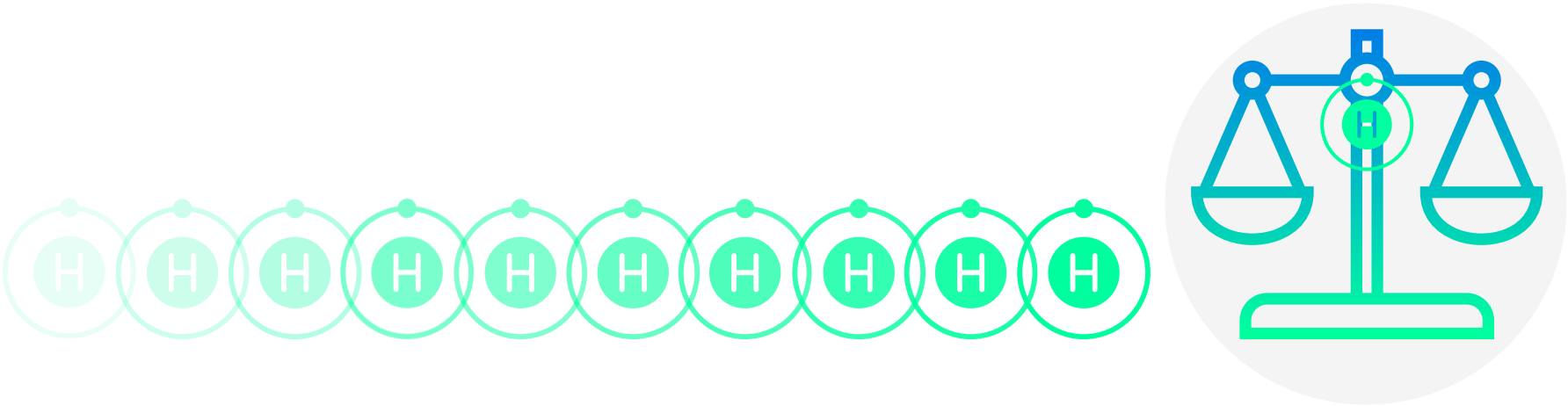
REGULATION PILLAR

Overview

This market pillar covers secondary parliamentary legislation, such as Statutory Instruments (SI), that impact the GB gas market. This type of legislation can be altered without Parliament having to pass a new Act.

The SI 'the Calculation of Thermal Energy Regulations (CoTER)' is extremely important to the GB gas industry as it sets out how end users are billed via the rules it sets out for the calculation of a flow weighted average calorific value (CV).

The shrinkage rules related to the calculation of a weighted average CV also impact biomethane producers, directly resulting in increased production costs through a requirement to add propane in their production process. The gas industry has been investigating reforms to these rules for a number of years, primarily through the Future Billing Methodology project.



CHANGE ACTIVITIES

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In Flight	BEIS Blending CBA	●	●								
Regulation	FBM/COTER Decision Making Process		●	●	●	●					
	No COTER Change (UNC Billing Change only)						●	●	●	●	
	"Enabling" Billing System Change						●	●	●	●	●
	Upfront System Feasibility				●	●					

> "IT IS EXPECTED THAT THE FUTURE BILLING METHODOLOGY PROJECT WILL DELIVER A FINAL REPORT, WHICH WILL THEN BE CONSULTED ON WITH THE INDUSTRY."

Future Billing Methodology Project – In Flight
The Future Billing Methodology project is a project run by Cadent. It has looked at a range of different future options for gas billing and will consult on options to allow alternative gases to be injected into the network without the need for pre-processing. It is expected that the Future Billing Methodology project will deliver a final report, which will then be consulted on with the industry. This will then be followed by the final project recommendations which is expected to be finished by the end of 2021.

FBM / CoTER Decision-making Process
Once the final FBM recommendations have been shared, it is then anticipated that BEIS and Ofgem will collaborate to agree what and how any changes should be implemented. It is expected that this process will include an industry engagement phase, along with an assessment on impacts to CoTER and associated Ofgem regulations. It is expected that this process will take about a year to complete. Should none of the FBM solutions be deemed appropriate then there will remain scope to proceed with hydrogen blending if a Strategic Approach to connections can be adopted.

No CoTER Change (UNC Billing Change only)
This timeline assumes the existing CoTER rules allows sufficient flexibility to implement the FBM recommendations to allow hydrogen blending without change. There is a high degree of uncertainty as to whether formal CoTER change is required or not, however it is expected that in all scenarios that there would be some level of UNC change required to deliver updated billing rules. In order to facilitate the target driven aspect of the timeline, it is expected that this UNC process could be completed within a year, which would be feasible if the proposed changes had industry acceptance.

"Enabling" Billing System Change

The project has determined that two kinds of system change will be required to deliver the requisite system changes to enable hydrogen blending. It is vital that IT systems are not a blocker to delivering the benefits associated with hydrogen blending. The project is therefore assuming that quick-win solutions will be implemented in the first instance; these have been termed as "enabling" system change.

"Enabling" system change is defined as light touch system change to deliver solutions that enable hydrogen blending to be delivered in the most appropriate fashion, building on industry experience from projects like HyDeploy.

The project recognises that enduring system change could be required in the future to deliver full automated solutions. This type of change could be delivered to meet not just a hydrogen blending solution but also using economics of scale system change to deliver solutions that meet the need of 100% hydrogen systems. In order to make the necessary changes to allow government targets to be met, the timeline has assumed that "enabling" system change could be delivered simultaneously with UNC code change for an efficient delivery process.

Upfront System Feasibility

Once government and regulator views are understood (expected to be middle of 2022) on the framework approach recommended via the FBM project, then it will be imperative to be able to deliver the "enabling" system change in a speedy and efficient way. It is therefore recommended that upfront system feasibility work is completed at the earliest viable stage to understand how quick-win system solutions could be delivered in preparation for the commencement of the formal change process. The upfront feasibility work should investigate options to deliver the system changes required to meet the needs of the industry with a view to undertaking the minimum viable change. The feasibility study should also engage the wider industry to understand impacts on third party systems from any change proposals.

CHALLENGES

It is not yet known if CoTER will need to change, but if change is required then this could have a significant impact on the proposed timelines.

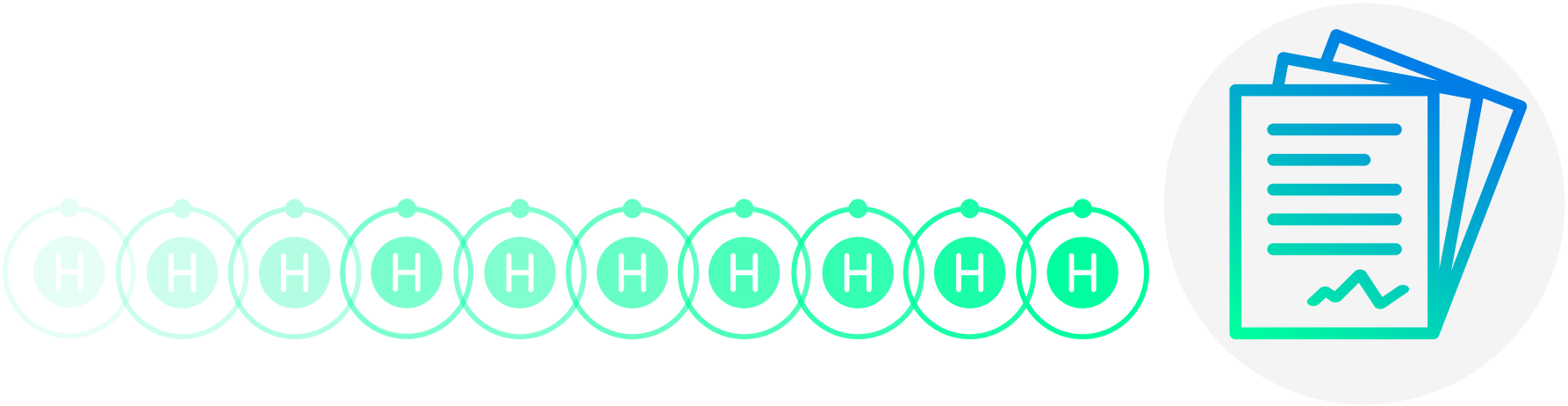
Changing a Statutory Instrument like CoTER would require some level parliamentary of oversight. Whilst it is expected that this process would be quicker than amending a full piece of primary legislation, there would still be process time to account for. This would have knock-on impacts on when code change process and associated system change processes could begin. Assuming that only UNC change is required is a realistic assumption, with a moderate probability but a high impact.

LICENCE PILLAR

Overview

The licence change process is formalised in the Gas Act 1986. The Ofgem website states that "The Gas Act (1986) prohibits certain activities unless the person carrying on that activity is licensed. There is a set of standard licence conditions for each licensable activity. Licensees are obliged to comply with the licence conditions for their type of licence from the day the licence is granted. Licensees must also become party to and/or comply with certain industry codes."

There are four types of gas licence: **Transporter**, **Interconnector**, **Shipper** and **Supplier**. It is not known how many of or to what extent the conditions within these licences would need to change to enable hydrogen network blending. Material changes to licences generally takes about five months to complete as codified in Gas Act 1986 Part I Section 23. A CMA appeal could extend this process by up to six months, but stakeholders have validated that such appeals are uncommon.



CHANGE ACTIVITIES

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In Flight	BEIS Blending CBA	●	●	●	●	●	●	●	●		
Licence	Gas Network Licence Review	●	●								
	Ofgem Led Licence Change Pre-work			●	●	●	●	●			
	Formal Licence Change Process								●	●	

> BEIS WILL COMPLETE AN INDICATIVE ASSESSMENT OF THE VALUE FOR MONEY CASE FOR BLENDING UP TO 20 PER CENT HYDROGEN INTO THE EXISTING GAS NETWORK BY LATE 2022 AND AIM TO MAKE A FINAL POLICY DECISION IN LATE 2023.

BEIS Blending CBA (In Flight)
The UK Hydrogen Strategy sets-out that BEIS will undertake a cost benefit analysis study to investigate the case for hydrogen blending. This work is a key dependency for when the formal licence change processes can begin, as it is deemed to determine the official policy position.

"We will complete an indicative assessment of the value for money case for blending up to 20 per cent hydrogen into the existing gas network by late 2022 and aim to make a final policy decision in late 2023".

Gas Network Licence Review
It is recommended that as part of the next phase of the GGG blending work, gas networks should review the licence change requirements needed to enable hydrogen blending. This work should lead to a greater understanding of what the minimum licence changes are to enable blending. The impacts on the different industry licences could vary, and therefore this work should not be limited to just transporter licence change.

Ofgem Led Licence Change Pre-work
Post the gas network Licence Review, there will be further clarity on which physical roll-out model is going to be taken forward along with initial thoughts on potential impacts on licences. This should then allow Ofgem to commence related licence change pre-work. In this period Ofgem could write modification proposals and undertake informal industry engagement to seek consensus prior to the formal licence change process beginning.

Formal Licence Change Process

It is assumed that the formal licence change process can only commence once there is policy clarity on whether hydrogen blending is going to be taken forward. The timeline expects policy certainty to be provided via the BEIS blending CBA in 2023. The timeline shows a fast-paced formal process change as it builds on the pre-work completed. The timeline therefore assumes a legal minimum of a 28-day consultation period, one-month consolidation and digestion of responses and one month for Ofgem to decide. A 56-day period between decision publication and entry into force means change effective from Q3 2023.

CHALLENGES

If the formal change process will only commence once there is policy certainty through the CBA or through primary legislation change, then either of these dependencies could have a significant impact on the licence change timelines.

The proposed indicative assessment from the CBA will be vital in providing guidance for how to proceed. Any advanced notice prior to the full completion of the CBA would help Ofgem start pre-work and give gas networks more certainty.

The timeline also assumes that there is industry willingness to commence vital pre-work before there is policy certainty; if industry players are not willing to engage early in a collaborative way then this could extend timelines. Gas networks also need to have confidence to commit resources to blending work. Messaging highlighting that work on blending will be deemed an efficient use of resources even in the event of an alternative approach being taken would be helpful. It is very important that there is clarity on how decarbonisation work is financed, especially in circumstances where a final policy decision is yet to be made. The risk of spend being deemed inefficient in retrospect could deter the collaboration and engagement required to deliver blending at speed.

CODE PILLAR

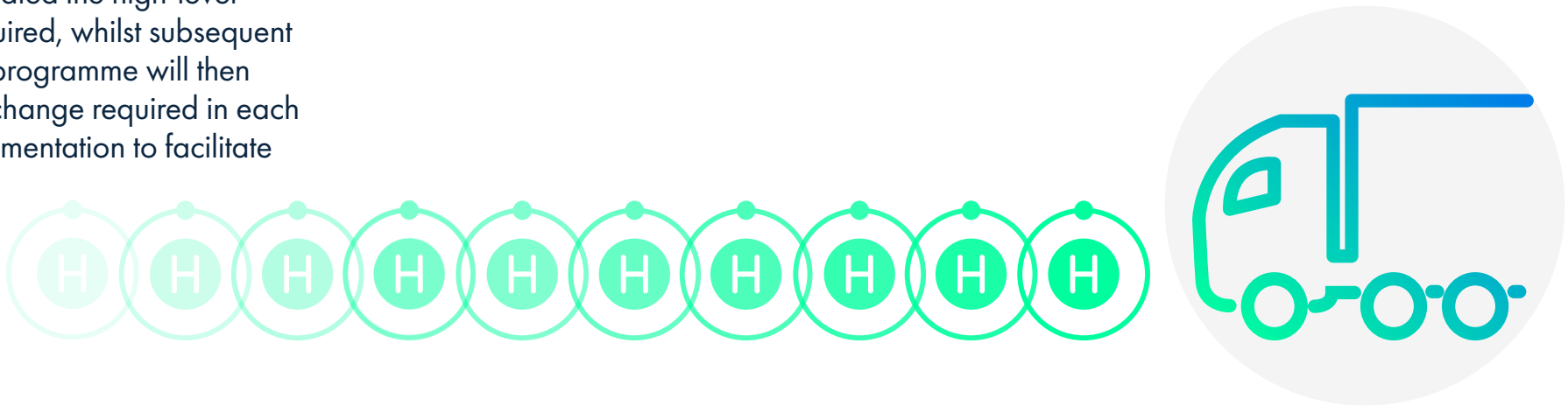
Overview

The Uniform Network Code (UNC) comprises of a legal and contractual framework to supply and transport gas. The UNC governs processes including the balancing of the gas system, network planning and the allocation of network capacity. If hydrogen is to be injected into the gas networks in a transition to a net zero future, a review of the UNC, including drafting potential amendments, will be required to ensure that hydrogen blending is allowed within the UNC framework.

The timeline has illustrated the high-level change activities required, whilst subsequent phases of the GGG programme will then identify the detail of change required in each section of UNC documentation to facilitate hydrogen blending.

Is it worth noting that there is currently an inability for gas transporters and shippers to derogate from the UNC to enable full scale hydrogen blending11. The UNC modification process is a well-used and well-defined process, which allows all signatories of the code to propose modifications and potential alternative modifications. The process also includes clear and transparent stakeholder engagement phases and can conclude with Ofgem making the final decision in certain circumstances.

There are alternatives to the UNC modification process, like a significant code review which with pro-active engagement from Ofgem could also be another option to deliver wide-ranging UNC change in an optimised way. There are several dependencies before the formal UNC modification could begin, and certainty around licence change and a formal policy position are deemed key dependencies.



CHANGE ACTIVITIES

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In Flight	BEIS Blending CBA	●	●	●	●	●	●	●	●		
Code	Gas Network Code Review	●	●								
	UNC Modification Pre-work			●	●	●	●	●			
	Targeted UNC Modifications								●	●	●
	"Enabling" System Change								●	●	●
	Upfront System Feasibility						●	●			

> IT IS EXPECTED THAT THE FUTURE BILLING METHODOLOGY PROJECT WILL DELIVER A FINAL REPORT, WHICH WILL THEN BE CONSULTED ON WITH THE INDUSTRY.

BEIS Blending CBA
The UK Hydrogen Strategy sets-out that BEIS will undertake a cost benefit analysis study to investigate the case for hydrogen blending. This work is a key dependency for when the formal code change processes can begin, as it is deemed to determine the official policy position.

"We will complete an indicative assessment of the value for money case for blending up to 20 per cent hydrogen into the existing gas network by late 2022 and aim to make a final policy decision in late 2023".

Gas Network Code Review
It is recommended that as part of the future phases of the Gas Goes Green programme, gas networks undertake pre-work to research potential UNC changes. This pre-work should look at the minimum viable changes to the code to facilitate blending. This work can feed into wider industry engagement to ensure industry alignment for a modification route to support hydrogen blending.

UNC Modification Pre-work (Extended Industry Engagement)
This is an expansion of the gas network pre-work, expanding the engagement and starting to utilise formal governance structures where appropriate. In order to meet the accelerated timelines, it is anticipated that this work will commence in Q1 2022 and runs until there is certainty from BEIS on a decision to develop hydrogen blending. The pre-work will be critical for gas networks and the wider industry to understand the level of change required to feed into a targeted UNC modification process.

Targeted UNC Modifications

Building on the collaborative industry pre-work, a targeted UNC modification process could commence in Q2 2023 after policy certainty is provided from the BEIS CBA. The proposed duration of the activity of nine months to provide the core changes to UNC is ambitious, but possible if there is strong industry-wide collaboration and coordination.

"Enabling" System Change

Associated system change is required in conjunction with modifications to the UNC. It is desirable that this change activity will be completed in tandem with the modification change process to provide an accelerated and agile timeline and ensure blended gas can get onto the network at the earliest possible opportunity. It is suggested that an upfront system feasibility assessment is completed prior to the formal change process. System change for the timeline delivers quick wins and provides the skeleton for supporting blending. This approach would maximise efficiencies as further "enduring" system change could incorporate 100% hydrogen, provided there is a decision to develop hydrogen in the Future of Heat policy 2025/26.

Upfront System Feasibility

It is recommended that upfront system feasibility work is undertaken over a six-month period, prior to the commencement of the formal UNC modification process. This early engagement would allow quick-win solutions to be developed to meet the accelerated UNC change process timelines. It could also include an engagement with connected third parties, highlighting potential impacts on their IT systems. It is also worth noting that there could be system change congestion with other industry priorities being delivered (e.g. faster switching), which could delay the implementation of required system change, again highlighting the need for early engagement and planning.

CHALLENGES

The risks for the Code market pillar are similar to those highlighted in the Licence pillar with the added complexity of delivering the related system change to meet the government timelines.

There must be an appetite for gas networks and the industry to undertake pre-work for UNC change before there is policy certainty.

Gas network and the wider industry should also begin to formulate thinking and develop groups for a wider strategic piece of work to encompass full system change for hydrogen blends and 100% hydrogen at the appropriate time. It is also worth explicitly referencing that whilst gas network system change is very likely to be required, there will also be likely change required for downstream connected shipper systems. These will need to be updated in a coordinated way.

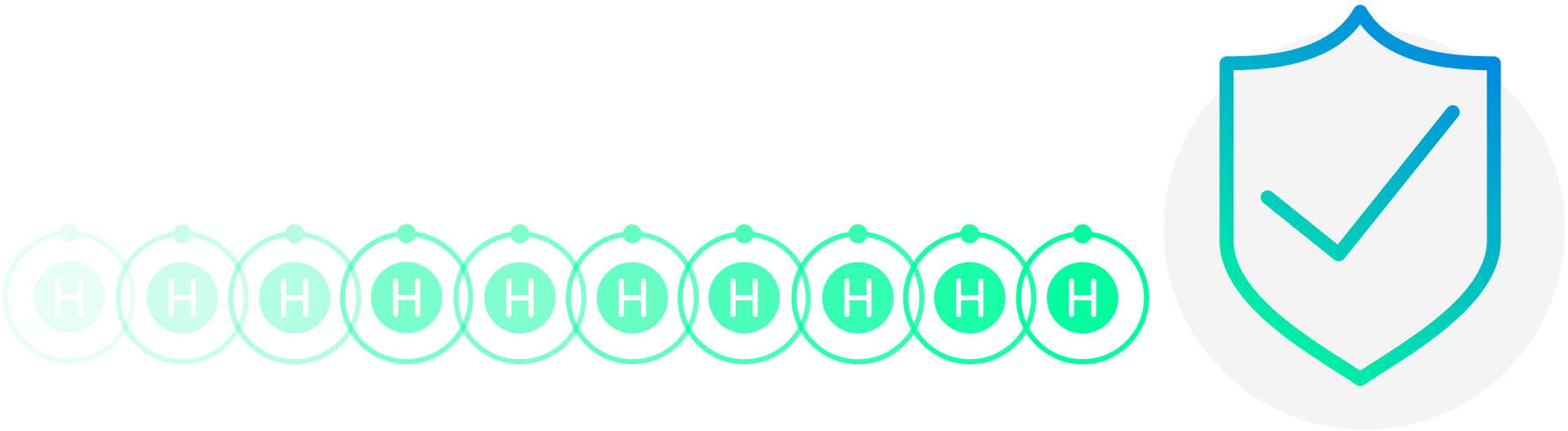
SAFETY PILLAR

Overview

Safety is of paramount importance to the operation, delivery, and utilisation of gas due to its combustible nature and potential harm from flue gases, such as carbon monoxide, in appliances. To ensure safe operations the delivery of gas to networks must be within certain pre-determined limits as set out in legislation. The current gas quality limits are set out in the GS(M)R. GS(M)R places limits on the type of gas entering the network.

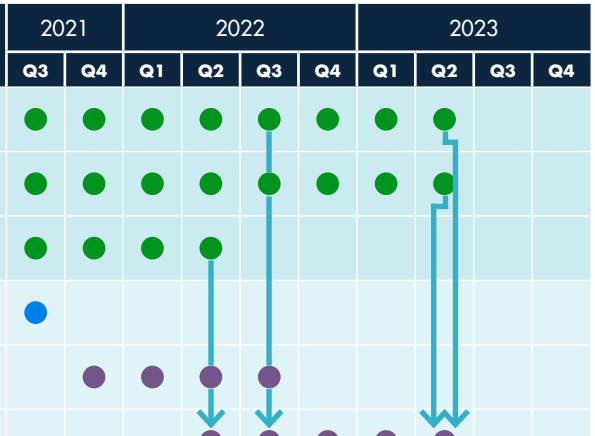
It also obligates transporters to only convey gas in their networks that conforms to these limits. Currently GS(M)R only allows 0.1% of hydrogen within the gas mix (unless an exemption is granted from the Health and Safety Executive).

The IGEM Gas Quality Working Group are preparing a case to the HSE to widen the Wobbe range of GS(M)R. The first proposed amendment to gas quality regulation does not include increasing the allowed limit of hydrogen in gas networks.



CHANGE ACTIVITIES

Pillar	Change Activity	2021		2022				2023			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In Flight	HyDeploy Project	●	●	●	●	●	●	●	●		
	FutureGrid Phase 1	●	●	●	●	●	●	●	●		
	HSE Consultation and Parliamentary Clearance – GS(M)R Phase 1 Change	●	●	●	●						
Safety (GS(M)R)	HyTechical Programme	●									
	Review of standards managed outside of IGEM		●	●	●	●					
	HSE Approvals Process/IGEM standard process				●	●	●	●	●		
	Updating HSE Safety Case for Hydrogen Blending								●	●	
	Update Existing Contracts (Existing Connections Only)								●	●	●
	Development of Connection Agreements			●	●	●	●				



HyDeploy1 and HyDeploy2

HyDeploy2 is gathering evidence to prove the safety case for blending up to 20% hydrogen into the Gas Distribution Networks. This work includes evidence gathering on the impact of hydrogen blend on industrial and commercial customers and a live trial of a 700-home network in Winlaton. This follows on from HyDeploy1, which provided hydrogen blends to buildings on Keele University Campus.

HyDeploy2 is scheduled to finish Q2 2023. The evidence provided by HyDeploy2 is a key input into the safety timeline. Ideally a decision on the HyDeploy2 evidence outputs and the completion of the BEIS CBA would be coordinated.

FutureGrid Phase 1

FutureGrid Phase 1 aims to demonstrate that the NTS currently used for transporting natural gas can be repurposed to transport hydrogen. The initial phase involves building an offline hydrogen test facility, to assess the impact that blends of hydrogen will have on NTS assets. The project involves building a hydrogen test facility from decommissioned NTS assets at Spadeadam. Flows of hydrogen blends with natural gas streams can then be tested at NTS pressures to understand the viability of NTS infrastructure for hydrogen blending. Outputs on the viability of blending are expected in Q2 2023.

HSE Consultation and Parliamentary Clearance (GS(M)R) Phase 1

The IGEM Gas Quality Working Group was set up with the principle aim of producing a new IGEM gas quality standard that includes the legal GB gas quality limits currently in GS(M)R Schedule 3. The completion of this process is estimated to be Q2 2022 and is an important feed into the timeline as it will provide the clarity on which change process is required to be completed.

HyTechnical Programme

The HyTechnical project has completed a desktop exercise to produce supplements related to the safe transmission and distribution of hydrogen. The revision of existing IGEM standards will enable the repurposing of existing natural gas networks and the design and construction of new assets for the transportation of hydrogen and natural gas/hydrogen mixtures. Although the HyTechnical programme has completed supplements to existing documents such as IGEM TD standards, there are a range of other standards that must be assessed.

Review of Standards managed outside IGEM

The HyTechnical programme developed a number of new supplements through IGEM governance and committees and reviewed supplements to existing TD standards for the distribution of hydrogen in existing natural gas infrastructure. Although this work has been critical in providing a steppingstone for industrial clusters and hydrogen trial projects to commence there are a variety of other standards that must be considered with the transition to hydrogen blends into the network. Discussions with stakeholders identified the requirement to review other standards outside of IGEM for their compliance with hydrogen blends (e.g. BSI and International standards).

HSE Approvals Process/IGEM Standard Change Process

Whilst it is anticipated that the HyDeploy project will finish in Q2 2023, it is understood that evidence from the project will be available to the HSE throughout 2022 to support their decision-making process, as shown by the red arrows on the timeline. The timeline has therefore assumed that the HSE approvals process would run between Q2 2022 to Q2 2023 to allow for HSE resourcing and review of HyDeploy evidence. There is still a lot of uncertainty as to whether a change will be needed to an IGEM Standard or exemption required from the GS(M)R Schedule 3.

The timeline has assumed a decision is going to be made Q2 2023, permitting up to 20% hydrogen blend into the Gas Distribution Networks subject to subsequent safety case and connection agreement change and thus meeting the 2023 UK Government target.

Updating HSE Safety Case for Blending

Under the target driven timeline one solution could be the use of the GS(M)R class exemption. If this is granted or if the IGEM Gas Quality Standard is changed to allow an increased level of hydrogen into the GB gas networks, individual gas networks would need to update their HSE safety case before being allowed to access the new hydrogen limits. The timeline has assumed this level of change would be classed as "material" and result in longer timescales. The timeline has allowed six months for this process to be fully completed.

Update Existing Contracts (existing connections only)

Current Network Entry Agreements stipulate the gas quality ranges at a particular site of injection. For hydrogen this will be below 0.1% as stated in GS(M)R. For blending of hydrogen onto the network, existing connections contracts will have to be amended. From a Gas Distribution Networks perspective this process can be agile with engagement between the gas network and connecting party. From an NTS perspective a modification of the UNC will need to be undertaken for changes to existing contracts on gas quality, and therefore nine months has been forecasted on the timeline. ENA are currently undertaking discussions to assess potential changes to existing contracts. It is suggested that further work should commence when there is clarity around the preferred roll-out model for blending onto the network.

Development of Connection Agreements

The timescales for development of connection agreements is based on previous experiences for amendments to agreements with biomethane connections. There are no significant barriers to the development of new connection agreements templates for hydrogen injection points. The timeline has assumed that work can be completed through 2022, once there is further clarity on the physical roll-out models to be used.

CHALLENGES

Key change activities must be conducted in a safe way. How the evidence case develops from projects like HyDeploy will have a fundamental impact on whether the safety legislation and frameworks can be amended in-line with the timelines shown.

Alongside this, there is a need for clarity over whether an IGEM gas quality standard will be created. Trying to assess potential change process timelines is challenging when there are potentially two different frameworks, one of which is not currently mature which may lead to additional delays in delivery. It should be noted that if safety regulations are unable to be updated in a holistic way, then the expectation is that the existing GS(M)R exemption process will be adequate to be utilised in the short term to continue to safely bring on-line hydrogen production facilities subject to the necessary HSE approves.

Creating clarity on how the gas quality limits and regulatory change will evolve over the decade ahead will help from a planning and engagement perspective. A roadmap of how policy makers expect the legal gas quality parameters to change would be welcomed by the industry.

7 SUSTAINED PROGRESS TIMELINE 2025 FRAMEWORK DELIVERY

The Target 2023 timeline has shown how market frameworks could be updated in an ambitious yet credible way to meet the government targets. There are many different ways market frameworks could change over the years ahead, and the idea of developing a second timeline is to provide the industry with visibility of different alternatives as a starting point to undertake the changes.

The second timeline created is called the 'Sustained Progress' timeline. It shows steady and continual progress of change across all market pillars over the next few years but showcases how with just a few minor alterations on key activities the timeline for updating the market frameworks and system could finish in 2025.

2025 Framework Delivery

Pillar	Change Activity	2021		2022				2023				2024				2025	
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
In Flight	BEIS Blending CBA	●	●	●	●	●	●	●	●								
	HyDeploy Project	●	●	●	●	●	●	●	●								
	Future Billing Methodology	●	●														
	FutureGrid Phase 1	●	●	●	●	●	●	●	●								
	HSE Consultation and Parliamentary Clearance – GS(M)R Phase 1 Change	●	●	●	●	●											
Primary Legislation	BEIS Gas Act Call for Evidence	●	●	●													
	Gas Network Regime Review	●	●	●													
	Legislative Review (including consultation)			●	●	●											
	Minimal Gas Act Change Required					●	●	●	●	●							
Regulation	FBM/COTER Decision Making Process			●	●	●	●										
	COTER & UNC Change							●	●	●	●	●	●				
	"Enabling" Billing System Change										●	●	●	●	●	●	●
	Upfront System Feasibility								●	●							
Licence	Gas Network Licence Review	●	●	●	●												
	Ofgem Led Licence Change Pre-work					●	●	●	●	●							
	Formal Licence Change (Longer than legally prescribed minimum)									●	●	●	●	●	●		
Code	Gas Network Code Review	●	●	●	●												
	UNC Modification Pre-work					●	●	●	●	●							
	Multiple UNC Modifications (and Alternatives)									●	●	●	●	●	●		
	"Enabling" System Change												●	●	●	●	●
	Upfront System Feasibility									●	●	●					
Safety (GS(M)R)	HyTechical Programme	●															
	Review of standards managed outside of IGEM		●	●	●	●			●								
	HSE Approvals Process/IGEM standard process				●	●	●	●	●	●	●						
	Updating HSE Safety Case for Hydrogen Blending											●	●				
	Update Existing Contracts (Existing Connections Only)											●	●	●	●		
	Development of Connection Agreements			●	●	●	●										

Activity Key

- Inflight / Proposed
- BEIS
- Ofgem
- BEIS & Ofgem
- Gas Network
- Industry / Others

THE DIFFERENCES BETWEEN TARGET 2023 AND THE SUSTAINED PROGRESS TIMELINES

PRIMARY LEGISLATION PILLAR

The difference between the timelines begins with the legislative review change activity; no primary legislation change is required in the target 2023 timeline. However, the sustained progress timeline showcases how the review could lead to a formal BEIS consultation and primary legislation change. Therefore, the key policy driver to enable the formal market change processes to begin moves from the completion of the CBA to the finalisation of changes to the Gas Act. As such, the Sustained Progress timeline shows the potential impact that even a small change to primary legislation can have, resulting in formal licence and code change processes beginning later in 2023. In such a case if legislative change is needed then the use of exemptions and derogations would need to be explored and considered in the short term in order to achieve the target drive timeline.

REGULATION PILLAR

The Sustained Progress timeline shows the decision-making process on the future billing framework beginning later and finishing at the end of 2022. As there is still uncertainty if changes to CoTER is required, the timeline then assumes both UNC and Regulation change is required. This process then takes 18 months and leads to significantly more system and modification change than originally planned, resulting in the framework and systems being fully completed in mid-2025.

LICENCE & CODE PILLARS

In the Sustained Progress timeline the longer lead time in getting a formal policy decision leads to piecemeal industry engagement. Coordinated industry collaboration efforts start later in Q2 2022 and last for 15 months. The Sustained Progress timeline assumes that an industry consensus on licence and code change couldn't be reached, resulting in extended formal processes, through additional consultations or alternative modifications.

SAFETY PILLAR

The key uncertainty from a safety perspective for the sustained progress timeline is the time required to approve the safety evidence to enable the gas quality frameworks to be updated. Building on the experience from the existing GS(M)R change process, even the 21 months shown in the sustained progress timeline could be seen as ambitious. If more time and evidence is required to deliver the necessary approvals for the safety change to the allowable hydrogen gas quality limits, then this will result in a delay in the safety case change and contractual change process.

The Sustained Progress timeline still showcases industry engagement and collaboration taking place throughout 2022 and 2023. It also results in all the market frameworks being updated by the end of the 2024 to enable blending, with residual system change being completed in 2025. It is important to highlight that even the sustained progress timeline has ambitious aspects to it, and without the coordination and collaboration even the timeframes within this timeline could be challenging.

8 RECOMMENDATIONS

RECOMMENDATIONS CATEGORISATION

Based on the analysis and research completed throughout the project, the recommendations have been structured into three categories

1. **GAS NETWORK ACTIONS:** THESE RECOMMENDATIONS HIGHLIGHT THE NEXT STEPS TO BE UNDERTAKEN BY THE GAS NETWORKS THROUGH THE GAS GOES GREEN PROGRAMME.

2. **CRITICAL WORK REQUIRED:** THESE RECOMMENDATIONS HIGHLIGHT POTENTIAL GAPS WHERE FURTHER WORK IS REQUIRED TO BE UNDERTAKEN ON KEY ASPECTS OF THE MARKET FRAMEWORKS.

3. **OVERARCHING INDUSTRY ACTIONS:** THESE RECOMMENDATIONS ARE THE PRINCIPAL ACTIVITIES THAT NEED TO BE UNDERTAKEN BY THE INDUSTRY TO HELP DELIVER THE MARKET FRAMEWORK CHANGE REQUIRED TO FACILITATE HYDROGEN BLENDING IN THE NEAR TERM.

GAS NETWORK ACTIONS

The gas network companies through the Gas Goes Green programme will take forward four bespoke hydrogen blending projects throughout the remainder of 2021 and into 2022.

Hydrogen Blending, Ownership, Roles and Responsibilities Project:
This project seeks to establish the basic fundamentals of how blending into the UK gas networks will actually work in practice, considering both the gas and hydrogen networks. This project will look to include an industry-wide consultation along with the methodology development recommended in Chapter 4.

Hydrogen Blending, Practical Operating Principles and Equipment Requirements Project:
This project will seek to establish at a high level the constraints for blending and the physical equipment and controls required to enable blending hydrogen into the gas network.

Hydrogen Blending, Market Regime Review Project:
This project seeks to establish the minimum required changes to the existing UNC and license arrangements to enable initial and early hydrogen blending projects to deliver a hydrogen blend into the UK's gas networks. It will also undertake any due diligence activities to minimise any primary legislation change.

Hydrogen Blending, Economic Comparison Project:
This project plans to undertake a cost-benefit analysis to appraise two methods of rolling out hydrogen blending. The new roll-out models to be included with the analysis will be consistent with those highlighted in Chapter 4.

CRITICAL WORK REQUIRED

Review of Standards managed outside IGEM:
It is recommended that there should be a review of the technical and safety standards which sit outside IGEM's remit to ensure they are aligned to enable blending. Discussions with stakeholders identified the requirement to review other standards outside of IGEM for their compliance with hydrogen blends.

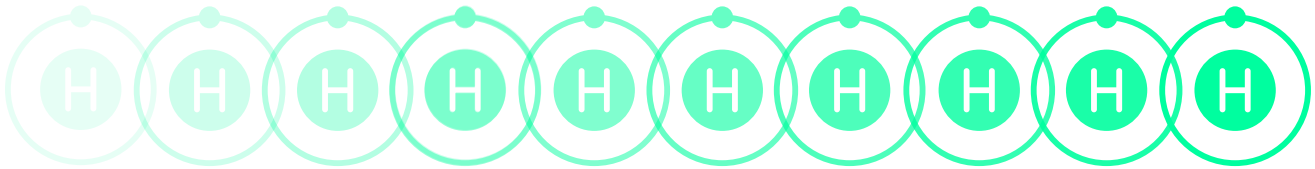
Upfront System Feasibility:
It is recommended that upfront system feasibility work should be completed at the earliest viable stage to understand potential quick-win system solutions, preparing the ground for the delivery of such solutions at the appropriate time. It is important to highlight the potential impacts to third party systems from changes to central systems; any early signal of change required would support the third party development process.

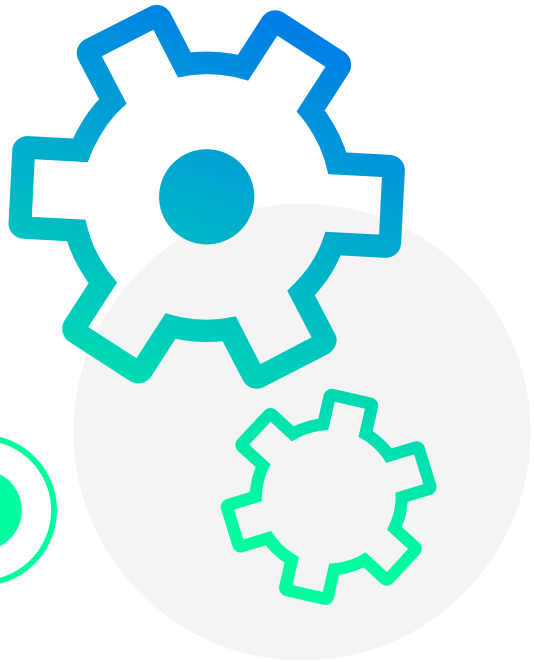
Wholesale Trading Rules:
Stakeholders have highlighted that there will be a need for work to be done to ensure wholesale trading rules and systems are prepared for hydrogen blends.

OVERARCHING INDUSTRY ACTIONS

Cross Stream Coordination:
In order to mitigate the risk of uncoordinated piecemeal change which would threaten the 2023 target, it is recommend that the 'Target 2023' timeline is utilised as the basis for a 'live plan' incorporating change plans from across the value chain (assets, operations etc) into a single plan, with robust coordination from a centralised body. It is vital that parallel working is undertaken during the framework change process, as ensuring there is communication across change streams will be a key component to delivering the changes required in a structured and coherent way.

Industry Collaboration:
Even though there is still uncertainty in the policy and safety space, it is vital that coordinated industry collaboration to prepare the market frameworks is driven forward, to ensure they become a facilitator to change and help deliver the benefits from blending. If the industry waits until there is formal policy and safety direction on blending before collaborating, then the 2023 target will not be met. Therefore, the industry needs to be prepared to engage in facilitating hydrogen blending on the understanding that it is doing so "at risk". It is also vital that those parties who are responsible for leading market changes activities (gas networks, regulators and policy makers), drive forward their activities, undertaking collaborative pre-work to ensure the relevant market changes are completed in a clear and ordered way.





KEY CONCLUSIONS

The key project conclusions can be summed up as follows.

1 2023 IS AN AMBITIOUS YET ACHIEVABLE TARGET.

The target 2023 timeline showcases how the 2023 date for market framework change can be met, through a route of minimum viable change to deliver blending.

2 EARLY POLICY CLARITY CAN ACCELERATE CHANGE.

With minimal infrastructure changes required to enable blending, the earlier policy clarity can be provided; the more it de-risks industry parties, the more it will drive up engagement and collaboration and the quicker formal change processes can commence.

3 DELIVERY OF THE TIMELINE REQUIRES CENTRALISED COORDINATION OF CHANGE PLANS.

Robust coordination from a centralised body of change plans from across the blending value stream would remove the risk of piecemeal change and ensure the change is delivered in a coherent and structured way. It is vital that change is undertaken in parallel and there is clear communication across the different work streams.

4 NEED FOR INDUSTRY COLLABORATION AND ENGAGEMENT BEFORE FINAL POLICY DECISION IS MADE.

If the industry waits until a formal policy decision is made before starting to try and answer some of the outstanding questions related to blending, it will delay the implementation of network blending. It is vital that those parties who are responsible for leading market change activities undertake collaborative pre-work to ensure the relevant market changes are completed in a clear and ordered way.

5 IMPLEMENT QUICK-WIN SYSTEM SOLUTIONS FIRST.

Central IT systems cannot be a barrier to innovation and change. Engaging with service providers at the earliest opportunity and implementing the quick wins in the first instance would reduce the potential risk of IT system change delaying the rollout of hydrogen network blending. The impacts on third party systems also need to be considered when developing quick-win system solutions to ensure the industry has time to complete their necessary changes.

STAKEHOLDERS' VIEWS ARE VERY IMPORTANT TO THE GAS GOES GREEN PROGRAMME AS THEY CAN HELP SHAPE AND ENHANCE FUTURE DELIVERABLES. IF YOU WOULD LIKE TO DISCUSS ANY ASPECT OF THIS PROJECT OR FIND OUT HOW YOU CAN GET INVOLVED IN THE WIDER GAS GOES GREEN PROGRAMME, PLEASE CONTACT ENA AT GASGOESGREEN@ENERGYNETWORKS.ORG.

ACKNOWLEDGEMENTS

The project would like to thank the various stakeholders we spoke to throughout the life cycle of the project for their time and for their insightful views, both during the workshops and in bi-lateral discussions. This includes members of the Gas Goes Green Advisory Group, the BEIS Blending Group and the Future of Gas Steering Group. Stakeholders' views will be vital in building a consensus on any future hydrogen blending regime.

STAKEHOLDERS CAN PROVIDE FEEDBACK ON THIS PROJECT OR FIND OUT HOW TO GET INVOLVED BY CONTACTING ENA GASGOESGREEN@ENERGYNETWORKS.ORG.

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