Gas
Transmission

Hydrogen Gas Market Plan

Market considerations to support a hydrogen town

nationalgrid

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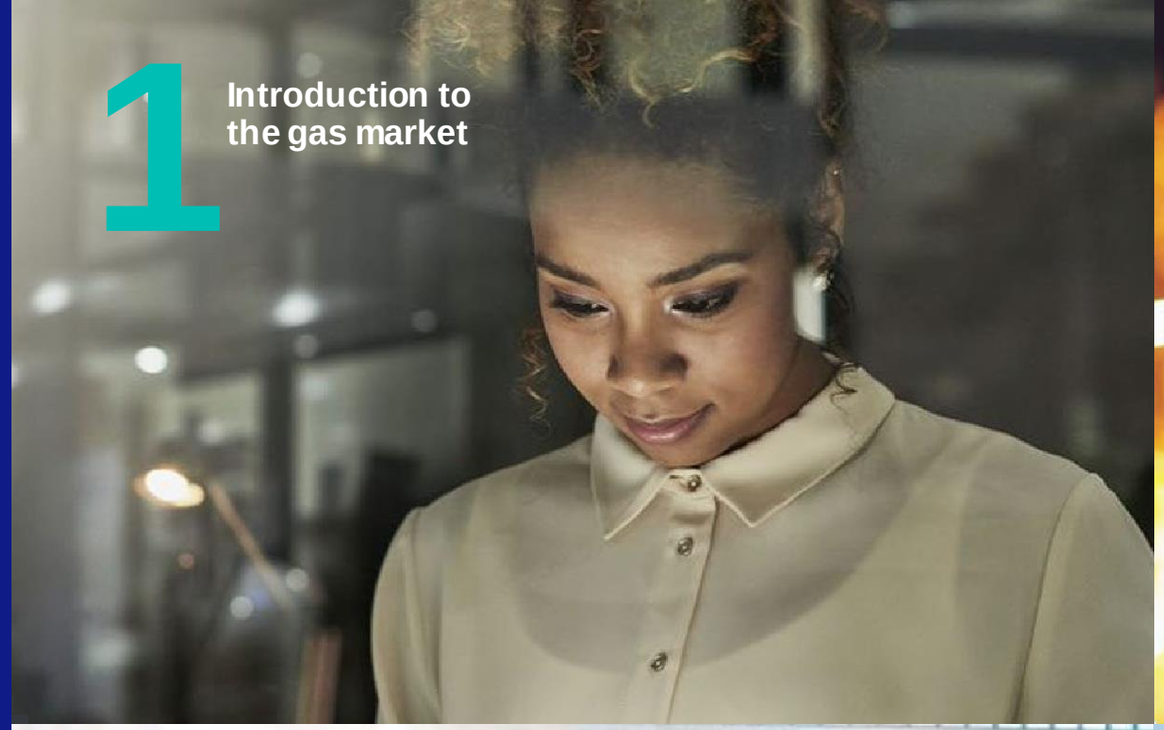


1 Introduction to the gas market

2 Introduction to the market impact of hydrogen

3 Case study on market frameworks to enable a hydrogen town

4 Next steps

1 Introduction to the gas market

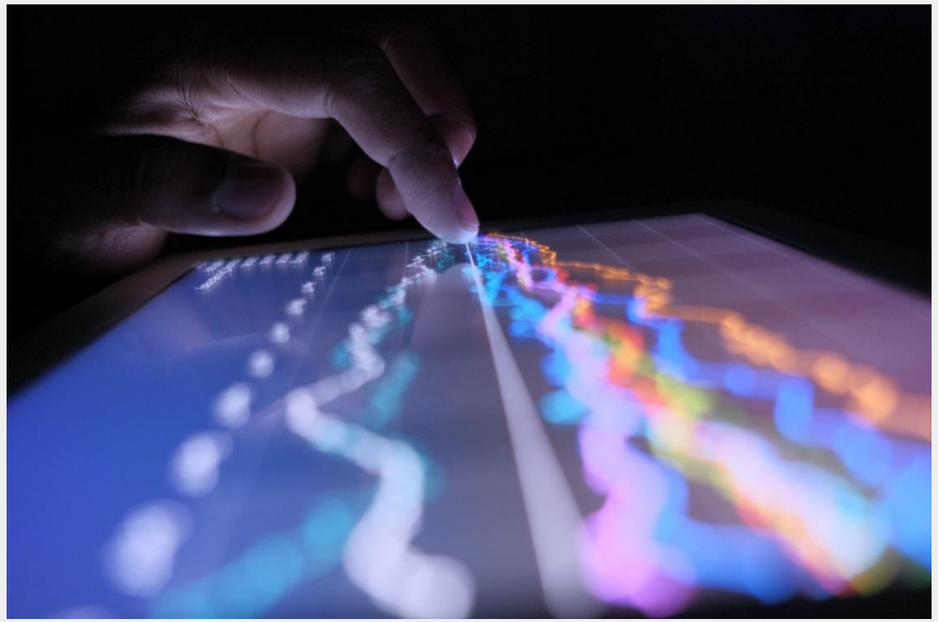
The gas market is heading into an era of unprecedented change

The gas market as we know it is set to change.

As we accelerate towards a net zero by 2050 target, we will likely move away from Great Britain's current market structure of beach to meter gas transportation, involving the transmission and distribution of gas from offshore producers to end users. Instead, we are likely entering an age of diverse and local gas generation where gas market operation will increasingly value flexibility. We are also likely leaving behind the era of top to bottom transformational change in our energy systems. Instead, we are much more likely to see an energy transformation that will grow from the roots upwards.

A clear example of transformational change is **hydrogen.** Hydrogen is expected to play a significant role in decarbonising energy consumption and could significantly impact our gas market. As an industry, we need to prepare for unprecedented changes to the way Great Britain's gas market works going forwards. We will need to consider detailed commercial framework changes as well as changes to roles and responsibilities of gas market players to prepare for a hydrogen future.

To provide helpful context to the analysis within this document, this chapter includes information on the existing gas market framework, current gas market participants and gas market functions.



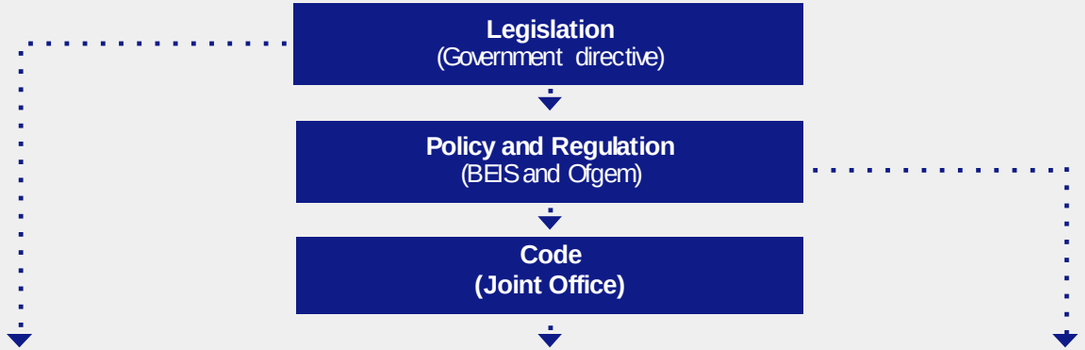
Overview of Great Britain's gas market framework

For the purpose of this document we used the following definition of a market: A market is where buyers and sellers meet to buy and sell products in a process facilitated and governed by rules.

The current gas market in Great Britain involves the supply of gas procured by shippers and traders that is transported in order to satisfy gas demand.

Gas products are bought and sold on the National Balancing Point (NBP), a process facilitated and governed by the Uniform Network Code. Although gas market participants have different rules, regulations and codes with which they must comply with, below we have outlined the hierarchy of Great Britain's existing gas market framework in figure 1:

Figure 1: Gas market framework



Primary gas legislation describes the main laws passed by the legislative bodies of the United Kingdom (UK), including the UK Parliament.

A key example of primary legislation that governs Great Britain's gas market includes the **Gas Act**, this contains the licensing arrangements for public gas transporters.

Secondary gas legislation is used to fill in the details of primary legislation and provide practical measures that enable the law to be enforced and operated in daily life. A key example of secondary legislation includes the **Gas Safety (Management) Regulations** that prescribes the management of the safe flow of gas, making it unlawful for gas to be conveyed in a system without a safety case accepted by the **Health and Safety Executive**.

Gas code establishes the rules that govern gas market operation and the terms for connection and access to the gas networks.

The **Uniform Network Code** (UNC) was implemented from the Gas Act in 1996. The UNC is the operating regime for Great Britain's competitive gas industry and is defined as the legal and contractual framework to supply and transport gas. It has a common set of rules for gas industry participants to facilitate competition on equal terms.

The UNC is managed by the Joint Office for Gas Transporters, who act as the code administrator to facilitate the smooth and efficient administration of the code.

Government policy provides signals of direction for gas market participants to prepare for.

Regulation is a policy tool used to incentivise market participant behaviours and address market failures. Market failures are usually defined as natural monopolies that are considered an essential facility, such as gas network infrastructure.

Ofgem is the Government appointed regulator for Great Britain's gas (and electricity) market. Ofgem's primary role is to protect energy consumers by promoting competition within the energy industry and regulating monopoly companies. Ofgem is also responsible for determining the content of gas licenses that contain the activities and conditions license holders (i.e. gas transporters, gas suppliers, gas shippers) must comply with.

Overview of Great Britain's gas market players

The flow diagram in figure 2 illustrates a high level overview of current gas market players and their interactions, as well as the direction of payments.

The gas flow diagram has been structured within the current gas market value chain, a value chain being the series of activities (including obtaining the resources, processing the resources, labour for all activities etc) required to deliver an end product.

Figure 2: Gas market players and their interactions

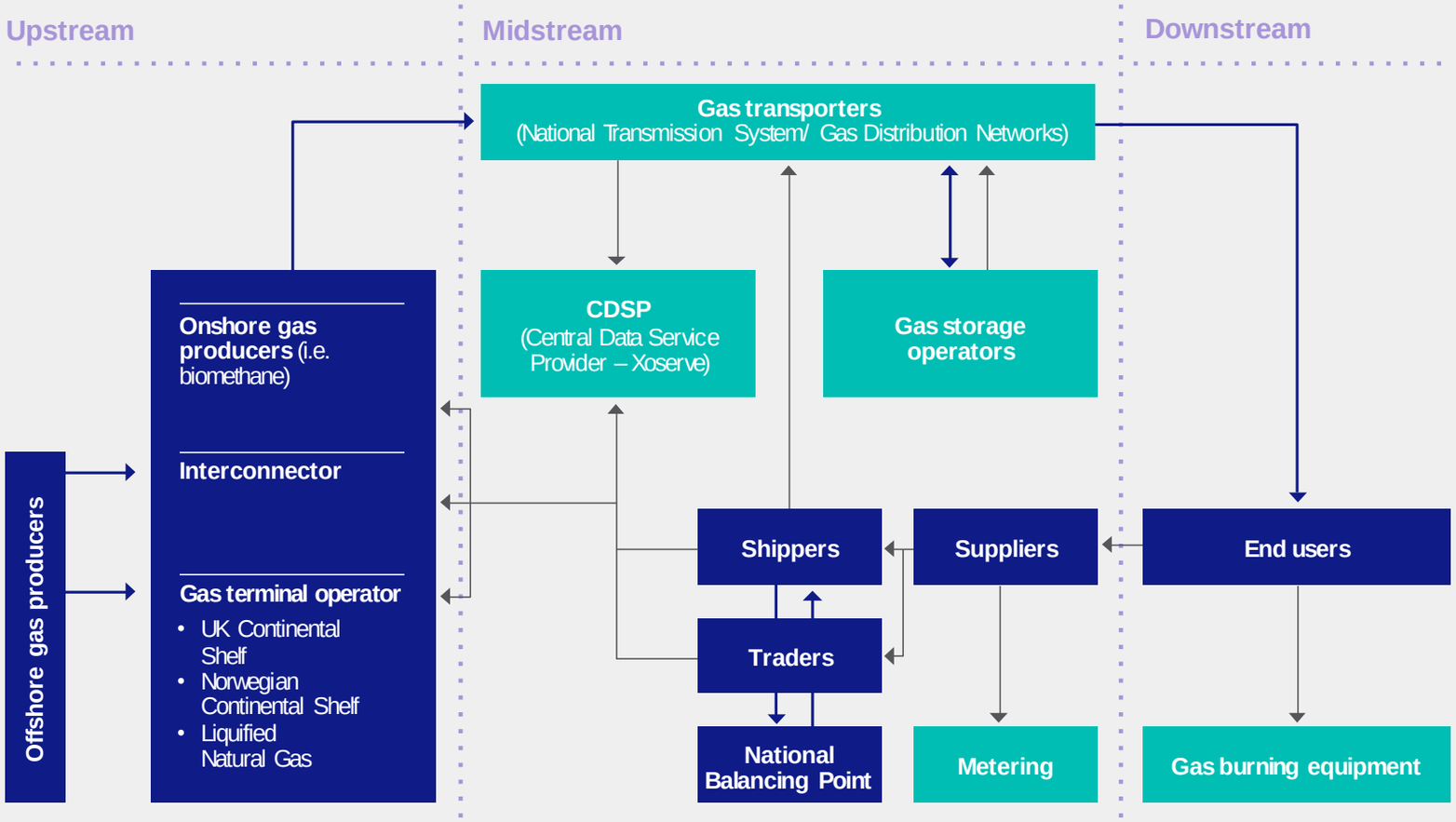


Figure 2 key:
- Movement of gas
- Service provider
- Payments
- Value chain

Overview of Great Britain's gas market principles

Market principles are the foundation of market design, and should promote competition on equal terms for all market participants.

For the purpose of this document we focused on seven market principles, and outlined these in context of the existing gas market in figure 3 (please continue to view).

Overview of Great Britain's gas market principles

Figure 3: Gas market principles

Energy Security

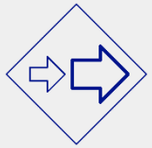
Energy security is the uninterrupted availability of energy sources at an affordable price.

Great Britain's gas energy security is impacted by a variety of factors including declining UK Continental Shelf gas supplies and changing gas supply mix due to increasing reliance on imported gas (i.e. through the interconnectors to Europe and through access to the global market in the form of Liquified Natural Gas).

Balancing

Balancing is ensuring that the same amount of gas is put into the system as is taken out.

Companies (shippers) transport gas through the National Transmission System from supply entry points to demand exit points. They are incentivised so that every day they put as much gas into the system as they take out, to match inputs with outputs.



Trading

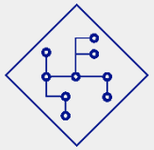
Gas trading is a tool to enable market participants to balance the gas system, hedge potential supply risk and optimise financial performance.

Shippers can trade between themselves on several markets linked to the National Balancing Point (NBP) to balance their portfolios.

Gas Quality

The quality of gas that enters the gas networks must be within pre-determined limits, primarily for consumer safety. The Gas Safety Management Regulations (GS(M)R) play a critical role in making sure the gas system operates safely and reliably.

Gas quality limits are monitored at system entry points and at specified points across the gas system.



Capacity

National Grid Gas Transmission makes entry and exit capacity available on the National Transmission System for companies (shippers) to transport gas from supply entry points to demand exit points.

Capacity booking includes the investment required for connections and to reinforce the network for new connections.

Charging

Billing consumers for gas consumed is a key aspect of charging.

In addition, gas transporters (National Grid Gas Transmission and the Gas Distribution Networks) are allowed by Ofgem to earn a specified level of return on their assets through network pricing. The cost of building and extending natural gas assets relates to the capacity they provide. The transporters' therefore raise revenue from capacity (and commodity) charges.

Connections

The National Transmission System and the Gas Distribution Networks have separate connection processes. Both the transmission and distribution networks offer three types of connection: entry, exit and storage.

Specific to the National Transmission System, in addition to the connections process customers may apply to reserve capacity for when their connection becomes operational.

System Operation is implicit, it plays a key role across each of these market principles.

Overview of Great Britain's gas market fundamentals

Finally, in figure 4 (on the following page) we have outlined some of the key market fundamentals within each of our selected market principles.

We defined the following market fundamentals as the functions within each market principle that contribute towards the operation of the current liquid, liberalised and competitive gas market.

Overview of Great Britain's gas market fundamentals

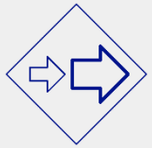
Figure 4: Gas market fundamentals

Energy security

- System planning
- Long-term demand forecasting
- Access to competitive supply sources
- Affordability

Balancing

- Nominations
- Notifications
- Storage
- Incentives
- Metering
- Short-term demand forecasting
- Data
- Constraint management
- Shrinkage

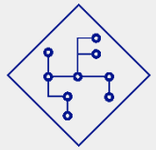


Trading

- National Balancing Point (NBP)
- On the day Commodity Market (OCM)
- Over the Counter Trades (OTC)
- Exchanges

Gas Quality

- Gas quality standard
- Entry requirements
- Exit requirements



Capacity

- Baseline capacity
- Incremental capacity
- Constraint management
- (NTS*) Capacity auctions
- (NTS) Planning and Advanced Reservation of Capacity Agreement (PARCA)
- (Interconnection Points) Capacity Allocation Mechanism (CAM)

Charging

- Settlement process
- Consumer billing
- (NTS) Commodity charges
- (NTS) Capacity charges
- (GDN*) Local Distribution Charges

Connections

- (NTS) Connection application
- (GDN) Connection application
- (NTS) Planning and Advanced Reservation of Capacity Agreement (PARCA)
- (Interconnection Point) Capacity Allocation Mechanism (CAM)

- NTS: National Transmission System specific market fundamental
- GDN: Gas Distribution Network specific market fundamental

System Operation is implicit, it plays a key role across each of these market fundamentals.

Great Britain has a mature gas market that has been designed in the context of delivering natural gas to end users. Considering a potential transition to a low carbon hydrogen future, the gas industry will need to prepare for detailed commercial framework changes as well as changes to roles and responsibilities of market players. Please continue to the next chapter to explore why we need to better understand how hydrogen could impact the gas market.

2 Introduction to the market impact of hydrogen

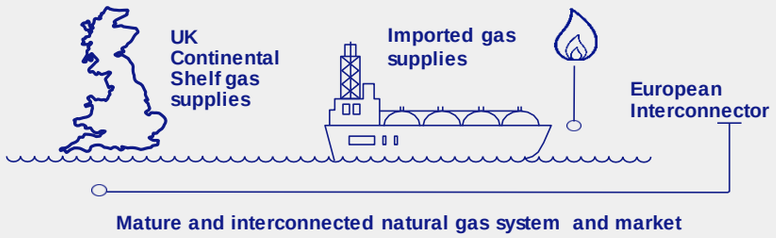
Considering a hydrogen transition for Great Britain, what is the market challenge?

If a hydrogen economy is to emerge within Great Britain, changes to existing market arrangements will need to take place.

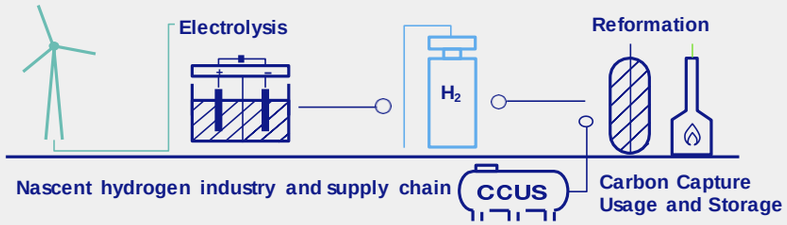
Within the tables to the right, we have identified several of the key differences between the existing mature gas market and the nascent hydrogen industry in Great Britain:

Mature natural gas market	Nascent hydrogen industry
Designed for physical properties of natural gas (i.e. UKCS* gas specification)	Different physical properties of hydrogen (i.e. Hydrogen molecules are 8x smaller than natural gas {methane} molecules and contain 1/3 of the calorific value)
Largely uniform gas quality set by Gas Safety (Management) Regulations	Lack of a hydrogen gas quality standard implemented in legislation
Liquid, competitive, liberalised natural gas market. The UK's trading hub (NBP) is ranked as the second most liquid trading hub in Europe	Lack of a hydrogen market framework
Mature gas system (Transmission and Distribution networks) with access to offshore gas supplies, interconnectors to access European gas supplies and access to global traded gas supplies through Liquified Natural Gas terminals	Existing hydrogen infrastructure is minimal, limited to private networks connecting single supply sources to a few users, with no hydrogen system connectivity
Mature value chain across upstream production, midstream transportation and downstream consumption	There are no business models to support hydrogen production or transportation and there are limited incentives for fuel switching to hydrogen
Natural gas demand spread across the UK	Hydrogen demand is concentrated in small isolated areas, such as within industrial clusters and a small number of transport refuelling stations.

* UKCS: United Kingdom Continental Shelf (offshore natural gas supplies)



Mature and interconnected natural gas system and market



Nascent hydrogen industry and supply chain

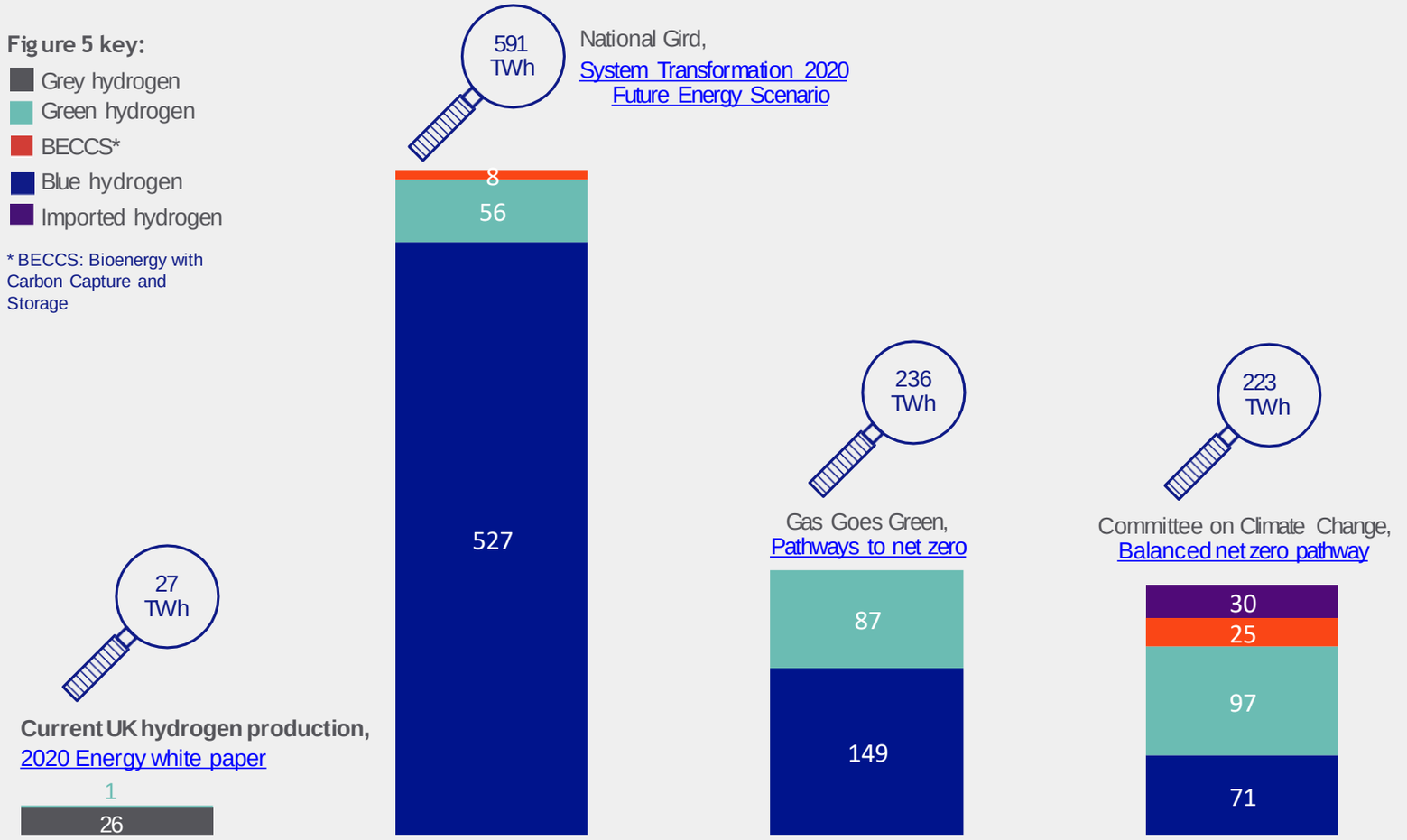
Considering a hydrogen transition for Great Britain, what is the market challenge?

Currently, there is no hydrogen market in Great Britain. The vast majority of the dominantly carbon intensive ~27TWh of hydrogen produced annually (see figure 5) is largely generated on site with demand and exchanged under bilateral contracts. There are no business models to stimulate investment in low carbon hydrogen production or transportation and there are limited incentives to fuel-switch to low carbon hydrogen.

Growing momentum from the energy industry, including recent publications from National Grid, Gas Goes Green and the Committee on Climate Change indicate that low carbon hydrogen must be deployed at scale to enable our net zero targets by 2050. However, the challenge will be developing an embryonic hydrogen industry to deliver a potential transition to a hydrogen economy.

While much of the gas industry's focus in Great Britain is currently assessing whether hydrogen technology can be used safely, with testing and trials occurring across the value chain, much less focus has been directed on the market impacts of a hydrogen transition.

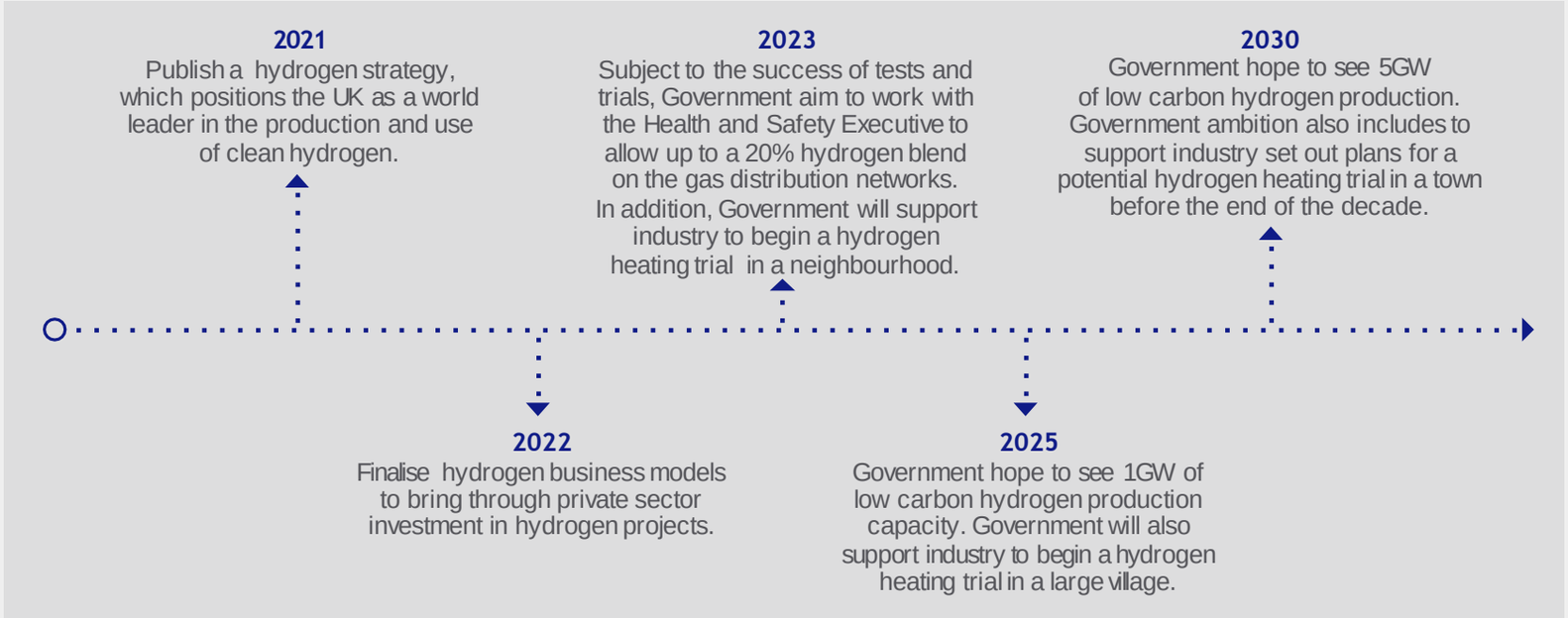
Figure 5: Comparison between current hydrogen production and projections in net zero pathways



Increasing policy signals indicate how hydrogen could develop, driving the need to better understand how hydrogen could impact the gas market

Multiple policy papers have recently been released that explore the potential role hydrogen could play within Great Britain's future energy landscape.

Key policy papers include the November 2020 Prime Minister's 10 Point Plan and the December 2020 Energy White Paper that include details on the following target milestones of Government hydrogen ambitions:



Clearly, there is a significant pipeline of policy signals to direct short-term ambitions for hydrogen development within Great Britain. However, uncertainty remains on the market impacts of a hydrogen transition.

Our approach to exploring the market impacts of hydrogen

We know that hydrogen is expected to play a significant role in Great Britain's future energy mix, and therefore will likely have a significant impact on the existing gas market.

As we have discussed, a lot of uncertainty surrounds the market impacts of a hydrogen transition. This document sets out a case study developed by the Hydrogen GMaP to explore potential market arrangements to enable a hydrogen town, with the intent to drive industry debate, decision making and change as we transition the gas system and markets towards a net zero future.

The Hydrogen Gas Market Plan (GMaP) is a stakeholder led project with National Grid Gas Transmission working in collaboration with industry, stakeholders and decision makers. We want to make sure the gas system and markets continue to deliver consumer value throughout Great Britain's potential transition to a hydrogen economy.

Hydrogen GMaP engagement approach:

The Hydrogen GMaP is a multi-stakeholder study that brings together gas networks, shippers, gas consumers, gas industry specialists, Xoserve, academia and Government to consider market change actitivies needed to integrate hydrogen into the energy mix with minimal impact to gas market participants.

3 Case study on market frameworks to enable a hydrogen town

We developed this document to explore a case study on market frameworks to enable a hydrogen town

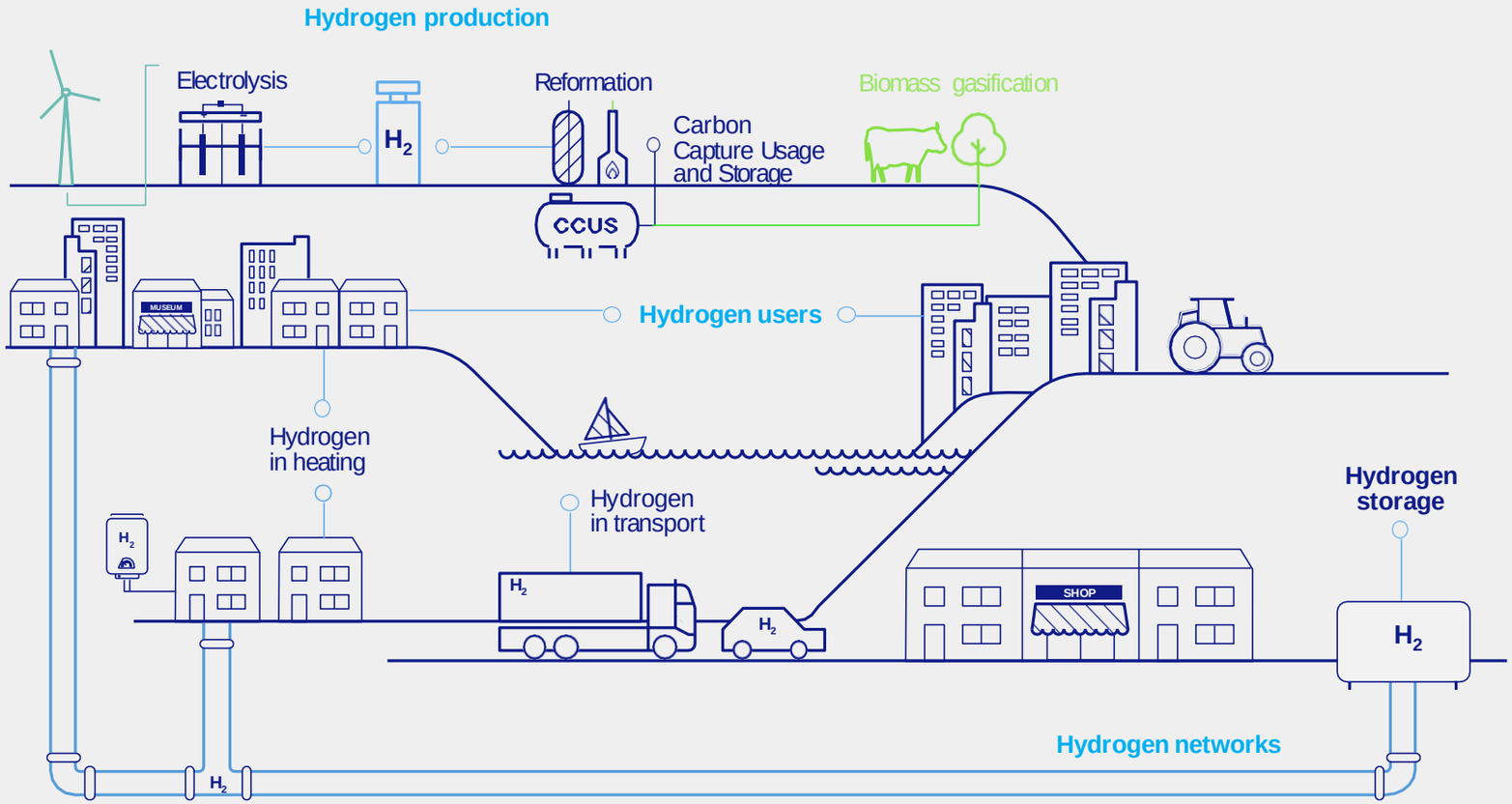
We developed this document to explore potential market frameworks for a hydrogen town. We chose this subject based on Government ambition within the Prime Minister's 10 Point Plan to support industry develop a plan for a potential hydrogen town before the end of the decade (*an ambition based on successful evidence from hydrogen trials, R&D and testing programs*).

Although a lot of uncertainty remains on the development of a potential hydrogen town, for example we don't know where a hydrogen town could be located, what infrastructure could be used or how many consumers could transition to hydrogen, for the purpose of this document we defined our view on what a hydrogen town could look like.

We know a town is a populated area that is larger than a village but smaller than a city, where a hydrogen town should include at least one hydrogen supply source providing hydrogen to buildings that have gas burning equipment (i.e. boilers) capable of accepting up to 100% hydrogen.

In figure 6 we have illustrated what a hydrogen town could potentially look like.

Figure 6: Visual representation of a potential hydrogen town



*Please note, the figure is for visual purposes only.

Assumptions for our case study on market frameworks to enable a hydrogen town

We developed the following case study on market frameworks to enable a hydrogen town based on the below assumptions:

Market frameworks for a hydrogen town should use existing market principles in a commercial arrangement that is as simple as possible to operate.

The mature natural gas market took decades to achieve its current levels of liquidity, liberalisation and competition.

Therefore, market frameworks for Great Britain's first full (100%) hydrogen town should implement basic existing market principles, and be as simple as possible to operate with minimum levels of complexity.

Until there is a reason to change existing market frameworks, such as to enable larger hydrogen systems, existing market principles should be implemented as much as possible.

Any changes to existing market frameworks should be made on a minimum changes required basis.

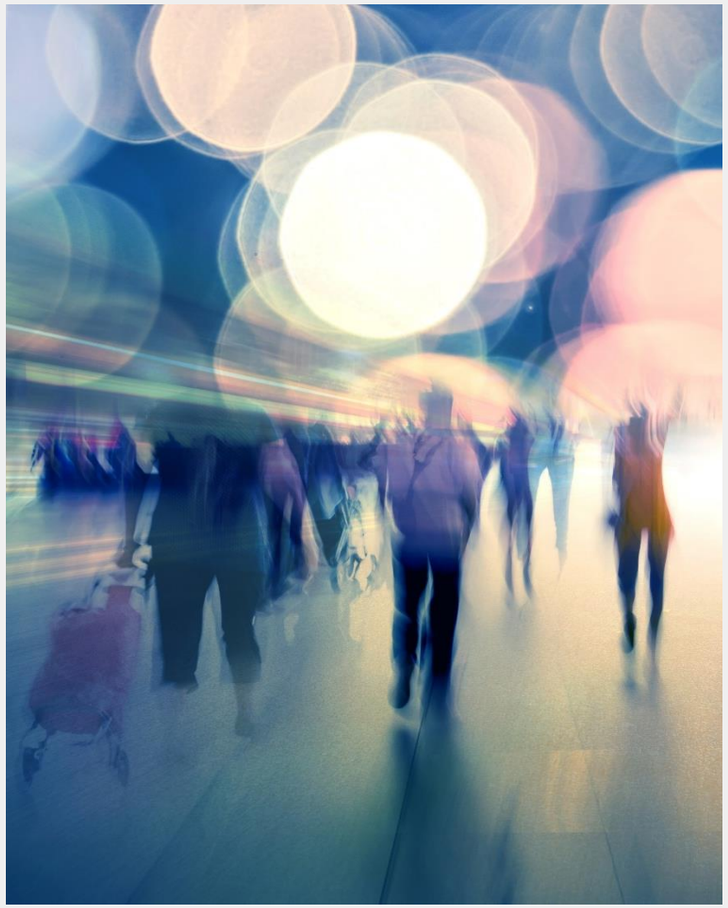
Any changes to existing market frameworks to enable a hydrogen town should be made with a view to a potential wider hydrogen transition. This should ensure that any market framework changes are aligned with future hydrogen market requirements.

Limited adaptions to existing market arrangements should be considered until watershed change is required, as triggered by a potential transition to a large-scale hydrogen economy within Great Britain.

Market frameworks for a hydrogen town should drive evolutionary changes to existing market frameworks.

The approach to a hydrogen market should be flexible and recognise that the development of hydrogen market frameworks should be an evolutionary (as opposed to revolutionary) process that develops over time.

Learnings and evidence gained from a hydrogen town should feed into a developing hydrogen market framework.



Limitations to scope

The following pages set out a case study on market frameworks for a hydrogen town, and it is important to note that we have not considered market frameworks for the below hydrogen developments:

- **Potential market frameworks for small-scale pilot hydrogen projects**.
- Market frameworks for a hydrogen neighbourhood or large village (projects outlined within the Prime Minister's 10 Point Plan) were out of our scope. We chose not to explore these examples of hydrogen development because these projects will be at such a small scale they will likely need to use entirely bespoke commercial arrangements.
- For example, the H100 project aims to develop a hydrogen heating trial, where 300 customers in Fife (Scotland) will transition to 100% hydrogen using a purpose-build new hydrogen network. The H100 project has the following bespoke commercial arrangement: 'Customers in Fife will be given the chance to participate in the world-first demonstration. Any customer that opts-in to the project will receive a free hydrogen connection, free replacement hydrogen appliances and free maintenance over the length of the project. They will pay the same amount for hydrogen gas as they would pay for natural gas.'
- **Potential market frameworks for blended hydrogen.**
- Market frameworks for hydrogen blending were out of our scope because extensive work has been completed and is ongoing in the hydrogen blending space. For further information on this topic please refer to the report on Hydrogen blending and the gas commercial framework.

Although exploration of market frameworks for the above hydrogen developments were out of our scope, it is important to emphasise that careful consideration will be needed in the transition from small-scale hydrogen pilot project projects to larger scale demonstrations, to ensure that any commercial code, legislative or regulatory changes made will also apply and work well in the transition to hydrogen use at scale.

Setting the scene for our case study on market frameworks to enable a hydrogen town

The following pages explore a case study on market frameworks for a hydrogen town, and we used the market principles on the right of this page as the basis for our analysis.

The key market benefits to be gained from initial hydrogen systems such as a hydrogen town include:

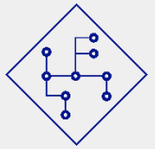
- To continue gathering the necessary evidence to improve efficiency or find alternative technologies and processes that lower the costs of hydrogen production, transportation, storage and end-use.
- To develop our understanding on what the best-fit market framework for hydrogen could look like, exploring whether the current natural gas market structure is an appropriate basis to implement a future hydrogen market, and if not, which aspects should be changed, simplified or added.
- To continue to build upon learnings provided by first of a kind hydrogen projects, to refine and develop standardised hydrogen market frameworks.

Initial hydrogen systems such as the first hydrogen town will play an important role in hydrogen market facilitation.

The emergence of a hydrogen town will likely play an important role in the evolution of market and regulatory frameworks for a wider hydrogen transition within Great Britain.

The following pages explore a case study on market frameworks to enable a hydrogen town, as well as considerations for market frameworks in an accelerating hydrogen transition beyond a hydrogen town, where more complex commercial arrangements will likely be required.

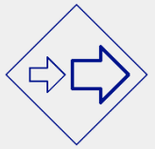
Energy Security



Capacity

Balancing

Charging



Trading

Connections

Gas Quality

Energy Security
Considerations for a hydrogen town

Market framework considerations on energy security for a hydrogen town:

- In contrast to the current mature natural gas system and market, a hydrogen town will likely only have access to a limited number of hydrogen supply sources. Therefore, a bespoke security of supply standard* will likely be needed.
  - * Current security of supply regulations includes system planning requirements to meet 1-in-20 peak demand. Further work will be needed to explore what mechanisms should be used to determine security of supply standards for a hydrogen town.
- Hydrogen storage will likely be critical to ensuring hydrogen security of supply for an hydrogen town, due to the limited nature of the hydrogen network and lack of interconnectivity with additional hydrogen systems.
- Although we do not know which production technologies could be used to supply a hydrogen town, we do know that different hydrogen production technologies require different security of supply considerations.
  - Electrolytic hydrogen would likely generate a flexible (intermittent) supply if the electrolysis facilities were powered solely from renewable* electricity (i.e. dependant on wind or solar energy). Hydrogen storage would likely be required to store excess green hydrogen supply for later use.
    - * Please note, if green hydrogen were produced from the decarbonised electricity network, the risk of intermittent green hydrogen supply would be mitigated.
  - Blue hydrogen production would likely generate a consistent (flat) supply, as reformation facilities are most efficient when operating at a consistent* rate. Hydrogen storage would likely be required to manage the flat supply profile against a variable demand profile. Additional hydrogen security of supply considerations include that blue hydrogen production relies on a de-coupled feedstock of natural gas as well as a carbon capture transport and storage process to permanently store the generated carbon by-product.
    - *Please note, autothermal reformation blue hydrogen production technology can be designed to have the ability to ramp down (reduce) hydrogen production, although this is not an efficient method to operate this technology and would not be advised for long periods of time.
- A hydrogen town would likely have a seasonal profile of demand, involving a high demand in the winter and a low demand in the summer. This seasonal profile would clearly need to be taken into account in order to optimise the size of hydrogen production facilities and potential storage facilities to deliver consistent hydrogen supplies to meet seasonal demand needs.
- The existing licensing* regime will likely need to be developed to include the roles and responsibilities of market players within a hydrogen town to mitigate energy security risks for hydrogen consumers.
  - *Please note, the 2020 Energy White Paper included Government commitment to 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 new licensing regime for previously unlicensed market players may also need to be considered for gas market players within a hydrogen town. Further work will be needed to explore the trigger for warranting a licensing requirement for previously unlicensed market players in a hydrogen transition.
  - For example, given the potential criticality of storage to security of supply for a hydrogen town, hydrogen storage market players may need to be licensed. The trigger for requiring licensing for storage market players could be linked to whether storage provision responds to market need, or if hydrogen storage is removed from price and solely developed to ensure hydrogen security of supply as hydrogen demand fluctuates.

Energy Security
Considerations for beyond a hydrogen town

Energy security questions that would need further exploration to enable a wider hydrogen rollout:

System Planning :

- Learnings and evidence from hydrogen trials should feed into how security of supply standards will need to evolve over time for hydrogen systems in a hydrogen transition.
- Hydrogen security of supply standards should assess required levels of investment (i.e. hydrogen storage, network connectivity) against the return on security of supply.
- In addition, system planning will need to consider the energy security impacts for all gas consumers in a hydrogen transition scenario where the natural gas network reduces as hydrogen networks accelerate.

Access to competitive supply sources:

- Further work will be needed to assess which market players own and operate components of a hydrogen system value chain (i.e. hydrogen production, transportation, storage etc) and how competition in a hydrogen transition can be facilitated on equal and fair terms for all market participants throughout a hydrogen transition.

Balancing
Considerations for a hydrogen town

Market framework considerations on balancing for a hydrogen town:

- The tools available to the System Operator* for a hydrogen town would have to ensure the limited hydrogen network remained physically and commercially balanced.
- Further work should consider the extent to which existing balancing market principles apply for a hydrogen town. For example:
  - In the existing balancing regime, shippers have the primary responsibility to balance the gas system, and the System Operator has the role of residual balancer (this involves stepping in to take balancing actions only if necessary, where the System Operator accesses the market to buy and sell gas to move the price and incentivise shippers to balance supply and demand). For a hydrogen town, factors such as the hydrogen production technology (or technologies) and the number of market players, will influence the level of central control that will be required to ensure system balance (as well as energy security), and to what extent existing balancing market principles will be applicable within a hydrogen town.

  - A hydrogen town network will be much smaller than the existing natural gas network, therefore the time for hydrogen production to be transported to meet hydrogen demand will be much shorter. Further work should assess whether the existing daily balancing regime would be appropriate for a hydrogen town network, or if shorter more granular balancing would be a best-fit option for a hydrogen town.
- There is also likely a strong case for hydrogen storage to meet balancing needs (both for daily, inter-day and inter-seasonal balancing needs) for the hydrogen town network, as well as to ensure security of supply for hydrogen consumers.

* Please note, we have defined the role System Operator as the party responsible for managing flows on a network securely, economically and efficiently, as well as managing access to and off the network. Although the role of System Operator may require a different title for its function within a hydrogen town (due to the limited nature of the hydrogen system), the function of a System Operator for a hydrogen town is likely still required.

Balancing
Considerations for beyond a hydrogen town

Balancing questions that would need further exploration to enable a wider hydrogen rollout:

Balancing regime:
- Depending on how hydrogen emerges within Great Britain's energy mix (i.e. the potential for regionalisation of hydrogen), there may be a need to introduce more granular balancing for hydrogen networks. Further work is needed to evaluate whether existing daily balancing arrangements will continue to be a best-suited market principle in a hydrogen transition.

Incentives:
- In a hydrogen transition, it is likely that increasing interactions between the gas and electricity markets will occur. For example, green hydrogen production will likely impact both the electricity market and the gas market. As we accelerate towards net zero targets, rules and incentives will likely need to be developed to benefit the whole system, taking into account both gas and electricity networks.

Shrinkage:
- Further work is needed to evaluate how a hydrogen transition could drive a shrinkage regime fit for purpose for hydrogen systems.

Data and demand forecasting:
- Further work is needed to explore how different hydrogen production technologies could affect balancing information provision for network System Operators and market participants.

Constraint management:
- Further work may be needed to explore how the emergence of hydrogen (i.e. regionalisation of a hydrogen rollout) could drive hydrogen network balancing arrangements and the suite of balancing tools including constraint management.
- Further work is also needed to explore how hydrogen storage could play a role in mitigating constraint management risks and balancing hydrogen networks, through flexibility provision to maintain consistent levels of hydrogen supply.

National Balancing Point (NBP*):
- As per our stated assumptions, we assumed the existing role of the NBP would continue through a hydrogen transition. In addition, we assumed a hydrogen town would be too small scale to affect the existing operation of the NBP.
- However, further work is needed to evaluate the trigger point for when the NBP could be impacted by a hydrogen transition. Depending on how hydrogen emerges within Great Britain, the continued use of the existing NBP may be appropriate, or could drive the need to establish a separate Hydrogen National Balancing Point. This question is especially relevant when considering how an accelerating hydrogen transition could lead to a shrinking natural gas market.
- *The NBP (National Balancing Point) is a virtual point where all gas is deemed to go through before leaving the National Transmission System. The NBP is a virtual trading point, where shippers nominate their buys and sells and where the Gas System Operator carries out daily balancing activities.

Trading
Considerations for a hydrogen town

Market framework considerations on trading for a hydrogen town:

- A hydrogen town will likely not require trading arrangements. This is because there likely will not be sufficient market players to generate an efficient traded market.
- Forcing market arrangements such as trading, when in reality a system may be too limited to require trading, could add unnecessary commercial complexity to a limited hydrogen system.
- However, if there is no traded market for the System Operator to participate in to influence the behaviour of hydrogen supply and demand, this may influence the level of central control required to ensure system balance and security of supply for the hydrogen town system.
- An alternative option to enable the hydrogen network System Operator to economically signal to market players (i.e. to adjust hydrogen supply to maintain system balance), could include the development of a commercial mechanism to indicate to hydrogen producers to reduce or increase production.

Considerations for beyond a hydrogen town

Trading questions that would need further exploration to enable a wider hydrogen rollout:

Trading:

- To facilitate a hydrogen transition for Great Britain, hydrogen trading arrangements will need to be developed to allow the discovery of efficient commodity prices.
- Hydrogen trading market questions that need further exploration include:
  - What could be the trigger point for requiring hydrogen trading (i.e. how many market players, such as shippers, are needed to effectively initiate a traded market? At what point does a network get to a size where a liquid traded market becomes valuable?)
  - Would regional traded markets function, would there be enough liquidity?
  - Should different types of hydrogen (based on their production technology) be traded as separate products with distinct prices*? What could be the commercial impact of not trading different types of hydrogen, and instead trading a homogeneous hydrogen product?
  - * Please note, hydrogen product pricing will depend on the outcomes of hydrogen business models, where Government aims to finalise hydrogen business models by 2022.
  - What role could Guarantees of Origin play in trading different hydrogen products based on the carbon impact of different hydrogen production technologies?
- In a hydrogen transition, further wok will also likely be needed to explore the systems that may need to be in place to ensure that products traded for commercially, physically reach their intended end user.

Gas Quality
Considerations for a hydrogen town

Market framework considerations on gas quality for a hydrogen town:

- The Hy4Heat hydrogen gas quality standard is likely to be used as the hydrogen specification within a hydrogen town, the Hy4Heat standard is set at a minimum of 98% hydrogen purity.
- An exemption to the existing gas quality standard (Gas Safety (Management) Regulations) will likely be required to enable a hydrogen town.
- The selected hydrogen production technology (or technologies) for a hydrogen town will likely generate slightly different gas qualities. Market frameworks for a hydrogen would have to take this into consideration to avoid prejudicing one technology over another. For example:
  - Blue hydrogen: Blue hydrogen facilities would be designed to generate the minimum required 98% hydrogen purity, however blue hydrogen will likely have lower hydrogen purity than green hydrogen.
  - Green hydrogen: Currently technology produces above 99.9% hydrogen purity.
- Further work is needed to explore the risk of contaminants to hydrogen gas quality, if existing gas pipelines are repurposed to transport hydrogen.
- It is key to note that fully converted hydrogen systems will not experience the levels of gas quality swings that is the current reality of the existing natural gas system. To provide further context:
  - Natural gas is not a single gas, but a blend of gases including methane, ethane, propane etc. The quality of natural gas can vary widely between different gas fields. This variety of gas quality in natural gas supplies has an important influence on existing market frameworks, including current gas quality standards and charging arrangements.
  - In contrast to the existing natural gas system, a hydrogen town will not have to accommodate for wide gas quality swings. However, there will likely still be trace gas quality parameters that the hydrogen transporter would need to monitor and potentially curtail the flow if breached. This could potentially highlight a security of supply risk, as a hydrogen town will likely have a limited number of hydrogen producers, as opposed to the currently highly interconnected natural gas system.
- For consumers within a hydrogen town who require a hydrogen purity above the implemented standard (such as hydrogen transport consumers), these higher hydrogen gas quality requirements will likely need to be resolved at point of use.

Gas Quality
Considerations for beyond a hydrogen town

Gas quality questions that would need further exploration to enable a wider hydrogen rollout:

Gas quality standard:

- To enable a hydrogen rollout, it is likely that a hydrogen gas quality standard will need to be developed and implemented into secondary legislation, the appropriate regulation (i.e. network licenses) and code (i.e. hydrogen network entry connection agreements) .
- Consumer engagement and research should provide insight on diverse consumer hydrogen gas quality acceptability and/or requirements, to feed into the development of a hydrogen gas quality standard.
- In a hydrogen transition, regionally flexible gas quality standards could also be considered to take into account factors such as:
  - Regional emergence of hydrogen
  - In the case of repurposing existing pipes to hydrogen, a gas quality standard that can be changed over time as different hydrogen production technologies emerge and contaminants within pipes are eliminated.

Network exit connection agreement gas quality requirements:

- In a hydrogen transition, further work should evaluate whether gas quality specifications should be included within exit* connection agreements, to take into account specific hydrogen consumer gas quality needs.
  - * Existing network exit agreements do not include a specific exit gas quality specification, although the transporter must provide gas that is compliant with Gas Safety (Management) Regulations.
- Further work is also needed to explore the role de-blending technology could play at network exit points to deliver hydrogen gas quality requirements to consumers.
  - De-blending technology could play an important role in providing the purity of hydrogen required by consumers, such as hydrogen transport customers who require high levels of hydrogen purity for use in fuel cells.

Capacity
Considerations for a hydrogen town

Market framework considerations on capacity booking for a hydrogen town:

- Access arrangements (both for capacity and network pricing) would need to be developed and in place between hydrogen producer(s) and the hydrogen town network owner and operator.
- There are several options for how network capacity could be accessed for the hydrogen town network, including:
  - Capacity could be bought for each day, or a fixed payment could be in place for a year of capacity (etc).

Considerations for beyond a hydrogen town

Capacity booking questions that would need further exploration to enable a wider hydrogen rollout:

Capacity allocation:

- In a hydrogen transition, network access requirements from hydrogen producers will likely add complexity to the existing gas network capacity allocation processes, especially if existing gas networks are repurposed to transport hydrogen.
  - However, considerations for capacity allocation mechanisms on hydrogen networks should be arranged in alignment with the development (i.e. wider rollout) of hydrogen infrastructure and hydrogen system connectivity.
- If a hydrogen rollout emerges in a regional manner, further work will likely be needed to explore how capacity allocation for regional hydrogen networks could function.
- Different hydrogen producers may require different types of capacity products, as some producers will be able to produce consistent and flat supplies (i.e. blue hydrogen), while other produces may operate more flexibly (i.e. green hydrogen). Capacity allocation mechanisms would likely be required to ensure System Operator dispatch mechanisms did not prejudice one hydrogen technology over the other.
- Based on learnings and evidence from hydrogen trials and triggered by an accelerating hydrogen transition, a standardised hydrogen capacity allocation process for the gas networks would likely need to be developed and implemented into a hydrogen network code.

Charging
Considerations for a hydrogen town

Market framework considerations on charging for a hydrogen town:

Consumer billing:

- Billing for hydrogen consumers within a hydrogen town will have to be a fully transparent process:
  - Consumers within a hydrogen town will likely be moving from the existing competitive natural gas system to a monopoly hydrogen system (i.e. it is likely a hydrogen town will be supplied by a limited number of hydrogen production facilities). Transparent billing (i.e. how prices are controlled) will be very important for consumers in a hydrogen transition.
- The outputs of the Future Billing Methodology project should provide solution options for billing consumers within a hydrogen town. For example, a potential solution option could include the use of a local charging zone to encompass the billing arrangements for a hydrogen town. In addition, learnings gained from smaller hydrogen pilot projects (such as the H100 project) should provide valuable lessons for consumer billing within a hydrogen town.
- Prices of hydrogen could be regulated (as a monopoly system), with a set price for pence per kWh of hydrogen.
  - Different prices could be set for different hydrogen customers that have different requirements (i.e. specific hydrogen purity, ramp rates etc) within a hydrogen town. For example:
    - Separate hydrogen prices could be set for hydrogen domestic heat customers, transport customers and commercial customers.
- Continuing the precedence set by the H100 project, hydrogen consumers could have access to the same supply competition as current gas consumers. This would mean that hydrogen town consumers could still have the ability to switch between suppliers for their hydrogen consumption.
  - However, whether hydrogen prices are regulated or market determined would inform whether or not consumer choice in relation to a supplier would be of value.
  - In addition, if there are only limited hydrogen producers for a hydrogen town, an assessment would likely be needed to determine how much value the ability to change supplier would add for consumers, and if there were any risks or costs associated with this market framework complexity.

Network pricing:

- A bespoke network pricing arrangement for a hydrogen town will likely be required until the appropriate trigger in Great Britain's hydrogen transition drives the need to develop and implement standardised hydrogen network pricing arrangements.
- A bespoke network pricing arrangement will allow hydrogen demonstrations such as a hydrogen town to innovate different network pricing solutions.

Charging
Considerations for beyond a hydrogen town

Charging questions that would need further exploration to enable a wider hydrogen rollout:

Network pricing (capacity and commodity charges):

- Further work is needed to evaluate how gas networks in a hydrogen transition are funded. Key unresolved charging questions include:
  - If existing Regulated Asset Based networks are repurposed to hydrogen, how should the risk of cross-subsidisation be avoided?
  - Who will pay for hydrogen network assets, including repurposing existing and the development of new assets? Should the cost be socialised across all gas users, targeted to the users who benefit, or should a combination of both approaches applied?
  - How do existing network pricing methodologies need to change to accommodate hydrogen and ensure cost-reflectivity?
  - How could the operating costs of hydrogen network System Operator(s) be fairly distributed if hydrogen emerges in a regional manner?
  - Should hydrogen network capacity charges be different for different customer needs, and how should this be charged? For example, should different charges be applied for users such as domestic heat customers, industrial users with unpredictable loads and power generators imposing ramp rates?
  - How should hydrogen network connection charge methodologies be developed?

Settlement process and consumer billing:

- Further work is needed to explore critical unresolved market questions relating to consumer billing including:
  - Will current metering arrangements be adequate in the transition to hydrogen? If not, what solution options should be implemented to ensure accurate metering can feed into consumer billing?
  - How could hydrogen charging arrangements affect existing consumer billing systems?
- Using evidence and learnings taken from the Future Billing Methodology project and hydrogen trials, the development of transparent, accurate and robust billing methodologies will likely need to be standardised and implemented into hydrogen system regulation and hydrogen network code.

Connection
Considerations for a hydrogen town

Market framework considerations on connections for a hydrogen town:

- A network connection contract will likely need to be developed for entry (hydrogen supply), exit (hydrogen consumers) and storage connections to the network for a hydrogen town. This could involve an adaption of existing connection agreements.
- Due to limited hydrogen demand requirements from a hydrogen town, it is likely a limited number of hydrogen production facilities would be required to connect (entry connection) to a hydrogen town network.
- For hydrogen supplies connecting to a hydrogen town network, the network entry connection offer would be agnostic to the hydrogen technology being connected to the network.
- In contrast to existing* license obligations, the network transporter for a hydrogen town would likely have to evaluate on a case by case basis whether it would be possible to accept additional hydrogen supplies (entry connections) or hydrogen customers (exit connections).
- *Existing gas transporter licenses include an obligation to meet all reasonable demands as long as it is economic to do so. However, the limited nature of a hydrogen town network would likely require additional evaluation before proposed additional hydrogen supply and hydrogen demand could be connected.

Considerations for beyond a hydrogen town

Connection questions that would need further exploration to enable a wider hydrogen rollout:

Connection application:

- Further work is needed to evaluate how connection contracts to hydrogen networks (both for Entry and Exit and for storage) would need to be developed to accommodate a growing hydrogen transition within hydrogen market frameworks.
- Further work is likely needed to explore how network entry connection agreements could be developed to ensure that the risk of prejudicing one hydrogen production technology over another would be avoided in an accelerating hydrogen transition.
- Further work could also explore whether location connection incentives could be used to drive commercial decisions on where hydrogen producers connect to networks, to benefit the efficient operation of a hydrogen transition.

Broad hydrogen market framework considerations, beyond a hydrogen town

We developed this case study on market framework considerations to enable a hydrogen town based on assumptions that the market framework should be as simple as possible to operate, any changes to existing market frameworks should be limited and that all market framework learnings should be used to develop a standardised hydrogen market framework.

Evidence gained from hydrogen trials such as a hydrogen town will develop our understanding on whether the existing gas market framework is an appropriate basis to implement a hydrogen market, and if not, which aspects of the existing market frameworks should be amended, simplified or added to.

Below we have outlined further exploration on options for hydrogen market framework development, beyond a hydrogen town:

- **Continue to develop existing market frameworks:**
  - Existing market frameworks could be developed to accommodate an accelerating hydrogen transition within Great Britain.
  - The benefits of continuing to develop existing market frameworks include that a known framework would be used as the basis for hydrogen market frameworks.
- **Generate new market frameworks:**
  - This solution option would also likely include enduring sections of existing market frameworks that would be taken forward within a new hydrogen market framework.
  - Developing new hydrogen market frameworks could be an opportunity to start afresh, and develop market frameworks that are easier to use and relevant to a modern, decarbonised gas system.
  - Developing new hydrogen market frameworks could be a more efficient route, depending on how complex and timely the process would be to develop existing market frameworks to accommodate hydrogen.
- **Hybrid approach**
  - Another approach could include generating new market frameworks to manage an initial hydrogen transition, and over time implementing existing market frameworks.

All of these solution options could still enable a hydrogen market framework to evolve over time, taking into account the complexity of change to accommodate an accelerating hydrogen transition for Great Britain's gas market participants.

4 Next steps

Next steps

There is a lot more work to do to prepare for a potential hydrogen economy in Great Britain.

Considering the growing momentum behind the role hydrogen could play in a net zero Great Britain, it is important that market frameworks do not act as a barrier to a potential hydrogen transition.

Clarity from Government on long term hydrogen ambitions will help support the gas industry to take early action on market framework considerations that have a long lead time.

In the meantime, collaboration between gas market participants will be critical to the development of hydrogen market frameworks.

Collaborate with us.

The Hydrogen Gas Market Plan project will continue to work with gas market participants to prepare for the transition to a hydrogen system and market.

Our upcoming Hydrogen GMaP projects will output:

- Deep dives into specific hydrogen topic areas that could have a market impact over the next 2- 10 year timeframe
- Recommendations to modify existing market frameworks (i.e. legislation, regulation code)
- Evaluation of new market rules, signals or tools needed to accommodate the addition of hydrogen into the energy mix.

Your input will help us to outline the key market change activities needed to integrate hydrogen into Great Britain's energy mix at minimal impact to gas market participants.

You can email us directly to get involved in our upcoming projects, or to find out more information about the Hydrogen Gas Market Plan:
box.FOGForum@nationalgrid.com

To find our more information or to get involved in the Hydrogen Gas Markets Plan, please view our website or email us at: **box.FOGForum@nationalgrid.com**

Hydrogen GMaP website

Future of gas website