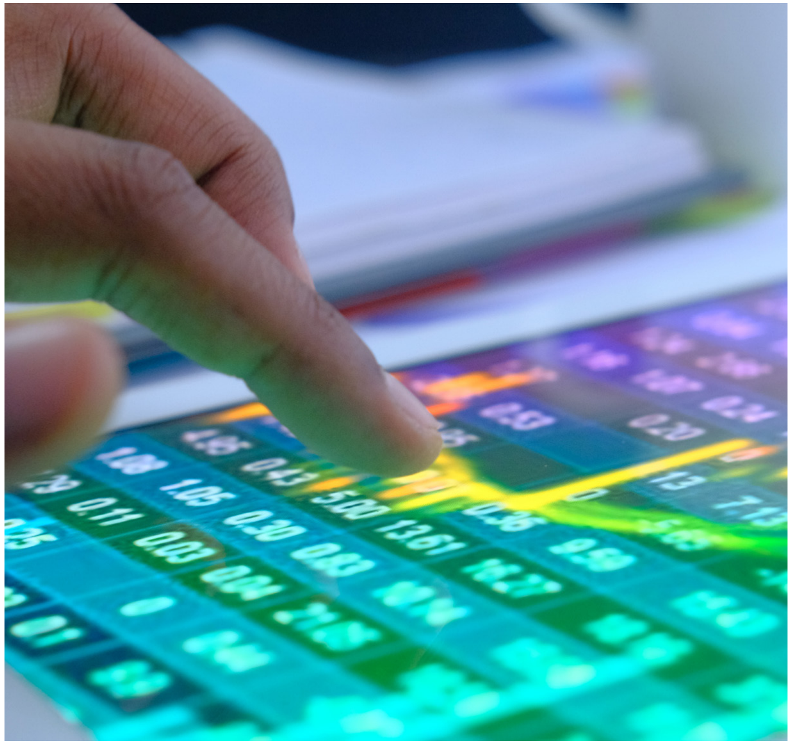
national gas

Hydrogen Gas Market Plan: Report on a commercial framework for Project Union



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Executive summary

To deliver this Hydrogen Gas Market Plan (GMaP) project, National Gas Transmission (NGT) collaborated with a working group representing the UK gas industry value chain (Fig.1), to explore how the existing gas sector market design and commercial frameworks may need to evolve to accommodate the development of Project Union and potentially other future 100% Hydrogen Gas Transmission Networks.

Project Union is an NGT flagship project that aims to repurpose a quarter (about 2,000 km) of the existing gas National Transmission System (NTS) network to develop a full (100%) hydrogen 'backbone network' by the early 2030's.

The objectives of Project Union include:

- Connecting hydrogen supply and storage to demand, initially linking strategic hydrogen production such as the industrial clusters, and providing the option to expand this initial network to connect additional consumers
- Delivering hydrogen system resilience with interconnectivity across the UK and with the European Union (EU), as well as by connecting to storage facilities
- Facilitating a UK hydrogen market.

Figure 1: Hydrogen GMaP working group

Project Union is an NGT flagship project that aims to repurpose a quarter (about 2,000 km) of the existing gas National Transmission System network to develop a full (100%) hydrogen 'backbone network' by the early 2030's.

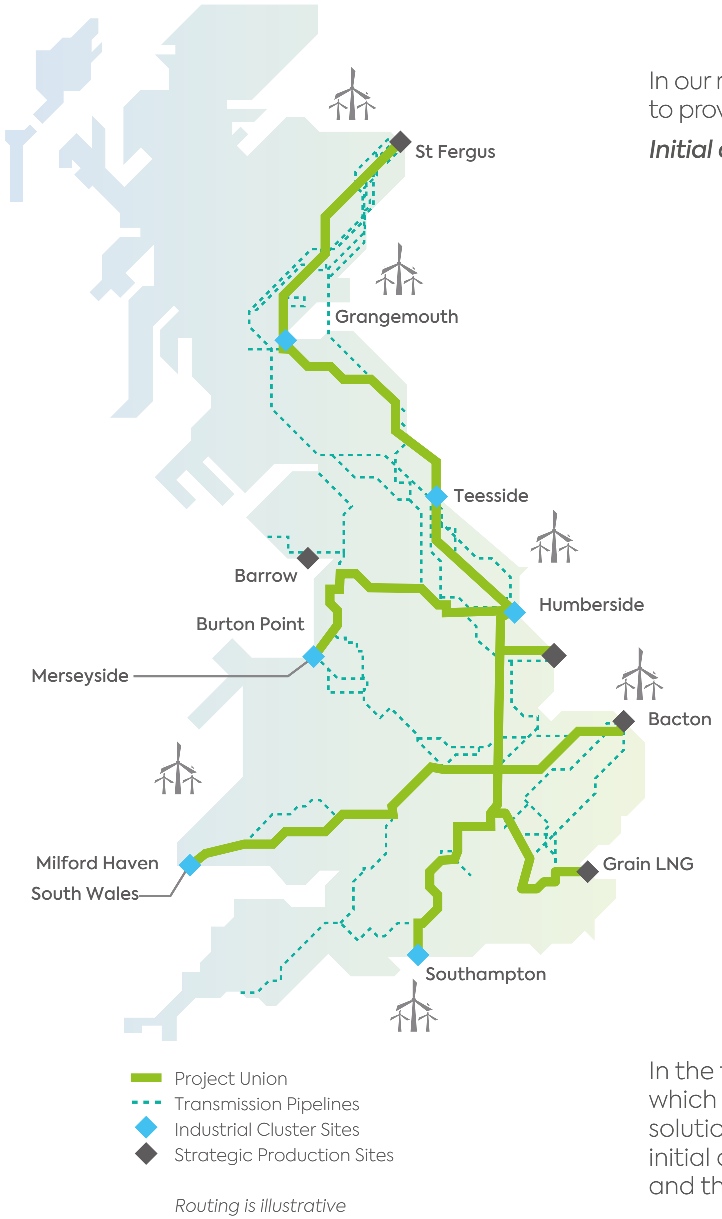
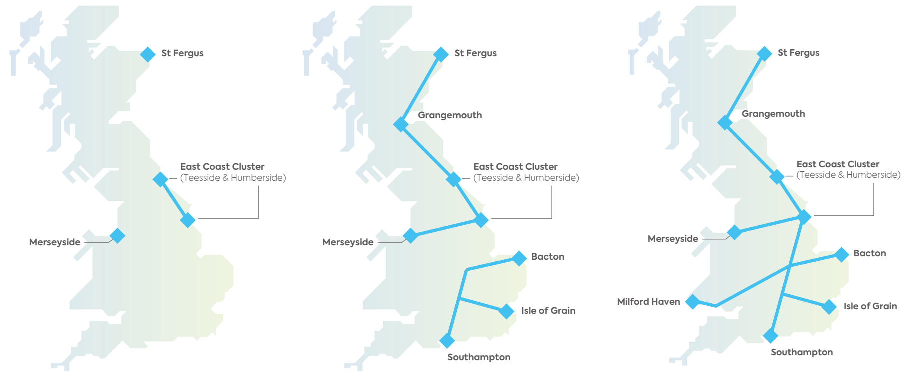


Figure 2: Project Union, illustrative network routing

In our report, we have utilised three phases of Project Union development to provide the context for our commercial framework consideration:

Initial connected cluster – Regional expansion – Mature backbone



Phase 1:
Initial connected cluster phase of Project Union, defined by limited use of hydrogen within clusters and limited transportation between clusters.
c.2027

Phase 2:
Regional expansion of Project Union where regional hydrogen networks emerge facilitating increasing hydrogen penetration between clusters and regions.
c.2030

Phase 3:
Mature hydrogen backbone phase of Project Union, where dispersed hydrogen production and demand are connected by networks, with high levels of hydrogen penetration.
c.2035

In the table overleaf we have outlined a summary of our exploration, which includes a view on the overarching commercial framework solution options for three phases of Project Union, considering the initial development phase of Project Union, the expansion phase, and the mature phase.

	System Operation	Balancing	Trading	Gas Quality	Connections	Capacity	Charging
Solution options for the initial connected cluster phase of Project Union (Phase 1)	**Interconnector role with command-and-control capabilities** System Operator (SO) has the authority to instruct market participants to increase or reduce supply or demand, to ensure network resilience	**Resilience balancing** Enhanced access to tools and powers to enable the System Operator to balance the network	**Minimal trading** Trading limited to any uncontracted hydrogen	**Exemption** Exemption to Gas Safety Management Regulations (GS(M)R) but with a Hydrogen specific Safety Case in place.	**Strategic** Location of connections determined by strategic direction, or dictated by Project Union System Operator	**Access based on flow** Users do not need to book capacity in advance of physical flow	**Charge based on flow (i.e., commodity charge)** Users charged on basis of use of network
Solution options for the regional expansion phase of Project Union (Phase 2)	**Introduction of market measures to support System Operation** SO tenders for services to support operations to ensure network resilience	**Introduction of market measures to support balancing** Development of physical location spot market to allow market participants to support balancing activities	**Introduction of market measures to facilitate trading** Physical locational trades are facilitated by development of hydrogen On-the-day Commodity Market (OCM)	**Add new hydrogen schedule to existing GS(M)R** Incorporate an additional schedule to the existing regulations to detail hydrogen gas quality specifications	**Market led with incentives** Connection incentives could include locational pricing for new connection points to maximise System Operation efficiency	**Access rights based on connection agreement** Use of network set out in connection agreement	*As above*
Solution options for the mature Project Union backbone phase (Phase 3)	**Incentivisation of market players to support System Operation** Market participants incentivised to balance supply and demand, with SO performing residual balancing role	**National Commercial Balancing regime** Development of framework and trading platforms to facilitate national Hydrogen Balancing Point	**National Commercial Balancing regime** National Hydrogen Balancing Point enables title hydrogen trade	**Hydrogen GS(M)R** Development of bespoke hydrogen Gas Safety Management Regulations	**Free market** First come, first serve basis for new connections to Project Union	**Commercial capacity regime** Users must book right to use network, in advance of physical flow	**Charging regime to facilitate commercial capacity booking** Users charged for capacity booking in advance of physical flow

Structure of this report

This report is structured into the below sections. Each of these include an overview of the existing regime, the challenges due to the development of Project Union, potential commercial framework solution options for each phase of Project Union.

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Introduction to the Project Union Hydrogen Gas Market Plan (GMaP)

Introduction to the Hydrogen GMaP

The Hydrogen GMaP, a focus area of the Future of Gas programme, is led by NGT in collaboration with the gas industry, stakeholders and decision makers. The purpose of the Hydrogen GMaP is to bring together gas market participants, including networks, shippers, consumers, industry specialists and decision makers, to explore the market change activities needed to integrate hydrogen into the GB energy mix, and to ensure the gas system and markets continue to deliver consumer value throughout the UK's hydrogen transition.

Introduction to the Project Union Hydrogen GMaP

This project involved NGT collaborating with a working group representing the gas industry value chain in the UK to explore how the existing gas sector market design and commercial frameworks may need to evolve to accommodate the development of Project Union. Project Union is the NGT project that aims to repurpose a quarter of the existing gas NT network to develop a full (100%) hydrogen 'backbone network' by the early 2030's.

It is key to note that while this Hydrogen GMaP focuses on Project Union, the findings could apply to the development of all open access 100% hydrogen networks. We have defined an open access network as being a national asset that market participants can access in a process governed and facilitated by rules.

The outputs from this project include:

- Articulation of the **key challenges** to the existing gas market design and commercial frameworks from the development of Project Union (please see the Spotlight in Appendix 1 for an overview of the existing gas market design)
- Exploration of commercial framework **solution options**, considering near-term and longer-term phases of Project Union
- Identification of key areas that will require **further refined exploration** to deliver a commercial framework fit for purpose for Project Union.

Why explore a commercial framework for Project Union?

Networks will be essential to enabling the UK's hydrogen transition. The recently published UK Government (HMG) consultation on Hydrogen transport and storage infrastructure asserted: ***'We aim to reach a large, liquid and competitive hydrogen market enabled by an integrated and resilient network with multiple entry and exit points, connected to several hydrogen storage facilities at various scales.'*** The consultation asserts that hydrogen networks can ***'help to support the market transition from a highly fragmented initial stage to a more integrated, competitive, and transparent end state.'*** In addition, the consultation recognises that ***'the overall need for a large, integrated, and resilient hydrogen transport and storage network' is 'not dependent on the decision on hydrogen use in heating.'***

Hydrogen networks will provide identical benefits to those currently enjoyed by existing natural gas network users, including:

- Access to a reliable, secure energy supply for consumers, from both a daily and seasonal perspective
- Connection to diverse, imported and indigenous, supply sources and storage systems to provide flexibility and resilience for end users
- Facilitating the necessary market pull and push forces to enable the development of liquid markets, enabling competition to drive efficient price point discovery for the benefit of consumers.

In a hydrogen transition, networks will provide added benefit by:

- Connecting distant hydrogen production locations (such as the current hydrogen industrial coastal locations) to demand centres
- Through connecting hydrogen consumers to diverse supply sources and strategic storage, enabling greater system security of supply, efficiency, resilience, and flexibility, as opposed to each hydrogen consumer requiring independent capacity to handle peak demand
- Providing the cheapest and fastest option for hydrogen transportation through repurposing existing networks
- Supporting the development of renewable electricity, such as the HMG target of 50 GW of wind by 2030 (British Energy Security Strategy), where for example electrolytic hydrogen production could translate 'excess' curtailed renewables to maximise connection of renewable electricity
- Stimulating hydrogen production and consumption through providing a route to market for hydrogen supplies and access to hydrogen in geographically disperse locations
- Enable indigenous hydrogen supplies and storage to achieve energy independence.

The right sizing of hydrogen networks will be critical to delivering a UK hydrogen transmission system able to meet our net zero ambitions. Please see our Spotlight below for an overview of the unique market challenges concerning the UK's hydrogen transition.

> Hydrogen networks will provide identical benefits to those currently enjoyed by existing natural gas network users.

Spotlight: Examining the market challenge in the UK's hydrogen transition

We developed this spotlight to illustrate some of the fundamental differences between the existing mature natural gas system and market, compared to the development and evolution of the hydrogen system and market.

Upstream

The current natural gas upstream market facilitated by the NTS is mature and diverse. The UK has four major coastal terminals to enable access to offshore gas fields in the UK Continental Shelf (UKCS) and the Norwegian Continental Shelf (NCS), a number of smaller GB Entry Points including onshore and Biomethane sources, two interconnectors to access European gas supplies as well as access to the global market through two Liquified Natural Gas (LNG) terminals.

- In the hydrogen transition, low carbon hydrogen production will have to increase from virtually nothing today, to supporting a UK hydrogen economy. Currently, the UK produces ~27TWh of hydrogen annually, but 97% of it is carbon intensive and primarily used in the petrochemical sector (Hydrogen Strategy, 2021). Government targets include achieving an additional 2 GW of low carbon hydrogen production capacity by 2025, and 10GW by 2030, with ambitions of growing a hydrogen economy supported by supplies of 240 – 500 TWh by 2050 (British Energy Security Strategy, 2022).
- Nuances with hydrogen production include that hydrogen is an energy vector, not an energy source, and therefore must be generated from existing hydrogen rich compounds. The key hydrogen production technologies include electrolysis of water (H_2O) for 'green' hydrogen production, and natural gas (CH_4) reformation with the added process of Carbon Capture Usage & Storage (CCUS) for 'blue' hydrogen production. This means hydrogen supplies will not be as readily available as our current access to offshore gas fields, driving a much greater need for hydrogen storage to ensure resilient hydrogen supplies to end users.
- Finally, hydrogen production is likely to include both large scale, steady flow profile from CCUS Enabled hydrogen production (similar to existing natural gas entry terminals), as well as from smaller scale 'green' (low carbon) production sites, and these could either provide a steady flow profile if they are operating at baseload, or, if connected to renewables, operating intermittently, potentially posing challenges to a hydrogen network System Operator to manage.

Midstream

The existing natural gas network system is mature, integrated, and resilient. Multiple network Entry and Exit Points connect gas supplies to gas consumers, offering security of supply and facilitating a liquid, competitive and liberalised market. The GB trading hub the National Balancing Point (NBP) is one of the most liquid trading hubs in Europe.

- Open access hydrogen networks, such as Project Union, will involve repurposing existing pipelines and also development of new pipelines to connect low carbon hydrogen producers and storage facilities with consumers.
- Strategic direction will likely need to be provided to play a central planning role in the hydrogen network transition, to determine pipeline routing and connection locations for hydrogen producers, consumers or storage sites, at least initially. Strategic direction will be essential to ensure security of supply and maximise hydrogen network system operation efficiency.
- The development of a hydrogen network and storage system will include lengthy development lead and construction times, and high capital costs. Therefore, Government has committed to design new business models for hydrogen transport and storage infrastructure by 2025.
- For the purpose of this document, we have identified three phases to distinguish Project Union's development, including:

  Phase 1 – Connected cluster: Project Union connects a small number of hydrogen clusters. This initial phase will be defined by limited large-scale hydrogen production sites and demand, predominantly from a few large industrial users. There is the potential to connect to a hydrogen village, town or potentially hydrogen transport hubs.

  Phase 2 – Regional expansion: A growing number of hydrogen clusters emerge, with more distributed hydrogen production and increasingly diverse customer demand. As regional hydrogen networks develop to support the growth of the hydrogen economy; Project Union would facilitate increasing hydrogen transportation between hydrogen clusters and regions. In addition, Project Union could enable hydrogen imports, which would play an important role in supporting hydrogen system resilience and security of supply and also enable export opportunities to global hydrogen consumers.

  Phase 3 – Hydrogen phase: The ambition is for a liquid, competitive, liberalised hydrogen market supported by dispersed hydrogen production and consumption. This phase would be defined by a high level of hydrogen penetration across Great Britain with consumers ranging from small to large, with interconnection to Europe. Hydrogen network systems including Project Union and hydrogen distribution networks would enable the hydrogen market transition and allow it to form part of an integrated energy system, alongside natural gas & electricity.

Downstream

Natural gas has a mature value chain across upstream production, midstream transportation, and downstream consumption. Natural gas has been a major source of energy supply, starting in the 1960's with the discovery of significant gas supplies in the UKCS (History of UKCS gas development, 2019). This has allowed natural gas demand to spread and be distributed across the UK, where natural gas is used to heat more than 85% of UK homes), it is the fuel for 40% of UK power generation and supports many of the UK's largest industrial and commercial sites (DUKES: natural gas, 2022).

- Low carbon hydrogen demand will need to grow from virtually nothing to supporting a competitive, liquid and liberalised hydrogen market.
- For the purpose of this document, we have identified three stages of Project Union's development, where we have anticipated hydrogen consumer demand to include:

  Phase 1 – Connected cluster: In this initial phase of Project Union, hydrogen will be used in a limited number of large industrial users and limited transport hubs, with the potential to be supporting a hydrogen village or town.

  Phase 2 – Regional expansion: As hydrogen penetration increases, with expected significant increases in hydrogen demand during the 2030's, we can expect hydrogen to be used for increasing heavy industry, for power generation, transport hubs and potentially for regional heating locations.

  Phase 3 – Hydrogen phase: With a dynamic, competitive, liquid hydrogen market in place, hydrogen will be consumed in heavy industry, power generation, heavy and light transport, and for a large proportion of the UK's heating demand, whether via Hydrogen fired boilers or through additional electricity generation to supply Heat Pumps.

Overview of Project Union Hydrogen GMaP

Project Union Hydrogen GMaP problem statement

The development of a shared national hydrogen transportation infrastructure, such as Project Union, will require a commercial framework in place to ensure consumer value and minimise disruption to gas market participants during the UK's hydrogen transition. However, there is uncertainty on how the existing gas sector market design and commercial frameworks may need to evolve to accommodate the development of Project Union.

Project Union Hydrogen GMaP aims

NGT and an expert industry working group collaborated on this thought leadership project to articulate the key challenges and explore potential solution options to enable a commercial framework that could facilitate the development of Project Union, based on the existing context of the emerging hydrogen policy landscape and ongoing hydrogen development projects.

We also identified the key commercial framework questions that require the next level of detailed exploration and refinement to develop a commercial framework to support Project Union, with a specific focus on enabling the initial phase of Project Union.

Project engagement

Industry stakeholder engagement for this project was conducted over a 12-month period, from January to December 2022, involving 15 workshops and numerous bilateral discussions. To develop the project, NGT collaborated with over 20 companies representing the UK gas industry value chain (see Figure 3 below).

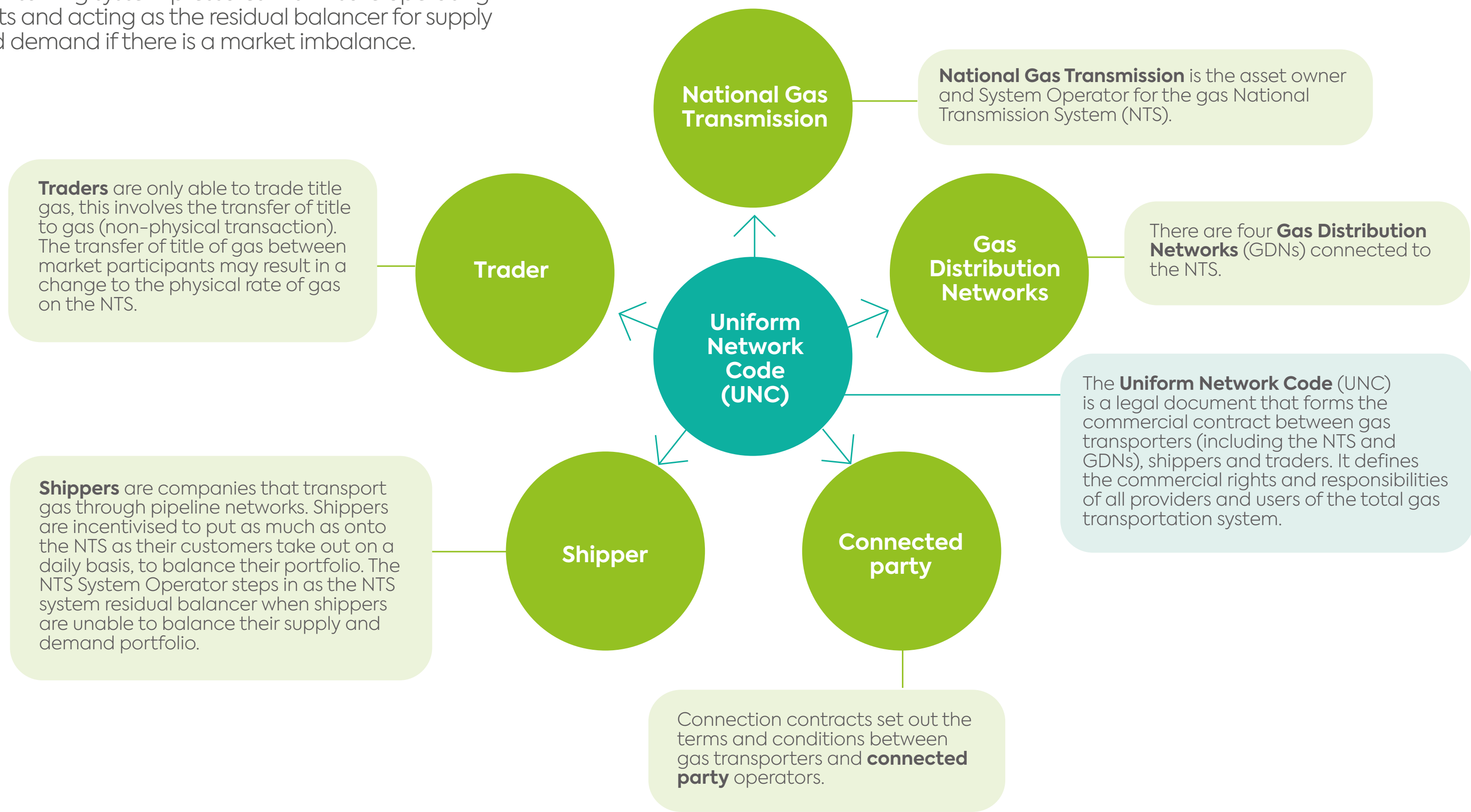
Figure 3: Hydrogen GMaP working group

Section 1: System Operation

1a. Defining the existing NTS System Operation regime

As the gas National Transmission System (NTS) Operator, our primary responsibility is to transport gas safely, efficiently, and reliably through the NTS, managing the day-to-day operation of the network. This includes maintaining system pressures within safe operating limits and acting as the residual balancer for supply and demand if there is a market imbalance.

The key gas market players in the existing NTS System Operation regime include:



The key elements of the current legislative hierarchy that govern NTS System Operation include:

Primary Legislation: Gas Act 1986

- The Gas Act prohibits certain activities unless the person carrying on that activity is licensed, and there is a set of standard licence conditions for each licensable activity.
- Gas market licenses are required for Transporter, Interconnector, Shipper and Supplier activities.

Secondary legislation GS(M)R

- No person shall convey gas in a network unless a safety case is prepared and has been accepted by the Health and Safety Executive.

Gas Transporter License

- Standard Special Conditions and Special Conditions apply to National Gas Transmission
- Licensees must also become party to and/or comply with certain industry codes

Uniform Network Code: (UNC)

- The UNC is the common rulebook for the system which defines the commercial and operational relationships between the gas transporters and shippers.

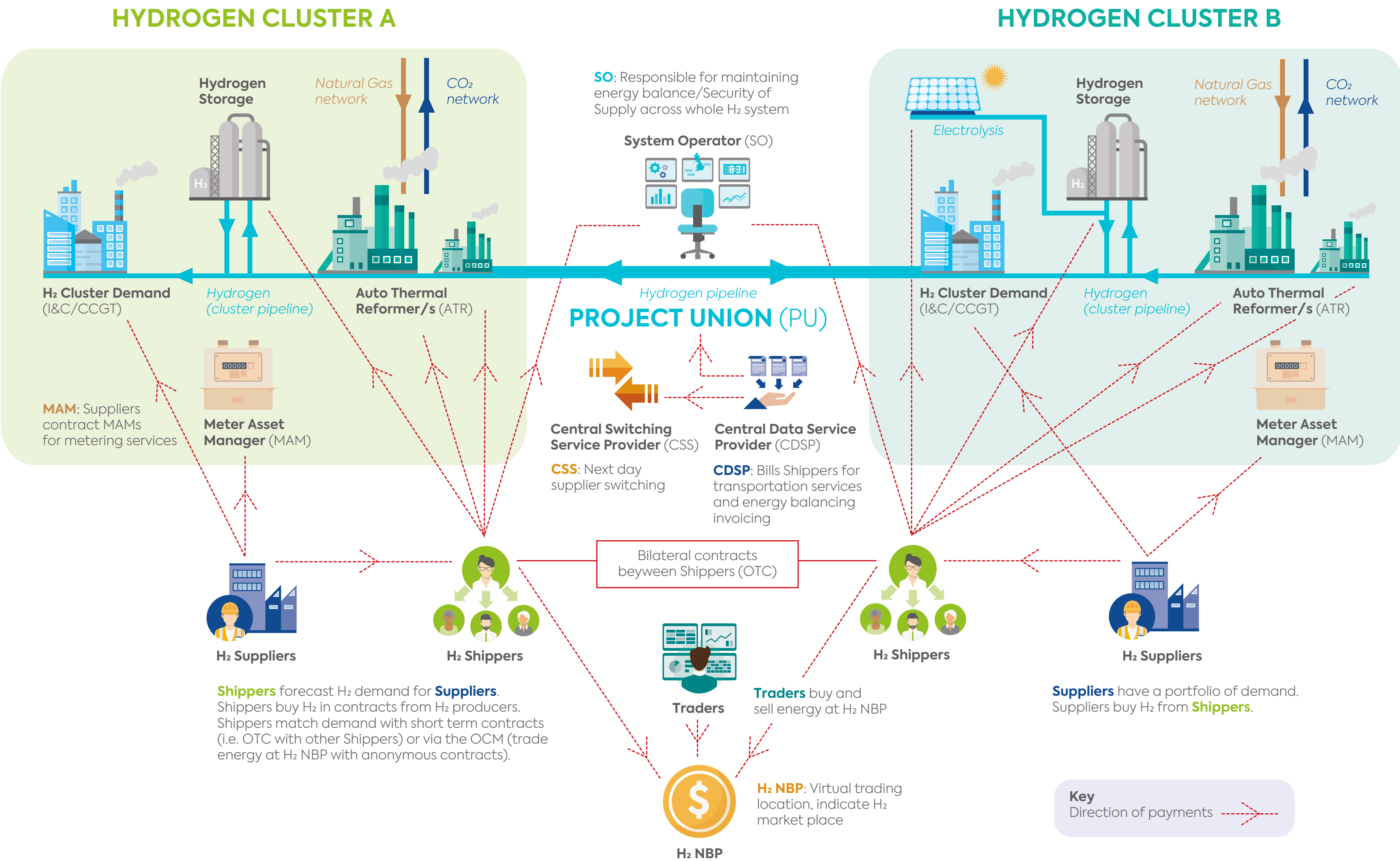
1b. Challenges to the existing System Operation regime from the development of Project Union

Operating Project Union will be very different to operating the existing NTS. To start with, there will be fewer pipelines, considering the existing NTS is 7,660km, and the mature Project Union hydrogen network will include approximately 2,000km of pipeline. The reduced pipeline will impact linepack capabilities, linepack being the inherent stored gas in pipelines. In addition, the energy content of hydrogen is 1/3 of that of natural gas, significantly reducing linepack storage. This will impact the ability of connected users to use the network flexibly and drives the need for additional hydrogen storage to mitigate reduced linepack to ensure network resilience for end users.

Most importantly, the existing natural gas commercial regime was developed and has evolved to govern the existing physical gas system, and the behaviour of market players using the system. The commercial regime for Project Union will also be required to govern the physical infrastructure and behaviour of the market players using Project Union, where currently, a lot of uncertainty lies.

The existing natural gas commercial regime was developed and has evolved to govern the existing physical gas system, and the behaviour of market players using the system. The commercial regime for Project Union will also be required to govern the physical infrastructure and behaviour of the market players using Project Union, where currently, a lot of uncertainty lies.

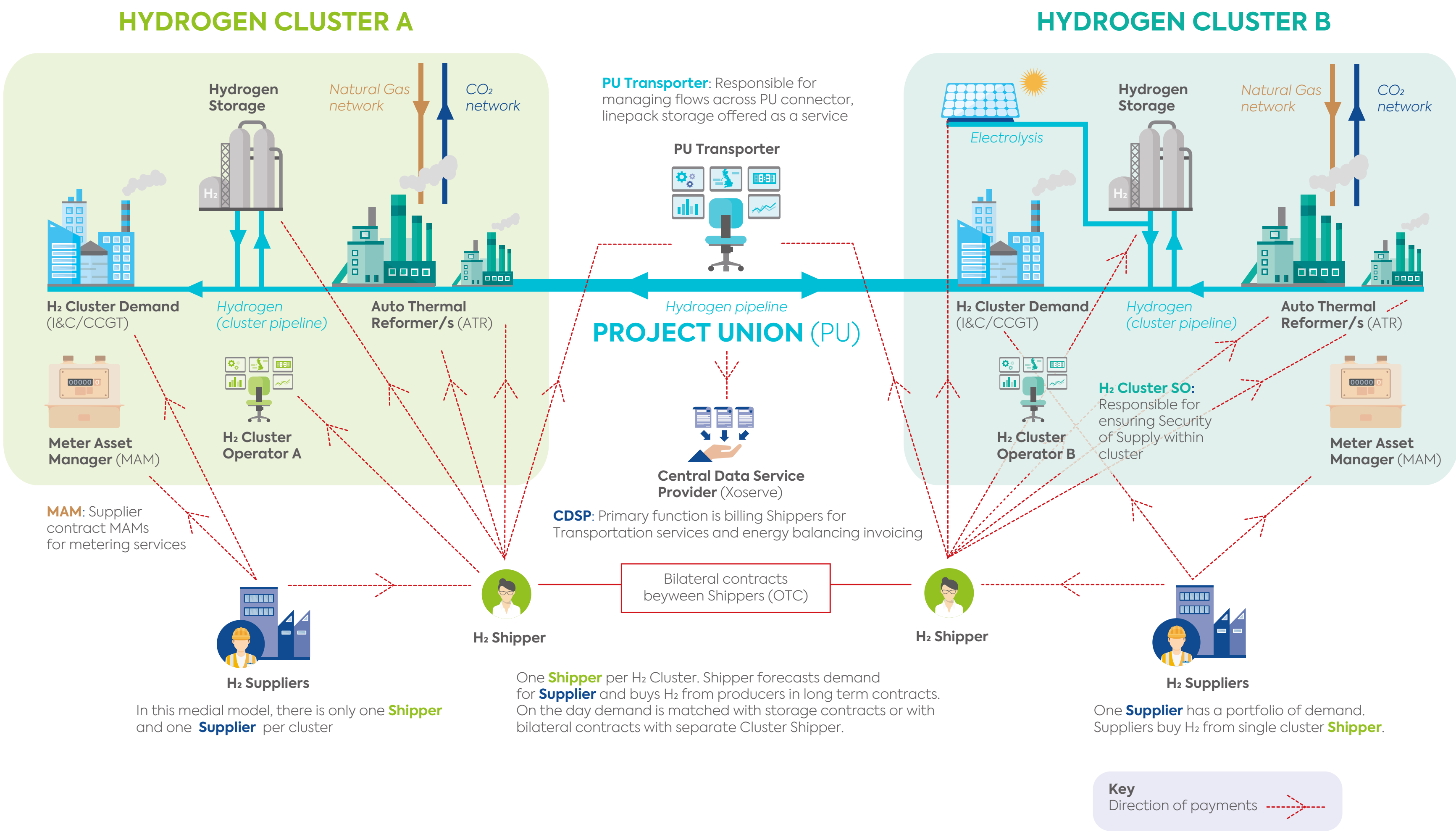
To demonstrate the challenge of planning for a commercial regime with uncertainty on the roles and responsibilities of market participants, below we have illustrated how Project Union could operate, using the existing regime market players:



However, if fewer market players were participating in the hydrogen market value chain, then roles and responsibilities would clearly be impacted, as illustrated in this medial model for Project Union, loosely based on the regime being considered for the hydrogen neighbourhood trial:

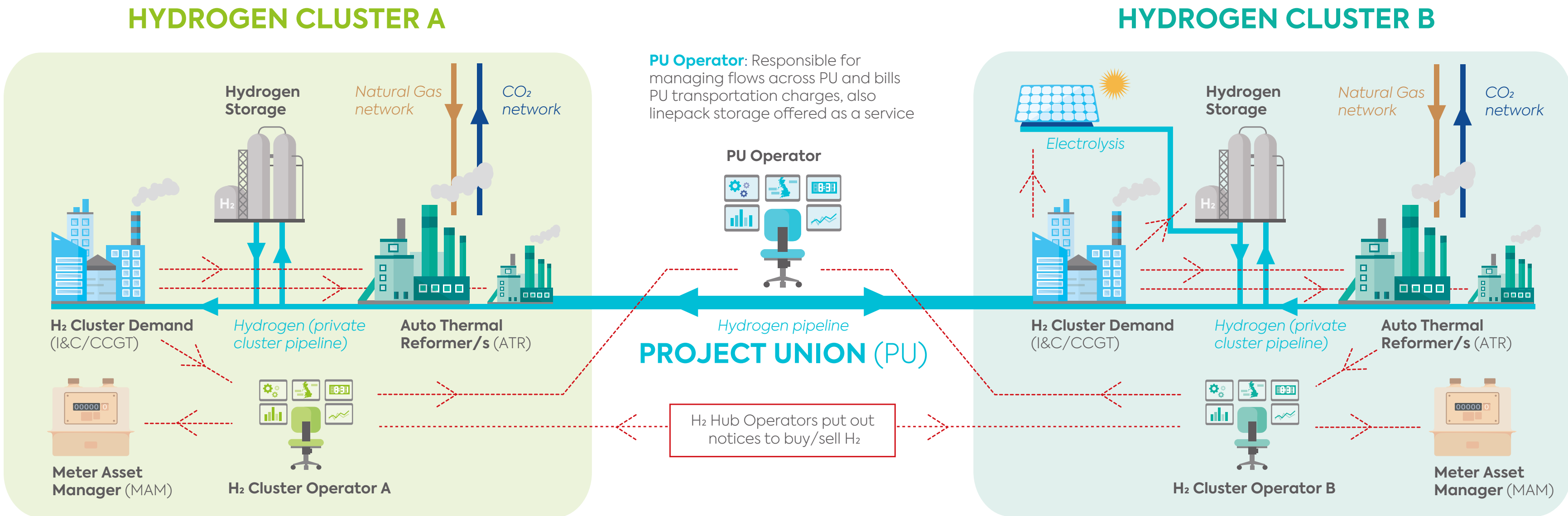
The concept of 1 Shipper has been applied to the below medial market participant model.

> *To facilitate H100, the hydrogen neighbourhood trial, a small number of changes to existing UNC commercial frameworks have been developed, one of these changes including one Shipper being registered against the H100 Entry Point* *UNC arrangements for H100*



Finally, in an extremely simplified model, again the remaining market participant roles and responsibilities would clearly be impacted. Below we have illustrated a simplified marker player model for Project Union, loosely based on the regime being considered for Hydrogen Business Model, which currently requires bilateral contracts between hydrogen producers and consumers:

In the Hydrogen Business Model, the Government is still considering whether there will be a role for risk taking intermediaries (i.e., parties such as shippers or suppliers that purchases hydrogen for the purpose of resale).



MAM: H_2 Cluster Operator contract MAMs for metering services

H_2 Cluster Operator: Responsible for ensuring SoS, including putting out notices to other Cluster Operator parties to sell/buy H_2 to manage short term supply/demand, and also bills transportation charges

In this simplified model there are no H_2 Shippers or Suppliers, no link into existing CDSP or CSS.

Key
Direction of payments

Clearly the benefits of applying the existing market player to Project Union include it is a well understood model, and it has been successful in supporting the development of the current liquid, competitive and liberalised natural gas market. However, it is clearly a complex system, and the advent of a new regime raises the opportunity to explore whether the current commercial arrangement should be enduring.

The medial and simplified models of market players to Project Union provide the benefit of simplified routes of communication to deliver security of supply. However, they pose revolutionary changes to the existing framework, and may only be appropriate for facilitating initial and developing phases of 100% hydrogen networks.

1c. Solution options to enable a System Operation regime for Project Union

It is key to note that as outlined in the government's minded to position in the Hydrogen transport and storage infrastructure report "the build-out of hydrogen transport and storage infrastructure, and in particular larger scale or systemically important assets, should be guided by centrally coordinated, locally sensitive, strategic planning that is integrated across energy and other relevant systems." In the interim, UK government, working closely with Ofgem and industry, will publish a 'hydrogen networks pathway,' to set out the next steps in the development of hydrogen Transmission & Storage infrastructure in the UK.

Considering the challenges to operating Project Union & developing a commercial framework, and considering the uncertainty on the roles and responsibilities of market players, below we have identified overarching System Operation solution options that could cater for the different phases of Project Union:

System Operation solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1

Interconnector role

The initial phase of Project Union could potentially operate similarly to the current interconnectors. Interconnectors connect gas sources and markets, where Project Union could enable flows of hydrogen between hydrogen clusters, pending hydrogen pricing, and supply & demand dynamics.

In an initial 'interconnector' role of Project Union, the System Operator would be focused on maintaining network resilience of the Project Union network and would have contracts in place with command-and-control capabilities to instruct connected parties to increase or reduce hydrogen supply or demand to ensure network resilience. Connected parties could include both Aggregated System Entry and Exit points from the clusters, and also directly connected customers.

The benefits of Project Union connecting clusters include enhancing cluster security of supply and reducing overall hydrogen cluster costs, as without Project Union, each cluster would need to (over)invest in their own individual resilience measures. Through connecting clusters, Project Union will also enable more competitive trading of hydrogen supply sources between market participants. For example, excess hydrogen from one cluster could be bought by demand sources in the connected cluster.

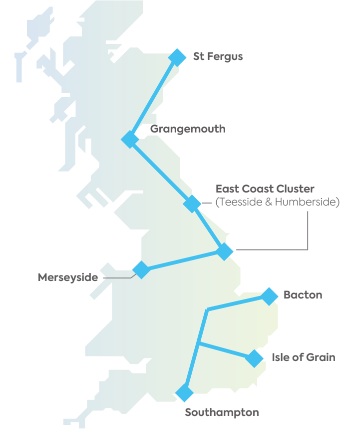
We believe that enhanced contracts with command-and-control capabilities will be required to facilitate the interconnector role of Project Union to enable a System Operation regime focused on simplicity, efficiency, and rapid response. Without access to command-and-control, strong incentives would be needed to ensure market participants balanced their supply and demand positions, which could hinder the development of the hydrogen market.

Clearly this is not an enduring solution and there will need to be a carefully managed transition pathway to more competitive access and use of the Project Union network.

System Operation solution options for Project Union (continued)

Solution option for regional expansion of Project Union:

Phase 2



Introduction of market measures to support System Operation

In the expanding phase of Project Union, the System Operator could competitively tender for services to support Project Union system operation.

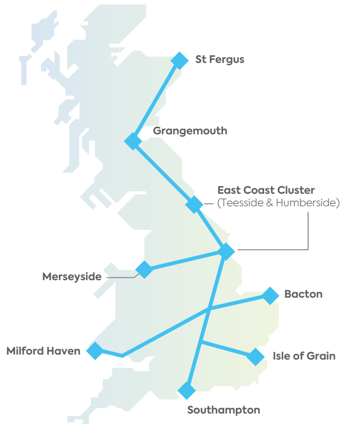
Examples of services that could be competitively tendered include supply response services, or demand reduction or flexibility services. The Project Union System Operator would select tendered services based on price and location.

This phase of Project Union could be operated in a similar manner to the existing Electricity System Operator (ESO). The ESO competitively tenders for ancillary services to support system operation, and also utilises the Balancing Market mechanism to select optimal bids and offers based on price and location to instruct market participants, in order to ensure security of supply and electricity system resilience (Electricity System Operator).

While it is likely command and control measures will still be required to ensure network resilience in the Project Union expansion phase, tendering for services to support the System Operator would enable the market to competitively participate in network balancing through market measures.

Solution option for mature Project Union backbone:

Phase 3



Incentivisation of market players to support System Operation

In the mature phase, the Project Union System Operator should perform the existing residual balancer role, with market participants incentivised to balance their positions as the primary balancing parties of the system.

The System Operator would continue to have ultimate responsibility to ensure the safe operation of the Project Union network and would monitor the supply and demand impact of connected party behaviour on the network through assessing system linepack.

However, instead of access to command-and-control contracts, the Project Union System Operator would aim to rely on market tools, such as trading hydrogen, to incentivise market players to respond and balance their positions in order to ensure network resilience and security of supply.

Potential impact to current legislative hierarchy to enable a System Operation commercial regime for Project Union:

Below we have articulated an overview of potential challenges to the existing legislative framework to enable the solution options we have identified as part of this project to enable a system operation regime for the phases of Project Union.

Primary Legislation: Gas Act 1986

- Regulated activities (licensed) include gas transportation, gas shipping, gas supply.
- There is uncertainty on whether existing natural gas market players roles will be required to be licensed for hydrogen, and if this is the case, if hydrogen specific conditions can be added to existing licenses, or whether new hydrogen bespoke licenses will be required.
- There is also uncertainty on whether the market player regime will be simplified (i.e., in the existing Hydrogen Business Model regime, there is no role for Shippers or Suppliers), or whether additional market players (i.e., such as storage) will be required to be licensed.

Secondary legislation GS(M)R

- No person shall convey gas in a network unless a safety case is prepared, and that safety case has been accepted by the Health and Safety Executive
- It is likely there will either be a requirement for a dedicated hydrogen safety case, or an addendum that could be added to the existing natural gas safety case, to facilitate Project Union.

Gas Transporter License:

National Gas Transmission plc Gas Transporter License Special Conditions

- NTS System Operator means the licensee when carrying out an NTS System Operation Activity.
- There will likely be a requirement for Project Union special license conditions to outline roles and responsibilities of the Project Union System Operator. These could be added to the existing NGT license special conditions, or a bespoke license could be created for Project Union. To accelerate the transitional stages of Project Union, a license Exception or Exemption could be considered for the initial phases of network development.
- There is also a clear need to evaluate what Security of Supply (SoS) obligations will be relevant for Project Union (i.e., 1 in 20/1 in 50, N-1), or if new SoS obligations need to be developed.
- Licensees must also become party to and/or comply with certain industry codes (i.e., Network Code and Uniform Network Code).

Uniform Network Code: (UNC)

- The UNC is a contract between Shippers and Transporters
- Common rulebook for the system which defines the commercial and operational relationships between the transporters (TSO and DNOs) and Shippers.
- Pending which market players are licensed will dictate the impact to the UNC.
- A range of options could be utilised to support the development of the UNC for the phases of Project Union, options include evolving the existing UNC, adding new sections to the UNC, or developing a new bespoke UNC. These options are not mutually exclusive.

Section 2: Gas Quality

2a. Defining the existing NTS Gas Quality regime

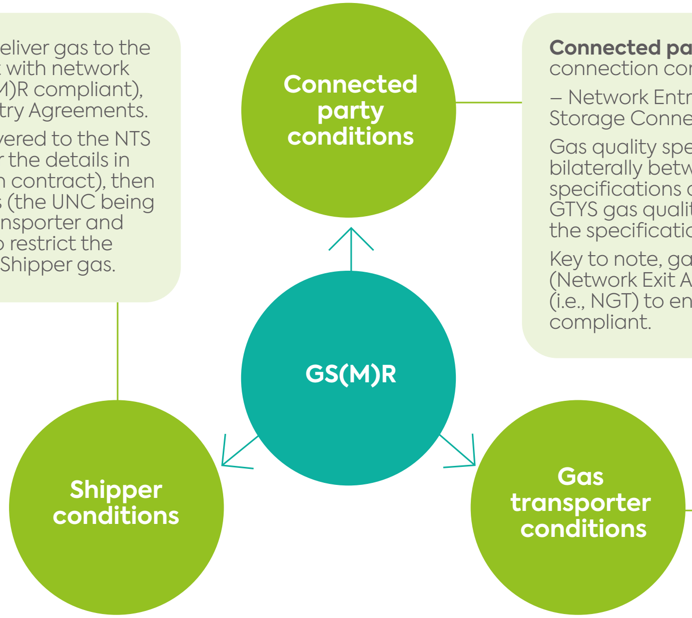
Licensed gas transporters in the UK, such as NGT, are required to ensure that gas transported through their network conforms to specifications set out within the Gas Safety (Management) Regulations 1996 (GS(M)R). These specifications are monitored closely at NTS Entry Points and at specified points across the network.

An overview of the key market participants and their roles in the existing NTS gas quality regime includes:

Licensed gas transporters in the UK, such as NGT, are required to ensure that gas transported through their network conforms to specifications set out within the Gas Safety (Management) Regulations 1996 (GS(M)R).

Shippers Shippers must deliver gas to the network that is compliant with network entry conditions (i.e., GS(M)R compliant), as detailed in Network Entry Agreements.

In the event that gas delivered to the NTS is off-specification (as per the details in Network Entry connection contract), then under the UNC conditions (the UNC being the contract between Transporter and Shipper) the NTS is able to restrict the entry of off-specification Shipper gas.



Connected party gas quality conditions are included within connection contracts:

– Network Entry Agreement (NEA) / Interconnector Agreements / Storage Connection Agreement (SCA)

Gas quality specifications within connection contracts are agreed bilaterally between NGT and connected parties, however the specifications are set out in GS(M)R, and also in GTYS (however, some GTYS gas quality specifications are indicative and can be flexed, while the specifications set out in GS(M)R are obligatory).

Key to note, gas quality specifications are not included within NExAs (Network Exit Agreements) – this is due to responsibility of transporter (i.e., NGT) to ensure gas made available to end users will be GS(M)R compliant.

GS(M)R sets duties for **Gas Transporters** to provide a safety case and ensure the content and characteristics of gas conveyed within the pipeline system meets specific conditions (GS(M)R).

The key elements of the current legislative hierarchy that govern the gas quality regime include:

Primary Legislation: Gas Act 1986

Section 16: Standards of Gas Quality

- (1) The Authority may, with the consent of the Secretary of State, prescribe (a) standards of pressure and purity to be complied with by gas transporters in conveying gas to premises or to pipe-line systems operated by other gas transporters; and (b) other standards with respect to the properties, condition and composition of gas so conveyed.
- Under Section **48(1)** of the Gas Act "gas" is defined as: (a) "any substance in a gaseous state which consists **wholly or mainly of** (i) methane, ethane, propane, butane, hydrogen or carbon monoxide; (ii) a mixture of two or more of those gases; or (iii) a combustible mixture of one or more of those gases and air
  - UNC Modification 0799 H100 Fife: The definition of gas in primary legislation is wider than the UNC definition and the Gas Act 1986 includes Hydrogen within its definition of gas *(i.e., no requirement for Primary Legislation change to definition of gas).*

Primary Legislation: Health and Safety at work Act 1974

Section 15: Health and Safety Regulations:

- Subject to the provisions of section 50, the Secretary of State ... shall have power to make regulations under this section for any of the general purposes of this Part *(i.e., this is the reference to GS(M)R)*

Secondary Legislation: GS(M)R 1996

- **"gas" means any substance in a gaseous state which consists wholly or mainly of methane;**
- 3. — (1) No person shall convey gas in a network unless (a) he has prepared a safety case containing the particulars specified in Schedule 1 and that safety case has been accepted by the Executive; and

  Content and other characteristics of gas
  8. — (1) ... the gas conforms with the requirements specified in Part I of Schedule 3

i.e., Transporters have obligation to not convey gas outside of GS(M)R

Gas Transporter License

- Gas Transporter License: Standard Conditions – no inclusion of gas quality specifications
- National Gas Transmission plc Gas Transporter License Special Conditions – NTS System operation Activity means engagements undertaken by the licensee pursuant to the operation of the NTS, including the provision of services relating to gas quality .... Plant and Equipment (also) means the equipment associated with maintaining gas quality and pressure

Uniform Network Code

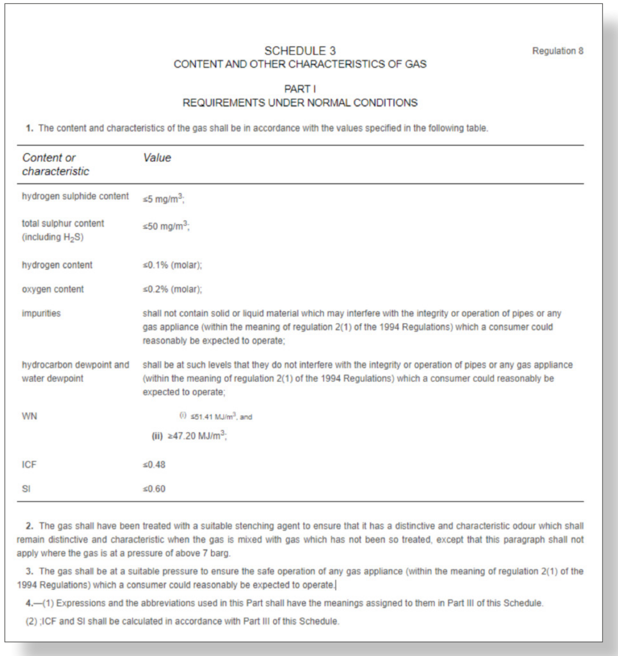
- Section I: Entry Requirements: "Gas Entry Conditions" in respect of a System Entry Point are limits or other requirements as to the composition, pressure, temperature and other characteristics of gas delivered or tendered for delivery to the Total System at the point or points of delivery (i.e., Shippers must delivery gas to the network that is compliant with network entry conditions *(i.e., GS(M))R compliant), as detailed in Network Entry Agreements)*
- Section J: Exit Requirements: "'Standard Offtake Requirements" are the requirements as to gas composition and pressure of the regulations from time to time applying pursuant to Section 16(1) of the Act (Gas Act) as they apply in respect of gas made available by the Transporter for offtake at any System Exit Point' *(i.e., Transporters have obligation to not convey gas outside of GS(M)R, and connected parties can expect to receive GS(M)R compliant gas)*
- General Terms: Section C Section 3.1.1. "Gas" is defined as any hydrocarbons or mixture of hydrocarbons and other gases consisting primarily of methane.

2b. Challenges to the existing Gas Quality regime from the development of Project Union

The principal challenge from the development of Project Union is the requirement to change existing gas quality specifications from one dominated by methane, to a new one dominated by hydrogen.

In the current gas quality regime, gas quality limits are set out in GS(M)R to ensure safe operation and delivery of transported gas. Natural gas is not a uniform entity, and pending its source gas field, can have different compositions and characteristics. Natural gas currently transported within the UK is predominately made up of methane (~90%+), however it may also contain trace amounts of other compounds like sulphur, oxygen and carbon dioxide. Please see Figure 4 below for the current GS(M)R specifications for gas conveyed through pipelines:

The existing GS(M)R has been amended in 2023 for the first time since the introduction of GS(M)R in 1996. This change process was driven by industry, the process having started in 2016 when the Institute of Gas Engineers & Managers (IGEM) set up a Gas Quality Working Group comprising of stakeholders from across the gas value chain to support its work to review the current gas quality specification within GS(M)R. The IGEM industry working group examined the case for change and led an industry consultation and submitted recommendations for change to the HSE, who conducted a consultation to seek views on HSE's assessment of the proposals and its plans to implement them in March 2022. The HSE published its response to the consultation in March 2023, with several amendments due to come into force in Spring 2023 and 2025 (please see Figure 4, right, for more information). Given this process began in 2016, we can see that changes to this document will take a considerable level of time and resource and so need to be considered as early in the process as possible.



SCHEDULE 3 — Regulation 8
CONTENT AND OTHER CHARACTERISTICS OF GAS

PART I
REQUIREMENTS UNDER NORMAL CONDITIONS

1. The content and characteristics of the gas shall be in accordance with the values specified in the following table.

Content or characteristic	*Value*
hydrogen sulphide content	≤5 mg/m³;
total sulphur content (including H_2S)	≤50 mg/m³;
hydrogen content	≤0.1% (molar);
oxygen content	≤0.2% (molar);
impurities	shall not contain solid or liquid material which may interfere with the integrity or operation of pipes or any gas appliance (within the meaning of regulation 2(1) of the 1994 Regulations) which a consumer could reasonably be expected to operate;
hydrocarbon dewpoint and water dewpoint	shall be at such levels that they do not interfere with the integrity or operation of pipes or any gas appliance (within the meaning of regulation 2(1) of the 1994 Regulations) which a consumer could reasonably be expected to operate;
WN	(i) ≤51.41 MJ/m³, and (ii) ≥47.20 MJ/m³;
ICF	≤0.48
SI	≤0.60

2. The gas shall have been treated with a suitable stenching agent to ensure that it has a distinctive and characteristic odour which shall remain distinctive and characteristic when the gas is mixed with gas which has not been so treated, except that this paragraph shall not apply where the gas is at a pressure of above 7 barg.

3. The gas shall be at a suitable pressure to ensure the safe operation of any gas appliance (within the meaning of regulation 2(1) of the 1994 Regulations) which a consumer could reasonably be expected to operate.

4.—(1) Expressions and the abbreviations used in this Part shall have the meanings assigned to them in Part III of this Schedule.

(2) ;ICF and SI shall be calculated in accordance with Part III of this Schedule.

Figure 4: 1996 GS(M)R and recent amendments

HSE March 2023: Amendments to GS(M)R consultation response

The key changes to GS(M)R are as follows:

Entry into force from 6th April 2023:

- Removal of the Incomplete Combustion Factor (ICF) and Soot Index parameters
- Introduction of a 0.7 relative density limit
- Increasing the permitted oxygen content on below 38 bar systems from 0.2mol% to 1.0mol%
- Extending the duty of cooperation for terminals to LNG operators
- Extending the requirement for a safety case to operators of biomethane pipelines

Entry into force from 6th April 2025:

- Reduction in the lower limit for wobbe index from 47.2 MJ/m³ to 46.50 MJ/m³

The future gas quality regime for Project Union includes, it is anticipated, that the minimum hydrogen content (for pipeline distributed hydrogen) will be 98%, with trace amounts of other compounds such as sulphur, oxygen and carbon monoxide. Please see Figure 5, right, for the latest IGEM hydrogen gas quality specification:

It is anticipated that the minimum hydrogen content (for pipeline distributed hydrogen) will be 98%, with trace amounts of other compounds such as sulphur, oxygen and carbon monoxide.

CONTENT OR CHARACTERISTIC	VALUE	RATIONALE
Hydrogen content minimum	98 % (cmol mol^{-1})	This value is a good compromise between hydrogen cost and effects on appliances.
Carbon monoxide	20 ppm (µmol mol^{-1})	A practical engineering limit based on achievable production limits and to meet long term exposure limits HSE EH/40
Hydrogen sulphide content	≤ 5 mg m^{-3} 3.5 ppm (µmol mol^{-1})	
Total sulphur content (including H_2S and odorant)	≤ 50 mg m^{-3} 35 ppm (µmol mol^{-1})	These values are taken from GS(M)R:1996 as any detrimental effects would be similar for hydrogen and NG.
Oxygen content	≤ 0.2% (cmol mol^{-1})	
Hydrocarbon dewpoint	-2 °C	Not more than -2°C at any pressure up to 85 bar.
Water dewpoint	-10 °C	Not more than -10°C at 85 bar
Sum of methane, carbon dioxide and total hydrocarbons	≤ 1% (cmol mol^{-1})	No detrimental effects to boiler, this limit is to reduce carbon content of the exhaust
Sum of argon, nitrogen and helium	≤ 2% (cmol mol^{-1})	To avoid transporting inert gases with no calorific value in the hydrogen gas (in agreement with ISO/FDIS 14687) and to limit the impact on Wobbe Number (see below)
Wobbe Number range	42 – 46 MJ m^{-3}	Range and percentage variation based on Natural Gas range in GS(M)R:1996 Wobbe Number is calculated at UK metric standard conditions of 15 °C and 101.325 kPa
Other impurities	The gas shall not contain solid, liquid or gaseous material that might interfere with the integrity or operation of pipes or any gas appliance, within the meaning of regulation 2(1) of the Gas Safety (Installation and Use) Regulations 1998, that a consumer could reasonably be expected to operate	

Figure 5: IGEM hydrogen gas quality specification

Executive Summary

Section 1: System Operation

2: Gas Quality

Section 3: Connections

Section 4: Balancing and Trading regime

Section 5: Capacity regime

Section 6: Charging regime

Conclusion and next steps

Appendices

2c. Solution options to enable a Gas Quality regime for Project Union

In a hydrogen transition, changes to gas quality rules will need to be transparent, encourage industry engagement and mitigate adverse economic and environmental effects. Below we have identified a range of solution options that could cater for the different phases of Project Union:

In a hydrogen transition, changes to gas quality rules will need to be transparent, encourage industry engagement and mitigate adverse economic and environmental effects.

Gas Quality solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1

Exemption to GS(M)R

For the initial phase of Project Union, when a limited section or sections of the NTS have been repurposed to 100% hydrogen, an exemption to GS(M)R (i.e., derogation to license obligation) could be viable. An exemption to GS(M)R could expedite the transition to enabling the transport of 100% hydrogen.

The Gas Act 1986 allows the Secretary of State to make orders giving exemptions from the need to hold licences. Exemptions can apply to individual cases or a class of activity and may be unconditional or subject to certain conditions including length of time. A Safety Case will still be required.

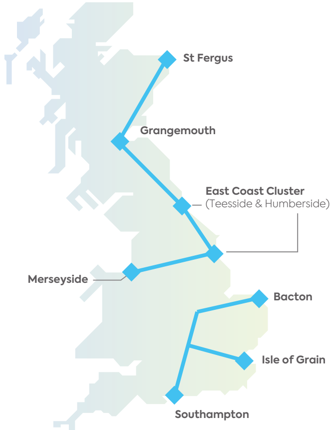
However, the more exemptions put in place the weaker the authority of the regulations, considering the potential for variety of different gas quality specifications on the gas networks in a net zero transition, including natural gas, biomethane, hydrogen blend, 100% hydrogen, 100% carbon dioxide etc. pipelines.

Clearly this is not an enduring solution, and there is a clear need to consider the vision for 100% hydrogen networks, as there will be a need for more material and permanent change to gas quality frameworks as 100% hydrogen networks develop.

Gas Quality solution options for Project Union (continued)

Solution option for regional expansion of Project Union:

Phase 2



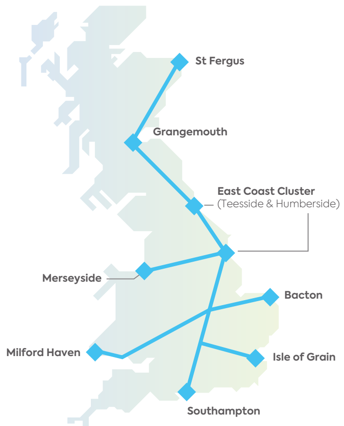
Add Hydrogen schedule to the existing GS(M)R

As hydrogen networks develop, this could trigger the need for more robust commercial frameworks, such a hydrogen schedule setting out specifications on the content and characteristics of hydrogen gas that licensed gas transporters must comply with, could be added as an additional schedule to the existing GS(M)R. For example, IGEM have already developed a hydrogen gas quality standard as an output from the UK Government funded Hy4Heat project.

Considering that we can expect Project Union would need to comply with much of the existing GS(M)R (i.e., how gas transporters keep networks safe and comply with a gas quality specifications), potentially the only major change we can expect to GS(M)R would be changing the technical specifications (i.e., increased hydrogen content) of the gas being transported. This would be applicable to all 100% hydrogen pipelines.

Solution option for mature Project Union backbone:

Phase 3



Develop and implement a separate hydrogen GS(M)R

When a mature hydrogen network is in place, this could trigger the need for a new statutory instrument, a hydrogen specific GS(M)R, to be developed and implemented.

For the reasons set out above, as we expect 100% hydrogen pipelines such as Project Union to be subject to the same obligations set out in the existing GS(M)R, the only major change to GS(M)R we can expect is changing the technical specifications of the gas being transported, therefore this solution option may not be required.

Another key consideration for a Project Union gas quality regime is that it will be necessary to indicate where (i.e., on which pipelines/section of pipeline) different gas quality specifications apply, for example, to differentiate between 100% hydrogen pipelines and blended natural gas/hydrogen pipelines, natural gas pipelines etc. We would recommend that the identification of gas quality specifications for 100% hydrogen pipelines should not be detailed within an existing statutory instrument (i.e., GS(M)R), but should be detailed in a separate document with appropriate governance and HSE oversight.
We recommend a separate document to detail this information to implement a more streamlined process for this activity, rather than having to undertake a potentially lengthy process to amend existing statutory documents to cater for different pipeline gas quality specifications, especially when considering an anticipated fast-paced transitional period.

In addition, it is key to note that currently there is one set of GS(M)R obligations for the gas networks, and one Safety Case per licensed gas transporter, as set out in secondary legislation. To facilitate 100% hydrogen pipelines such as Project Union, different obligations to the existing prepared safety cases will be required to accommodate the different risk factors associated to hydrogen. Solution options could either include the development of a separate hydrogen safety case statutory instrument for each licensed hydrogen gas transporter, or amendments to existing licensed gas transporter safety cases.

Potential impact to current legislative hierarchy to enable a Gas Quality regime for Project Union

Below we have articulated an overview of potential changes to the existing legislative framework to enable the solution options we have identified as part of this project to enable a gas quality regime for Project Union.

Primary Legislation: Gas Act 1986

- The Gas Act does not prescribe a limit on hydrogen concentration, hydrogen is included within definition of gas, therefore it is possible there is no need for Primary Legislative change:
  Under section 48(1) of the Gas Act "gas" is defined as: (a) "any substance in a gaseous state which consists wholly or mainly of (i) methane, ethane, propane, butane, hydrogen, or carbon monoxide; (ii) a mixture of two or more of those gases; or (iii) a combustible mixture of one or more of those gases and air

Secondary legislation GS(M)R

- To facilitate Project Union, solution options (as developed through this project) could include:
  - Phase 1: Exemption to GS(M)R
  - Phase 2/3: Add Hydrogen Schedule to existing GS(M)R
  - Phase 3: Develop new Hydrogen GS(M)R statutory instrument
- For all phases of Project Union, there is a requirement to develop a separate document to GS(M)R to indicate which pipelines hydrogen gas quality specifications apply to (i.e., 100% hydrogen).

  For all phases of Project Union, there is a requirement to develop and implement a new Safety Case, approved by the HSE [either added to existing NGT safety case, or developed as a separate document].

Gas Transporter License

- Licenses do not include gas composition or gas quality specifications.

  It is not suggested that a change in the composition of gas would impact the nature of a licensed activity (i.e., fundamentally, the licensed transporter would still be conveying gas through a pipeline).

Uniform Network Code: (UNC)

- To access changes to GS(M)R for hydrogen, there will be a requirement to amend UNC to change the definition of gas (General Terms: Section 3.1.1.1).

Section 3: Connections

3a. Defining the existing NTS connections regime

Any party wishing to physically connect to the NTS can arrange for a connection directly with us, through a process called Application to Offer (A2O).

We offer four types of connection services, including:

- Entry and Exit connections
- Storage connections
- International interconnectors
- Disconnection and decommissioning

Any party wishing to physically connect to the NTS can arrange for a connection directly with us, through a process called the Application to Offer (A2O).

It is key to note that the capacity process (i.e., gaining entitlement to flow gas on or off the NTS) is separate to the connections process. There is a risk that capacity may not be available when needed (i.e., for a new or expanded connection point). Therefore, we designed the Planning and Advanced Reservation of Capacity Agreement (PARCA) process to run in parallel with the A2O. It is only through the PARCA process that the release of funded incremental (i.e., additional) capacity can be applied for. Therefore, the PARCA provides an important investment signal that allows us to plan network development economically and efficiently.

An overview of the key market participants and their roles in the existing NTS connections regime includes:

Connected party conditions are included within connection contracts:

- Network Entry Agreement (NEA)
- Network Exit Agreement (NExA)
- Interconnector Agreements
- Storage Connection Agreement (SCA)
- Disconnection and decommissioning*

* *Modifying an existing connection contract requires the same approach as a new NTS connection*

Some legacy NTS connection contracts also include Shippers, however current practice is that connection agreements are contracts between Transporter and Connected parties

Key to note, connection contracts between the NTS and the Gas Distribution Networks (GDNs) are governed by the Offtake Arrangement Document (OAD)

New connections could also include an entity who develops the connection, where the physical connection is then bought by a separate entity to operate.

Connected party

Planning and Advanced Reservation of Capacity Agreement (PARCA): A bi-lateral commercial contract that allows an applicant to reserve NTS Entry and/or Exit Capacity ahead of when the capacity will be needed, while customers develop their projects (i.e., including new or expanding connections).

A2O

Those wishing to connect to the NTS will need to follow the Application to Offer process (A2O). The A2O process follows the steps outlined in the Uniform Network Code (UNC) – Transportation Principal Document (TPD) – Section V (General) – 13. NTS Connections.

Gas transporter

NTS transporter conditions for connections:

Gas Act: Duty of a gas transporter to comply, so far as it is economical to do so, with any reasonable request to connect

Gas Transporter License: Standard Conditions: Condition 4B: Connection Charging Methodology

National Gas Transmission plc Gas Transporter License Special Conditions: Appendix 1: Connections service, Disconnections service

Uniform Network Code Section V: General: Section 13 NTS Connections provides robust and transparent framework for the A2O for new connections and connection modifications.

Key to note, connection contracts between the NTS and the Gas Distribution Networks (GDNs) are governed by the Offtake Arrangement Document.

The key elements of the current legislative hierarchy that govern the NTS connection regime include:

Primary Legislation: Gas Act 1986

Section 9: General powers and duties (of public gas transporters)

- It shall be the duty of a gas transporter to develop and maintain an efficient and economical pipe-line system for the conveyance of gas; and to comply, so far as it is economical to do so, with any reasonable request for him to connect to that system, and convey gas by means of that system to, any premises, or to connect to that system a pipe-line system operated by an authorised transporter.
- It shall also be the duty of a gas transporter to avoid any undue preference or undue discrimination in the connection of premises or a pipe-line system operated by an authorised transporter, to any pipe-line system operated by him

Section 10: Duty to connect certain premises

Gas Transporter License

Gas Transporter License: Standard Conditions:

- Condition 4B: Connection Charging Methodology (the licensee may charge the person requiring the connection in respect of the cost of supplying and laying the pipe)

National Gas Transmission plc Gas Transporter License Special Conditions:

- Appendix 1: Connections service, Disconnections service (carrying out of works to provide any new connection or modify any existing connection to the Transportation System)
- Part 1: Long Term Development Statement (likely development of the system, facilities and other pipeline systems which the licensee expects to be taken into account in determining the charges for making connections to the pipeline system
- Gas Ten Year Statement: Outlines 4 types of NTS connection contracts as well as option to modify existing connection contracts, and also details elements of gas quality that are not specified in GS(M)R but are important to NTS operation.
- Licensees must also become party to and/or comply with certain industry codes (i.e., Network Code & Uniform Network Code).

Uniform Network Code

Section V: General: Section 13 NTS connections

- provides robust and transparent framework for new connections/modifications including, application process, definition of initial connection offer, definition of full connection offer, how to modify full connection offer, timescales for NGT to produce connection offer, timescale for customers to accept initial/full connection offer, application fees.
- This forms the basis of NGT Application to Offer process.

Section Y: Part A-II

- The gas transmission connection charging methodology (published in accordance with Standard License Condition 4B) i.e., How NGT discharges licence obligation

NGT also publishes an annual connections charging statement

3b. Challenges to the existing connections regime from the development of Project Union

The Gas Act 1986 states gas transporters "must develop and maintain an efficient and economical pipeline system and comply with any reasonable request to connect premises, as long as it's economic to do so".

However, the existing process for connections to the mature gas NTS will not be suitable for the development of Project Union, especially not for the initial phases. Applying the current first come first serve approach to connections will not be suitable because in the hydrogen transition there will be limited infrastructure available to facilitate the hydrogen market. We will not be able to assume access to diverse sources of plentiful hydrogen supply in the initial hydrogen transition, as hydrogen is a vector and not an energy source like natural gas. In a hydrogen transition we will need to have a more calculated and strategic approach to network planning to ensure security of supply and system resilience, especially in initial stages of the Project Union transition.

Connections play a key role in network planning. Below we have considered a range of connection regime options that could be suitable to facilitate the different phases of Project Union development.

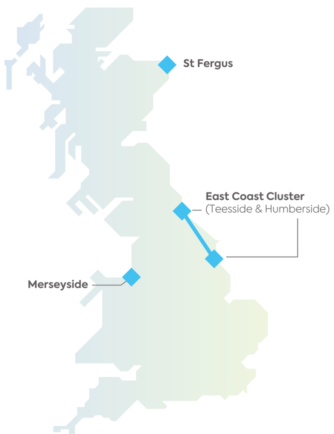
3c. Solution options to enable a connections regime for Project Union

We have assumed there is a need for an overarching contractual framework, as opposed to individually negotiated connection contracts to Project Union. We believe this is important in order to set out a uniform and consistent approach to connections to Project Union.

Connection solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1



Strategic connections regime

For the initial phase of Project Union, when a limited section or sections of the NTS have been repurposed to 100% hydrogen, strategic direction will be required to determine connection locations. Strategic direction to connections is needed to maximise system operation efficiency for Project Union, and to minimise the impact of new connections to existing connected parties.

Strategic direction would likely be provided by a central strategic planner, with the authority to determine connection locations for potential hydrogen producers, consumers, or storage sites.

A precedent for strategic direction connections to Project Union can be taken from the outputs of our Project Customer Low Cost Connections (CLoCC). The outputs of Project CLoCC included a new process where we can now offer a Standard Design connection to the NTS. These can only be offered at suitable block valve locations, restricted to certain geographic locations.

The authority and transparent process for the role of central strategic planning will need to be established. The strategic planning role could be undertaken by:

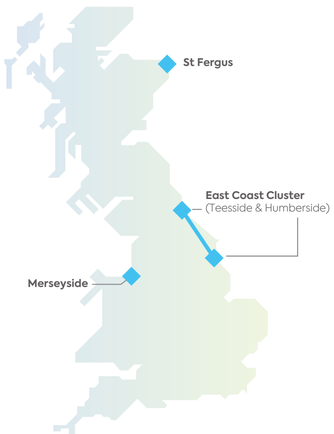
- Project Union System Operator (SO)
- Future System Operator (FSO)
- Hydrogen producers (due to their requirement to need to know the physical energy supply to meet potential new connected demands)

continued >>

Connection solution options for Project Union (continued)

Solution options for initial connected cluster phase of Project Union:

Phase 1



Strategic connections regime (continued)

If the Project Union SO does not take on the role of managing strategic connections at this stage, then the selected strategic planner would need to work closely with the Project Union SO to ensure efficient operation of the Project Union network. It is likely that in the long term, a whole-system strategic planning body (such as the FSO) will take on the role of central network planner, considering a whole-system perspective to deliver value for UK energy consumers.

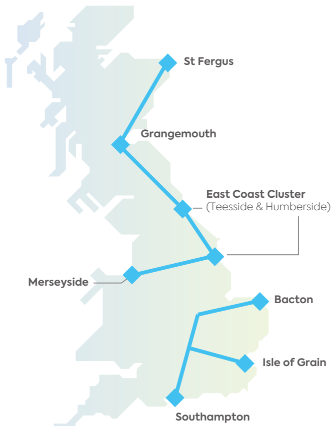
It is key to note that in this initial phase of strategic direction for connections to Project Union, there would be limited market driven investment signals for network development. Instead, the development of Project Union, at least for this initial phase, would be driven by central strategic planning.

In addition, we recommend that initial Project Union connection contracts include enhanced specific conditions (i.e., obligations to respond to SO instructions for dispatch) to provide the Project Union SO with the tools required to ensure system resilience and security of supply for connected parties.

Clearly a strategic direction connections regime is a significant departure from the current free market approach to NTS connections. There will need to be a transition pathway in place to a more competitive, market driven connections process, and we only recommend this solution as an initial necessary first step in the pathway to an enduring competitive connections solution.

Solution option for regional expansion of Project Union:

Phase 2



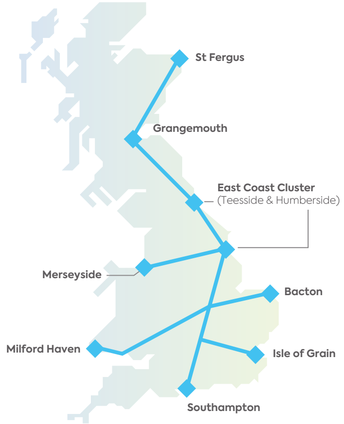
Market led with incentives connections regime

In this regime, as Project Union develops into an increasingly integrated network with multiple Entry and Exit Points, a progressively market driven approach to connections would emerge. For example, incentives could encourage market participants to connect in certain locations to maximise system operation efficiency. These incentives could involve cheaper exit connection costs offered in network locations of network capacity constraint due to high hydrogen flows, or cheaper Project Union entry connections offered in network locations close to high offtake demand.

It is likely connection contracts would still include enhanced specific conditions to provide the Project Union SO with the mechanisms required to ensure system resilience and security of supply on the system and for all connected parties.

Connection solution options for Project Union (continued)

Solution option for mature Project Union backbone:
Phase 3



Free market connections regime

When Project Union is sufficiently mature, and has reached the phase of achieving a large, integrated, resilient network, a similar connections regime to that which is currently in place could be implemented. This would involve taking a free market, first-come, first-serve approach to connections 'so far as it is economical to do so.'

We believe that the existing process for NTS connections is portable to the Project Union transition, as the principles would remain the same. For example, the Project Union System Operator would want to understand where customers wanted to connect and their requirements through a connection application, followed by the development of a connection offer, completed by the connection construction.

The key changes to the Project Union connection regime will include the approach to connections and the substance of the connection contract that detail the conditions the connected party and the Transporter must adhere to. In addition, for all phases of Project Union network development, there is likely to be a need for continued additional strategic planning to Project Union connections. This is due to the smaller size of the Project Union network in its development to maturity, and the different operating conditions based on different user behaviour compared to the existing natural gas regime. There is a precedent for continued enhanced strategic planning powers to network connections in the electricity networks, as with the current Electricity System Operator (ESO) managing the current connection agreements that impact the Electricity Transmission network.

Changes to the Project Union connection regime will include the approach to connections and the substance of the connection contract that detail the conditions the connected party and the Transporter must adhere to.

Potential impact to current legislative hierarchy to enable a connections regime for Project Union

Below we have articulated an overview of potential changes to the existing legislative framework to enable the solution options we have identified as part of this project to enable a connections regime for Project Union.

Primary Legislation: Gas Act 1986

Section 9: General powers and duties (of public gas transporters)/
Section 10: Duty to connect certain premises

- Depending on the approach to connections taken, there is potentially a need to amend rules of offering connections, especially if considering a strategic approach [i.e., direction provided on location connection] or incentivised approach [i.e., incentives to connect in certain locations] that may not adhere to the current regime of 'avoid undue preference or undue discrimination in the connection of a premises or a pipeline system'.
- However, the current condition of accepting 'reasonable [connection] request' could potentially be used to implement strategic/incentivised connection regimes.

Gas Transporter License

- Gas Transporter License: Standard Conditions: Condition 4B: Connection Charging Methodology: Requirement for Project Union Connection Charging Methodology (taking into account any additional amended charges due to hydrogen infrastructure connection needs).
- National Gas Transmissions plc Gas Transporter License Special Conditions Requirement for categories of directly renumerated services for Project Union connections – this would be especially relevant if a separate License is developed for hydrogen network transporters such as the development of Project Union
- Requirement for Long Term Development Statement to detail Project Union network connections
- Requirement for Transmission Planning Code to 'cover all material technical aspects relating to the planning and development of the pipeline system to which this licence relates that may have a material impact on persons connected to or using (or intending to connect to or use) that pipeline system' especially if a new license is implemented for hydrogen network transporters

Uniform Network Code

Section V: General:

- The UNC was not designed to be a connection code (unlike the Electricity system CUSC – Connection and Use of System Code): i.e.: 'If a User or any other person (the "Connection Applicant") wishes to request...' Because the UNC is the commercial contract between a Gas Transporter and Users (i.e., Shippers, Traders, GDNs), the UNC cannot apply to 'any other person', therefore the UNC cannot prescribe connections process to 'any other person'.
- The technical and operation conditions of connections [Entry and Exit] are currently agreed between the connection facility operator and the NTS. The rules for connections could be detailed instead within Transporter Licenses or Code to provide a consistent approach to connections, to prevent bilateral negotiations to connection agreements leading to diverging connection contracts.
- Connection agreements outlined in code would be consistent with approach taken for carbon networks, as included within the Indicative Heads of Terms To the document entitled "Carbon Capture, Usage and Storage: CCUS Network Code.
- In addition, as hydrogen production will play a much more critical role in system operation for hydrogen networks, there will likely be a need for additional obligations to be placed on hydrogen producers, and these obligations will likely change over time. It would be very challenging to need to change each bilateral connection agreement as obligations changed over time, therefore including a standardised approach to network connections within code would help to facilitate an evolving commercial framework.
- There is a requirement to outline a more strategic approach to the existing NTS Connection, A2O, process (see below)
- Requirement to consider the approach to managing repurposed connections (i.e., converting existing connection contracts from natural gas to hydrogen)

NGT Application to Offer process.

- Depending on the approach to connections taken, a specific outline of the rules to the connection process (A2O) to Project Union would be required. For example, the A2O process for Project Union will likely include a more strategic approach and with more processes in place than today to undertake detailed impact assessments, such as potentially including network analysis as part of a pre-connection impact assessment.

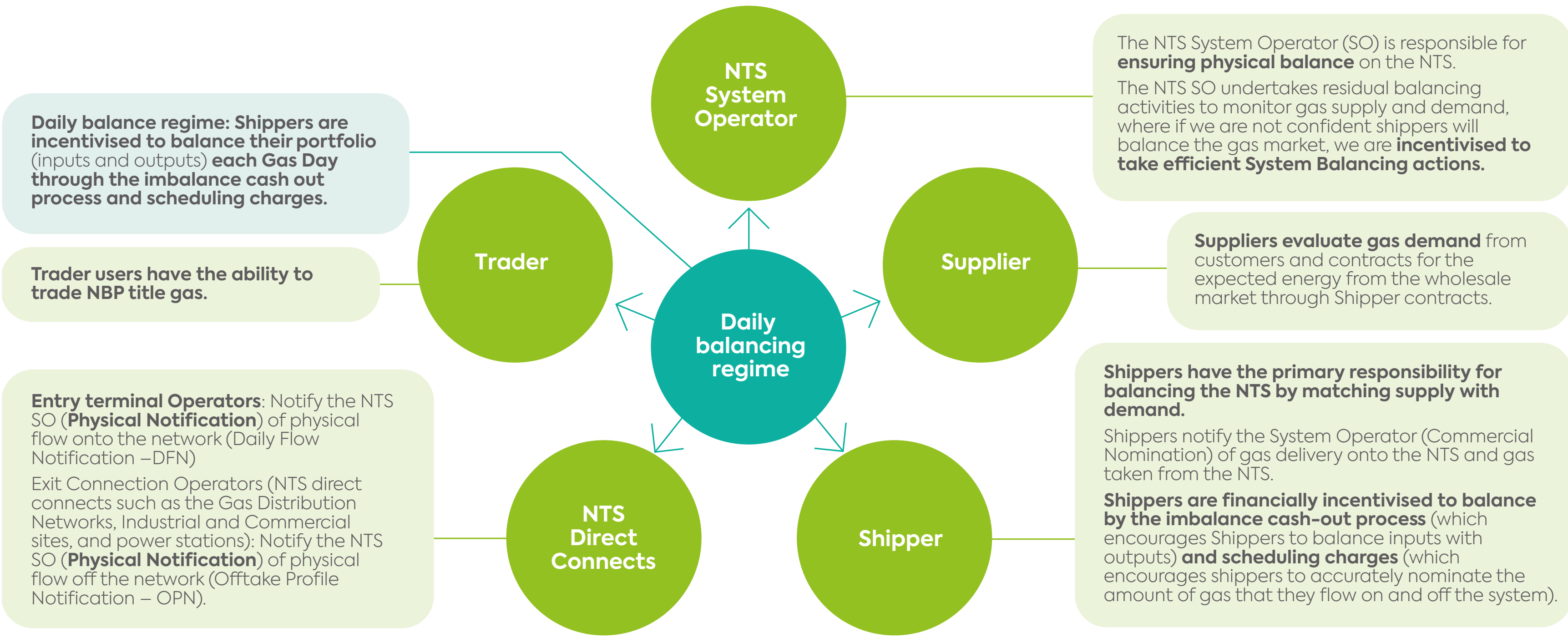
Section 4: Balancing and Trading regime

We have bundled balancing and trading considerations together, considering the close interaction between these mechanisms, as illustrated in this section.

4a. Defining the existing NTS balancing regime

The premise of the existing NTS balancing regime is simple: gas which is taken off the system (i.e., the network) must be matched by gas delivered to the system, for each balancing period (Gas Day – 5am to 5am). For more information on the fundamentals of the existing NTS balancing regime, please refer to our End-to-End Balancing Guide.

An overview of the key market participants and their roles in the existing NTS balancing regime includes:



Defining the existing NTS trading regime

Trading is a tool to ensuring market participants are in balance, to hedge potential supply risk or optimise financial performance. The gas day (5am – 5am) establishes the trading window for exchanging day-ahead and daily gas products on relevant trading platforms and is harmonised with EU energy markets to promote cross-border trading.

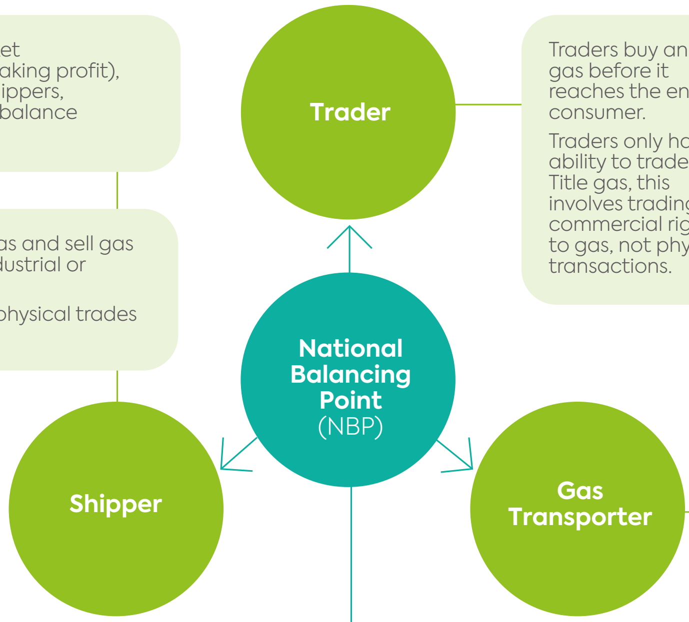
An overview of the key market participants and their roles in the existing NTS trading regime includes:

Trading is a tool to ensuring market participants are in balance, to hedge potential supply risk or optimise financial performance.

It is key to differentiate between Trading market participants (who only trade for purpose of making profit), versus trading as an activity undertaken by Shippers, Suppliers and Gas Transporters (who trade to balance portfolio delivered to physical customers).

Gas shippers buy gas from producers, trade gas and sell gas to either gas suppliers or to large scale (i.e., industrial or power generation) gas consumers.

Shippers can undertake NBP title trades, NBP physical trades and Physical Locational trades.



Traders buy and sell gas before it reaches the end consumer.

Traders only have ability to trade NBP Title gas, this involves trading the commercial rights to gas, not physical transactions.

Within the Gas System Operator (GSO), the NTS Gas National Control Centre (GNCC) monitors, throughout the day, the NTS System Balance:

Opening Linepack + (Supplies – Demands)

As the Residual Balancer of the NTS, GNCC takes trade actions to ensure the NTS is operationally secure and to balance efficiently. The only market the GNCC can trade on is the On the Day Commodity Market (OCM). By taking trade actions, the GNCC also influences the cash-out incentive for Shippers to balance their portfolios. The GNCC can undertake NBP title trades, NBP physical trades and Physical Locational trades on the OCM.

The GSO also trades for Shrinkage reasons (*shrinkage is energy used to operate the NTS or unaccounted for due to measurement reasons*). GSO shrinkage trades can be made on the OCM or via the Over The Counter (OTC)

The NBP is a virtual location originally created by the Uniform Network Code to support the balancing of the gas system. However, it evolved to also become a trading point, and it is where Shippers and Traders nominate their gas buys and sells, and where the GNCC carries out our daily balancing activities.

The key elements of the current legislative hierarchy that govern the balancing regime include:

Primary Legislation: Gas Act 1986

- 7: Licensing of public gas transporters
- 7A: Licensing of gas suppliers and gas shippers

License

- Gas Transporter License: Standard Conditions – [daily energy balancing/physical balancing role]
  - In relation to each day, means the taking of such measures as may be available to the licensee affecting the relationship between deliveries of gas to and offtakes of gas from the pipe-line system on the day in question, to maintain pressures at levels which will not prejudice the safety or efficiency on that day or on subsequent days
- National Gas Transmission plc Gas Transporter License Special Conditions – [NTS physical balancing role/residual balancing incentive/ OCM independent market for balancing]
  - NTS SO activity: procuring and using of balancing services to balance the NTS
  - Residual balancing incentive
  - Special condition 9.2, independent market for balancing (OCM). Licensee must appoint operator to ensure the market is conducted in orderly and proper manner
- Gas Shipper Standard License:
  - Primary balancer role, imbalance incentive/daily balancing regime
  - Nomination of proposed deliveries of gas to, or offtakes of gas from, that system/imbalance between the amounts of deliveries of gas to, and of offtakes of gas from, the relevant transporter's pipe-line system/transporter to monitor, on a daily basis, the licensee's compliance with the terms
  - Licensees must also become party to and/or comply with certain industry codes (i.e., Network Code and Uniform Network Code).

Uniform Network Code:

- UNC is Schedule 2B of the Gas Act - Code - rights & obligations of licence holders and consumers, contract between Shippers/ Traders and Transporters
- **Section C**: Nominations:
  - Daily nomination of quantities of gas for delivery to and taken from the Total System, enabling the operation of the NTS and Operational Balancing
- **Section D**: Operational Balancing and Trading Arrangements: [Shippers incentivised to balance supply with demand, primary balancing role]
  - Arrangements made to maintain the balance between the quantities of gas delivered to and offtaken from the Total System. Trading arrangements are also covered, inc. market transactions and contract renominations, contingencies, and multi-day balancing actions (Annex D for further info)
- **Section E**: Daily Quantities, Imbalances and Reconciliation [Imbalance and cash-out process – NTS residual balancer – concept of NBP (title market/ accessed via OCM)]
  - Determination of the daily quantities input and offtaken from the Total System by each Shipper and the associated charges, together with the determination of daily imbalances
- **Section F**: System Clearing, Balancing Charges and Neutrality [Imbalance and cash-out process – NTS residual balancer – concept of NBP (title market/ accessed via OCM)]
  - Clearing of each Shipper's daily imbalances, the calculation and payment of daily imbalance charges
- **Section K**: Operation margins requirements: [Storage as a balancing tool]
  - NTS needs to ensure safe operation of the system to manage short-term impact of operational stresses before market responses (i.e., sudden loss of supplies, compressor trips, large change in demand). NTS procures OM, OM gas can be called upon at short notice and supports the system, includes contracts for flexibility gas and storage, storage stocks must be maintained so that gas can be made available when required.

The key elements of the current legislative hierarchy that govern the trading regime include:

Primary Legislation: Gas Act 1986

- Trader User does not need a license, therefore trading rules are within Network Code: Unlicensed Entities Trader User means an entity bound by the Shippers Framework Agreement (a signatory to the Uniform Network Code) for the submission of trade nominations, but not for the purpose of arranging for gas to be introduced into, conveying by means of, or taken out of the NTS.

Gas Transporter License

Gas Transporter License: Standard Conditions

- Definition of trading business: activities connected with the acquisition and disposal of gas in Great Britain/ activities connected with storage
- The licensee shall use its best endeavours to secure that no information relating to, or derived from, its transportation business is disclosed for the benefit of any trading business

National Gas Transmission plc Gas Transporter License Special Conditions – [Independent market to trade for Balancing - OCM]

- Special condition 9.2, independent market for balancing (OCM). Licensee must appoint such operator to ensure that the market is conducted in an orderly and proper manner

UNC Uniform Network Code: (UNC is contract between Shippers and Transporters)

- UNC framework created the NBP, which has since evolved into a trading point [mechanics of trading gas at NBP in NBP Terms and Conditions 2015]
- **Section D** Operational Balancing and Trading Arrangements: [Residual balancing NTS trading arrangements]
  - Arrangements to maintain the balance between the quantities of gas delivered to and offtaken from the Total System.
  - Trading arrangements include market transactions, contract renominations, contingencies, and multi-day balancing actions (Annex D for further info)
- **Section E** Daily Quantities, Imbalances and Reconciliation [Imbalance and cash-out process – NTS residual balancer – concept of NBP]
  - Determination of the daily quantities input and offtaken from the Total System by each Shipper and the associated charges, together with the determination of daily imbalances
- **Section F** System Clearing, Balancing Charges and Neutrality [Imbalance and cash-out process – NTS residual balancer – concept of NBP]
  - Clearing of each Shipper's daily imbalances, the calculation and payment of daily imbalance charges
- **Section N** Shrinkage: [Shrinkage]
  - National Gas Transmission NTS will estimate each Day, the quantity of NTS own use gas, NTS unaccounted for gas and Calorific Value (CV) Shrinkage on the following Day
  - A Shrinkage Provider (NTS) may purchase gas in respect of shrinkage by making Trade Nominations

4b. Challenges to the existing balancing regime from the development of Project Union

Balancing the Project Union network will be a key challenge, considering the need to manage any misalignment between hydrogen production and hydrogen demand.

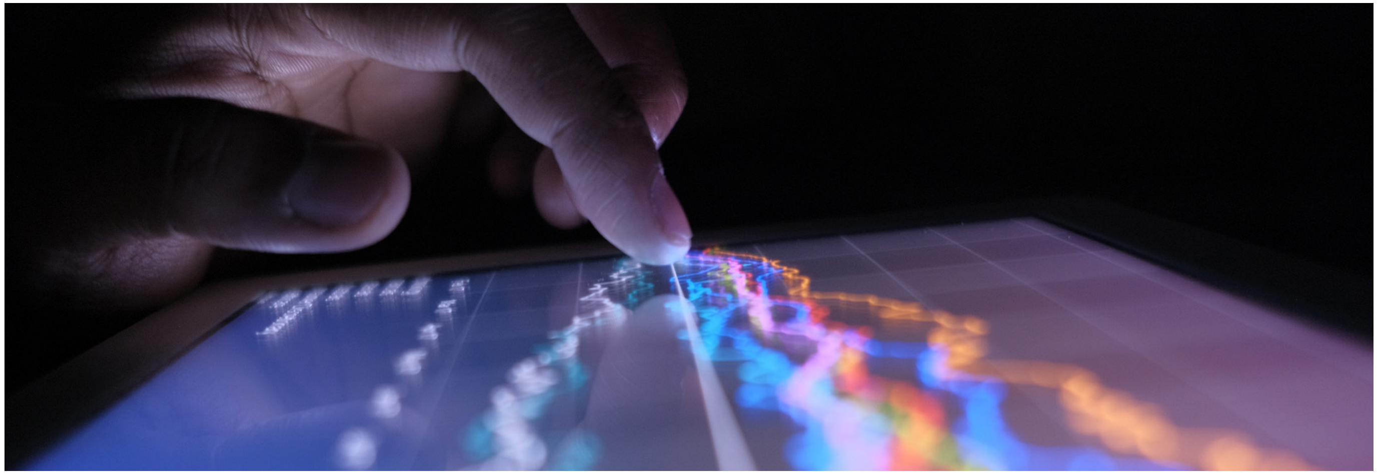
The key sources of hydrogen production will likely involve a combination of CCUS enabled methane reformation ('blue' hydrogen) and electrolytic ('green') hydrogen. Green hydrogen could provide either a baseload hydrogen supply if connected to the electricity network or could provide much more intermittent hydrogen supply if connected to renewable energy sources.

Blue hydrogen is generally best suited to providing a baseload, steady supply of hydrogen. According to the HyNet Low Carbon Hydrogen Plant report produced for BEIS, this is a well-developed technology which has been used internationally for ammonia and methanol production. Whilst any plant will operate most economically at baseload, it is important to establish that it can meet turndown, and ramp-rate requirements to meet market demand.

> The interaction between hydrogen supply and demand will drive times of hydrogen excess and hydrogen scarcity, driving the need for Project Union to have access to mechanisms to balance the network to provide flexibility, and ensure resilience and security of supply for connected customers.

Hydrogen demand connected to Project Union will likely involve a number of different end users including baseload industrial and commercial sites, flexible power generation, and potential seasonal domestic heating demand (pending Government decisions on hydrogen for heating), alongside potential flexible transport demand as well.

The interaction between hydrogen supply and demand will drive times of hydrogen excess and hydrogen scarcity, driving the need for Project Union to have access to mechanisms to balance the network to provide flexibility, and ensure resilience and security of supply for connected customers.



Spotlight: on storage

A key challenge to Project Union will be managing the reduction to linepack (linepack is the inherent gas stored within pipelines). Linepack will be reduced due to the lower energy content of hydrogen, hydrogen is only one third of the energy density per unit volume in comparison to natural gas. Because of this, linepack will diminish more quickly and provide less of a buffer than it currently does on the existing natural gas NTS for connected parties to utilise. The reduction of linepack on Project Union due to a combination of lower energy content of the gas and a shorter total pipe length will reduce how flexibly connected parties can utilise hydrogen. The reduction in linepack capability will also cause operational challenges for the Project Union System Operator, likely increasing the need to rely upon compressors to distribute hydrogen supplies to meet connected party pressure requirements.

The challenge of reduced linepack in combination with the challenge of managing any misalignment between hydrogen supply and demand, will drive the need for significantly more storage to support the Project Union network to ensure resilience and security of supply for connected market participants.

We recommend that an essential mechanism to support balancing of the Project Union network will include access to fast cycle flexible storage to manage inter-day and day ahead balancing needs, as well as large scale storage, for seasonal purposes. We believe this will be essential at all phases of Project Union and will remain so regardless of the decision on hydrogen for domestic heating.

Access to hydrogen storage has many important benefits including:

- **Whole system benefits:**
  - Access to storage enables maximisation of renewables to connect to the UK's electricity networks. Any curtailed renewable energy could instead be translated into hydrogen through electrolysis and stored until needed. This would make a better use of cheap energy sources and could reduce consumer exposure to volatile energy prices.
- **Total system benefits:**
  - Storage should reduce the overall need to invest in energy infrastructure, by providing a route to store energy until needed to meet energy demand in a secure and efficient manner.
- **Insurance benefits:**
  - Storage would ensure security of supply or additional demand offtake, in case of any unexpected supply or demand imbalances.

By working in tandem, hydrogen storage and the Project Union network could deliver resilience and ensure security of supply for connected parties in the hydrogen transition.

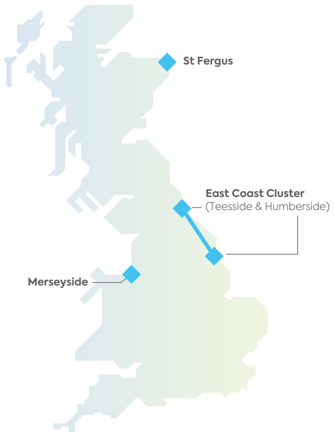
The challenge of reduced linepack in combination with the challenge of managing any misalignment between hydrogen supply and demand, will drive the need for significantly more storage to support the Project Union network to ensure resilience and security of supply for connected market participants.

4c. Solution options to enable a balancing and trading regime for Project Union

Balancing and Trading solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1



Resilience balancing

To begin with, it is key to note that we have assumed for each phase of Project Union, a daily balancing regime is likely to be the most appropriate choice. We did explore the concept of a more granular balancing period, however, due to the physical characteristics and behaviour of gas, we believe that continuing to allow a day to balance the Project Union system will likely continue to be appropriate. There is every chance a shorter more granular balancing period may be put in place, especially for the initial phase of Project Union, if the initial Project Union network is limited in size, pending the behaviour of connected market participants, and also pending access to storage facilities to support balancing activities.

In the initial phase of Project Union, it is likely that hydrogen producers and hydrogen consumers will engage in bilateral contracts, where limited trading could emerge for any uncontracted hydrogen volumes.

Bilateral contracts will likely be in place in this initial phase, due to the need for certainty of demand to justify investment for hydrogen producers in the nascent stages of hydrogen market development. The Hydrogen Production Business Model also requires bilateral contacts between the hydrogen producers and the end User.

In this initial phase, Project Union would operate much like the current interconnectors, with Project Union connecting systems through bi-directional connections, such as connecting the emerging industrial clusters. Project Union will provide greater flexibility to connected clusters through access to additional hydrogen supply, as well as opportunity to service additional hydrogen demand. These clusters can be expected to balance their own networks, where the role of Project Union System Operator would be to balance the Project Union network and maintain pressure agreements at the Entry/Exit points to the clusters. It is also important to note that even in the initial phases of Project Union, there is the potential for customers to directly connect to Project Union as well.

The Project Union System Operator would perform the role of resilience balancer. In this role, the Project Union System Operator will require enhanced access to tools, and command-and-control powers, to enable the System Operator to balance the network, ensure security of supply and resilience of the system. These enhanced tools will likely include the ability to instruct connected sites to reduce or increase flow onto the Project Union network, as well as potential access to strategic storage facilities or enhanced operating margins, and the potential to blend excess hydrogen supplies onto the natural gas network (*pending the Government decision on hydrogen blending*).

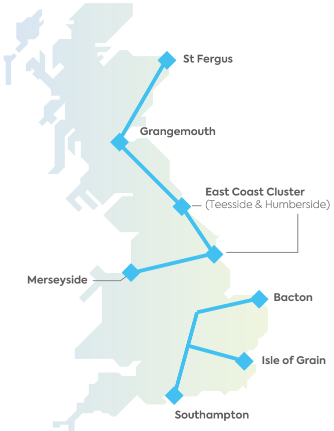
- In the case of directly connected sites to Project Union, these customers will need to be compensated for following command-and-control instructions, the financial incentives could be included within connection contracts for example.
- In the case of aggregated connection points, such as a single connection into an industrial cluster including both hydrogen supply and demand, their connection agreement could include provisions for mechanisms for enhanced flexibility, such as contracts to use linepack or connected storage sites.

In this stage of Project Union, there is likely to be very limited hydrogen price transparency within hydrogen trades, considering most hydrogen contracts will be made within private and confidential bilateral contracts.

Project Union will provide greater flexibility to connected clusters through access to additional hydrogen supply.

Balancing and Trading solution options for Project Union (continued)

Solution option for regional expansion of Project Union: Phase 2



Introduction of market measures to support balancing

As Project Union evolves and connects increasing industrial clusters as well as facilitating increasing direct connections to hydrogen producers, consumers or storage sites, we can expect market players to take a more active role as the primary balancers of the system.

The Project Union System Operator will still likely require enhanced access to tools to manage misalignment between hydrogen supply and demand, however these tools could be provided through more market-based measures, as opposed to contractual command-and-control measures.

Market based measures to support balancing could involve the development of a physical locational spot market. This would involve physical locational trades between market players as well as with the Project Union System Operator, taking place on a spot market, such as the development of a hydrogen On-the-Day Commodity Market (Hydrogen OCM). Market participants would be able to place physical locational trade bids and offers to balance positions, and the System Operator would also make balancing trades on the platform.

The concept of a physical locational spot market is based on the previous flexibility market that was created when the Uniform Network Code (UNC) was first being established in the mid 1990's. The natural gas physical locational spot market was not a title market (i.e., title market involves trades of contractual rights to gas, and is not based on a specific location nor will it ensure physical delivery of gas), but rather a mechanism for physical trades related to a specific location. This market was put in place as the gas industry transitioned from pre-UNC (i.e., when British Gas operated as a state-owned monopoly delivering gas to end users) into a competitive regime.

In the natural gas physical locational spot market, gas Shippers placed bids and offers on a screen-based system to fine tune their own balance of inputs and offtakes, and the Gas System Operator could perform the role of residual balancer through buying or selling gas volumes at specific locations.

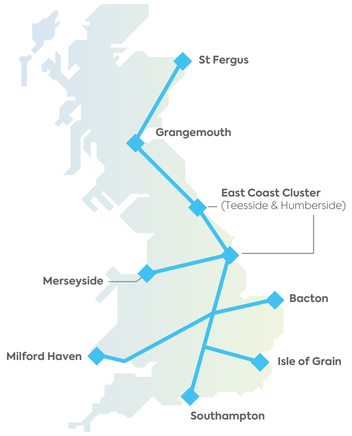
In the case of Project Union, the development of a physical locational spot market trades would for example enable trades to take place at connection points from the clusters into the Project Union system.

The development of a physical location spot market would enable emerging hydrogen price transparency, where pricing information could be posted alongside anonymous trades.

Balancing and Trading solution options for Project Union (continued)

Solution option for mature Project Union backbone:

Phase 3



National commercial balancing regime

In the mature stage of Project Union, we can expect that a national balancing regime will commercially incentivise market players to balance their portfolio. Market participants would perform the role of primary balancers, with the Project Union System Operator performing a residual balancing role.

When sufficient hydrogen market liquidity has emerged supported by sufficient market players, with satisfactory hydrogen network capability in place, this can give confidence to trigger the development of a hydrogen National Balancing Point (NBP) to enable not only physical location trades, but title trade of hydrogen gas. Establishing a hydrogen NBP will require the development of a framework to capture the rules and mechanisms, such as there is currently in place for the natural gas NBP.

It is key to note that even in the mature phase of Project Union, the Project Union System Operator will likely require enhanced tools or services to ensure system balance and resilience. This will still be required as the hydrogen market will still likely have limited liquidity.

The development of a hydrogen NBP would enable a single national price for hydrogen to be established at a single hydrogen balancing point.

We have assumed that the distinct role of Trader will only emerge at more mature phases of Project Union, when sufficient hydrogen market liquidity has developed. For the initial phases of Project Union, the activity of trading will be conducted by market participants to manage portfolio balancing or will involve limited trading of uncontracted hydrogen volumes.

Even in the mature phase of Project Union, the Project Union System Operator will likely require enhanced tools or services to ensure system balance and resilience. This will still be required as the hydrogen market will still likely have limited liquidity.

Potential impact to existing balancing legislative framework

Below we have articulated an overview of potential changes to the existing legislative framework to enable the solution options we have identified as part of this project to enable a balancing and trading regime for Project Union.

Primary Legislation: Gas Act 1986

- Gas Act includes principles of Shippers contracting with upstream producers, Shippers contracting with Transporter to convey gas, Shippers contracting with Suppliers, with Suppliers contracting with end users.
- Which market player will have responsibility for primary balancer, and how could this impact the legislative framework? And, if primary balancer evolves, how are transition issues mitigated?
- i.e., Initially, if there are no 'risk taking' intermediaries as per HBM, this contradicts the Gas Act and requires Primary Legislation change – if H_2 producers contracting with H_2 ends users?
- If PU or Cluster SO's or new market player role (i.e., System Architect) are selected as primary balancer with enhanced powers to ensure SoS, how/does require derogation/exemption/amendment/new Primary legislation?
- Does it matter if the concept of Shipper/Supplier is not used for H_2? i.e., Existing framework can stay in place in Gas Act but not utilised for H_2 networks?
- Can different market players take on role of Shipper [i.e., market player to procure H_2 supply and gain transportation rights on behalf of end users] i.e., H_2 producer?

License

- Gas Transporter License: Standard Conditions – Daily energy balancing/ responsible for physical balance
- Change to License if balancing regime granularity changes i.e., Not daily but 12 hourly balancing etc?
- National Gas Transmission plc Gas Transporter License Special Conditions – Residual balancing role to maintain physical balance/OCM
- If SO is primary balancer (i.e., for initial command & control phase), does this require license change, i.e., enhanced powers? Or would increased obligations on market players be better placed within connection contracts?
- Trigger needed (i.e., sufficient market player/network integration maturity) to initiate development of framework for market balancing measures, likely starting with physical locational trades on OCM, then development of NBP with title trades
- If PU SO owned storage for balancing purposes – i.e., strategic storage, how would this impact licensing regime?
- Gas Shipper Standard License: primary balancing responsibility/daily imbalance compliance
  - Passive Shipper - does this require license change if Shipper Nominations instructed by SO? (Precedent from H_2 trials?)
  - If H_2 producers/ storage/ new market player is selected as the primary balancer, is there an immediate requirement for the selected party to be licensed?

Uniform Network Code:

- Schedule 2B of the Gas Act- Code - rights & obligations of licence holders and consumers, UNC is contract between Shippers and Transporters
- **Section C**: Nominations: [daily energy balancing regime]
  - Initial H_2 networks may only require physical notifications, not commercial nominations [this regime may be in place for significant length of time]
- **Section D** Operational Balancing and Trading Arrangements: [Shippers incentivised to balance supply with demand, primary balancing role
  - See above, and: Which market players will be responsible for primary balancing role in H_2 transition? Long term?
- **Section E** Daily Quantities, Imbalances and Reconciliation [Imbalance and cash-out process – NTS residual balancer – concept of NBP]
  - Trigger needed (i.e., market player/network integration maturity) to initiate development of market framework for market balancing measures, potential regional H_2 NBPs, vision to achieve single national NBP
- **Section F** System Clearing, Balancing Charges and Neutrality [Imbalance and cash-out process – NTS residual balancer – concept of NBP]
- **Section K:** Operation margins requirements [Tool to manage short-term impact of operational stresses & balance - before market responses]
  - Additional storage services likely need to be developed to support balancing – potential need to license storage players to fulfil enhanced obligations or for PU SO to own storage

Potential impact to existing trading legislative framework

Trader User does not need a license, therefore trading rules are within Network Code

- Unlikely to require distinct role of Trader for significant length of time, until more market players introduced/competition emerges

Uniform Network Code:

- (UNC is contract between Shippers and Transporters)
- Definition: Trader User in its capacity as a person bound by the Code pursuant to the Shippers Framework Agreement
- UNC framework created the NBP, which has since evolved into a trading point [mechanics of trading gas at NBP in NBP Terms and Conditions 2015]

Section D Operational Balancing and Trading Arrangements:

- [Residual balancing NTS trading arrangements]

Section E Daily Quantities, Imbalances and Reconciliation

Section F System Clearing, Balancing Charges and Neutrality

Section N Shrinkage: [Shrinkage trading]

- Development of market measures for balancing arrangements, such as potential development of H_2 NBP, likely to take significant length of time (ultimate vision if H_2 networks sufficiently interconnected/at scale/mature)
- Trading arrangements will likely begin with the trade of uncontracted H_2 volumes between market players (uncertain on which market players – which could lead to significant levels of legislative change – i.e., if there is no role for H_2 Shippers as per HBM)
- Initial market driven trading arrangements could emerge through physical location trades taking place on spot market such as a H_2 OCM (as was the case in the initial liberalisation of UK gas market). Require development of separate trading platform to allow trades (i.e., request ICE to generate hydrogen product to trade/ tender for new H_2 OCM), and also new section(s) to UNC code to establish rules of physical locational trades.

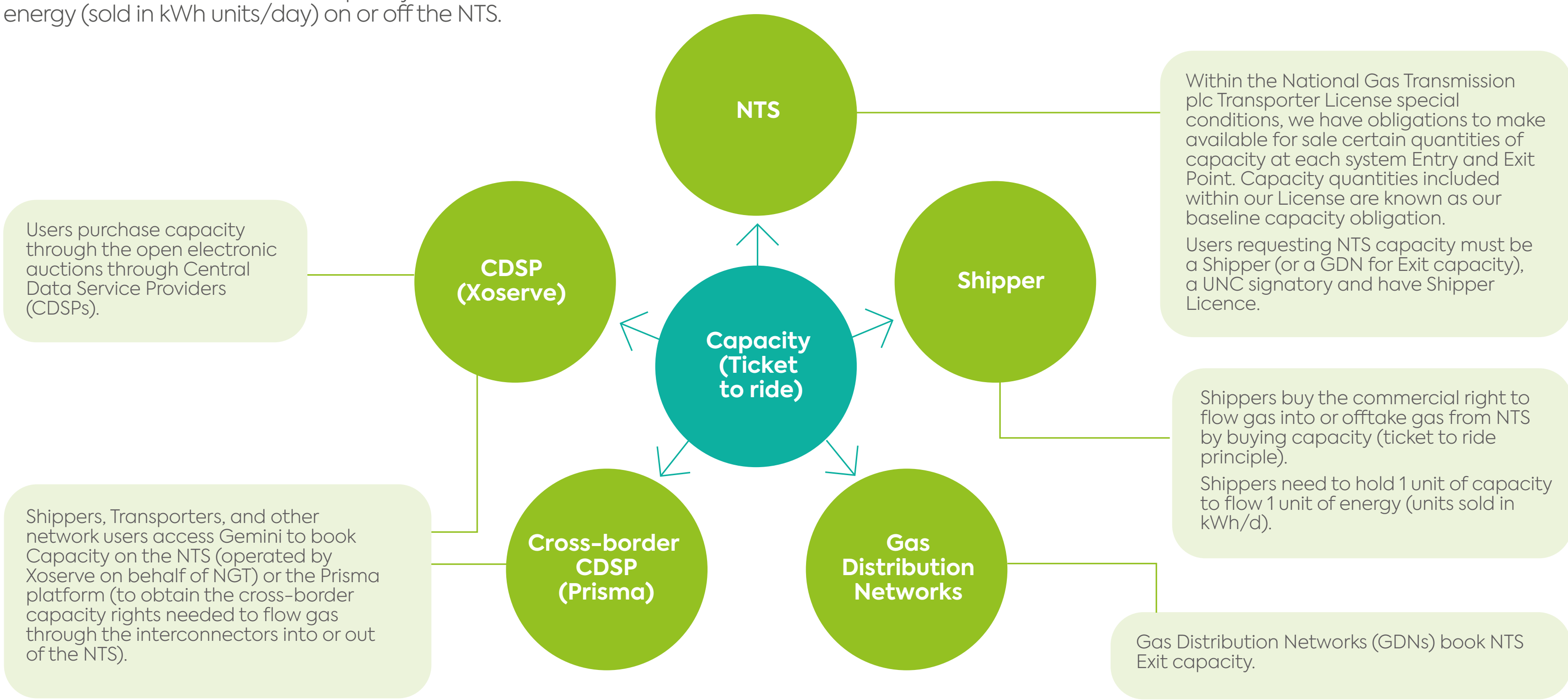
Section 5: Capacity regime

5a. Defining the existing NTS capacity regime

Capacity is the mechanism that enables Users to obtain the commercial right to flow gas on and off the NTS. Entry Capacity provides the right to deliver gas onto the NTS and Exit Capacity the right to offtake gas from the NTS. A User needs to hold one unit of capacity to flow one unit of energy (sold in kWh units/day) on or off the NTS.

This is known as the 'ticket to ride' principle, where capacity (i.e., space on the network) must be bought ahead of gas flow. For a detailed overview of the NTS capacity regime, please refer to our Capacity Guidelines.

An overview of the key market participants and their roles in the existing NTS capacity regime includes:



5: Capacity regime

It is key to note that any capacity that is released over our current License obligation is called Incremental Capacity, and can be provided through various means including:

- Capacity substitution (moving unsold capacity from one system point to another)
- Commercial mechanisms, i.e., specific types of contracts
- 'Funded,' where NGT incurs cost to deliver additional capacity for which we apply to Ofgem for funding through a 'Revenue Driver'. Funded incremental capacity can only be requested through PARCA (Planned and Agreed Reservation of Capacity) and indicates user financial commitment. Applicants who are not Shippers or Transporters can reserve capacity by exception through the PARCA process.

If capacity is bought over License obligated levels, this is an investment signal for NGT to consider network development.

There are a variety of NTS Entry and Exit products that we describe below, and to provide some helpful context it is key to note that capacity can be either Firm (contractually and financially agreed to be available) or Interruptible or Off-peak capacity (this can be withdrawn by NGT, this type of capacity product was designed to prevent the hoarding of capacity as it is deemed anti-competitive).

NTS Entry Capacity products include for each Entry Point or ASEP (Aggregated System Entry Point):

- Firm Entry volumes: Baseline, incremental (permanent), incremental (non-obligated at NTS discretion)
- Interruptible Entry: Use It or Lose It (unused firm capacity over past 30 days), discretionary

NTS Entry capacity auctions timetable includes options to book Capacity; Quarterly up to 16 years ahead, Monthly for the next 12 months, Weekly nine days ahead of use, Day Ahead or Within Day.

NTS Exit capacity auctions include for each Exit Point (offtake) or CSEP (Combined System Exit Point):

- Firm Exit volumes: Baseline, incremental (permanent), incremental (non-obligated at NTS discretion)
- Off-peak Exit: Use It or Lose It (based on unused firm capacity calculated on a rolling 30-day basis), Un-utilised maximum NTS Exit Point offtake rate, discretionary

NTS Exit capacity auctions timetable includes the option to book Capacity via Annual Enduring up to six years in advance, Annual Yearly up to three years in advance, Day ahead or Within day auctions.

Interconnector capacity products:

- Bundled capacity refers to the purchase of Interconnector Capacity, at both sides of the Interconnector
- Unbundled capacity refers to the purchase of Interconnector Capacity, only on one side of the interconnector, for our purposes we would only consider Capacity purchased on the GB side
- Long term capacity products are sold through Ascending clock auctions, these typically include a number of bid rounds and can lead to price steps to enable market players to set the market price for the capacity,
- Short term capacity products are sold through uniform price auctions, this includes one bid round for a certain amount of capacity, the bids are ranked from highest bid to lowest, where the highest bidders will get their requested capacity at the lowest cost of the successful bids.

The Interconnector capacity auctions timetable allows for Annual yearly between year Y+5 and year Y+15, Quarterly within the current gas year, Monthly, Daily or Within Day.

If capacity is bought over License obligated levels, this is an investment signal for NGT to consider network development.

The key elements of the current legislative hierarchy that govern the balancing regime include:

CAM code – Capacity Allocation Mechanisms Network Code (CAM)

- EU code on CAM came into effect 2015
- EU capacity products and the process for charging capacity are standardised/ harmonised for EU cross-border Entry and Exit allocation via transparent auctions on joined booking platforms (PRISMA for UK Interconnectors)
- The Capacity Allocation Mechanism (CAM) incremental process allows capacity to be allocated for interconnection points (IPs).
- Incremental process has several phases, including certain requirements that need to be fulfilled before an incremental project can be initiated based on market demand and new capacity requirements.

European Interconnection Document

- sets out provisions relating to Interconnection Points which differ from, or are additional to, the provisions of the Transportation Principal Document
- UNC Section B: Capacity, provides for how capacity at Interconnection Points may be allocated to Users, bundled with capacity in an Interconnected System, and transferred, converted or surrendered by or withdrawn from Users

Gas Act 1986:

- Underpins all contracts and license obligations – i.e., Transporter and Shipper Licenses - in UK gas industry.
- Licensees must also become party to and/or comply with certain industry codes (i.e., Network Code).

Gas Transporter License

- Gas Transporter License: Standard Conditions
- References works to increase capacity in connection charging methodology

National Gas Transmission plc Gas Transporter License Special Conditions

- Entry capacity and Exit capacity constraint management incentive (incentivises NGG to maximise release of capacity and minimise cost of constraint through constraint management actions – i.e., capacity scale back, firm capacity surrender etc)
- Special condition 9.13: Capacity requests (obligated to publish requests for firm capacity), baseline capacity (obligated to state level and adjustments of entry/exit capacity, published 1st April in GWh/d for each NTS Entry/Exit point, Users can only request capacity if point is included within license) and capacity substitution (obligated to set out process of approval and maintain record of capacity substitution instances – where unsold non-incremental obligated capacity is moved from one or more NTS points to meet demand for incremental obligated capacity at another point)
- Special condition 9.17: Entry Capacity and Exit Capacity obligations and methodology statements (detail Entry and Exit capacity obligations on the licensee)
- Special Condition 9.18: Methodology to determine the release of Entry Capacity and Exit Capacity volumes (Methodology statement requirement to detail for how to release Entry/Exit capacity obligations)

Uniform Network Code: (UNC is contract between Shippers and Transporters)

- TPD (Transportation Principal Document) Section B: System Use and Capacity
- NTS Entry Capacity (different types of Entry Capacity, auctions, availability, allocation, constraint management, curtailment of Interruptible NTS Entry Capacity, surrender, different types of charges, and neutrality arrangements)
- NTS Exit Capacity (registration at different points, different types of charges, surrender, Firm Capacity Application)
- Capacity Transfer; NTS Offtake Capacity (Statement, registration, charges).

The key elements of the current legislative hierarchy that govern the balancing regime include: (continued)

Reserving capacity (PARCA)

- Developer and/or NTS Users (Shippers or GDNs) can reserve firm NTS capacity through the Planning and Advanced Reservation of Capacity Agreement (PARCA) process. A PARCA is a bilateral contract that allows Entry and/or Exit capacity to be reserved for the customer while they develop their own projects.
- The reserved capacity will need to be allocated to an nominated NTS User before it can be utilised.
- The financial commitment to the capacity (allocation of capacity) is only allocated if a full connection offer has been accepted.
- Gas connections portal is used to submit PARCA applications

Capacity Methodology statements: (Required in License)

- These are reviewed every 2 years. Enables changes to capacity rules/processes without lengthy UNC modification process
- Entry capacity release: Determine amount of entry capacity NGT will release to meet obligations in License/UNC. Also details circumstances for NGT to accept applications for incremental entry capacity from shippers, and the level of financial commitment required from those shippers.
- Exit capacity release: Determine amount of exit capacity NGT will release to meet obligations in License/UNC, and details the commitment that shippers and DN users make when applying for, and being allocated, longer term exit capacity
- Entry capacity substitution: Determine proposals for the indefinite substitution of NTS entry capacity from one NTS Aggregate System Entry Point (ASEP), where it is not required, to another ASEP where demand for entry capacity exceeds existing quantities
- Exit capacity substitution and revision: Determine proposals for

(1) substitution of NTS exit baseline capacity from one NTS Exit Point (where it is not required) to another in response to request for additional capacity

(2) revision to NTS baseline exit capacities where new pipeline infrastructure installed, in order to facilitate the release of incremental entry capacity that has a beneficial impact on the availability of exit capacity

- Entry capacity transfer and trade: Transfer of unsold, or the trade of sold, NTS firm entry capacity, for the month ahead, from one ASEP to another ASEP

5b. Challenges to the existing capacity regime from the development of Project Union

One of the key premises for the development of a capacity regime is that space (i.e., capacity) within the network is a competitive product. The current NTS capacity regime, with capacity products being made available via auctions, provides a transparent process for Users of the network to book and therefore guarantee space within the network, where additional mechanisms are in place to enable price discovery should the capacity products become more competitive (please see the section below on charging).

However, for initial hydrogen networks, such as the initial stages of Project Union, space within the network may not be a competitive product. This is because initially, there will be very few 100% hydrogen market players connected to a limited 100% hydrogen network. Therefore, it would likely be overly complex and costly to transfer the existing ticket to ride capacity booking system to (at least) the nascent stages of the hydrogen market and Project Union development. Indeed, simpler long-term solution options could be considered to allow market participants to access the Project Union network.

In addition, it is key to consider that capacity currently provides signals for network planning and reinforcement. For this project, we have explored alternative mechanisms that could provide the Project Union System Operator with adequate signals for the need for network planning and reinforcement, for example, through the role of Strategic Planning.

5c. Solution options to enable a capacity regime for Project Union

It is key to note that the solution options for capacity are interdependent on solution options for charging, as detailed in the following section.

Capacity solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1

No ticket to ride capacity regime

In this regime, market players would not need to book capacity prior to flowing gas on or off Project Union (no ticket to ride). Instead, the Project Union System Operator would either accept or reject:

- Daily Flow Notifications (DFNs) from Users wishing to flow hydrogen onto Project Union, or
- Offtake Profile Notifications (OPNs) from Users wishing to offtake hydrogen from Project Union.

These physical flow notifications from connected parties would be submitted (as per the existing regime) at the Day Ahead stage for each hour of the following day.

A transparent and fair process would be required to support Project Union System Operator selection of DFNs and OPNs that would also ensure safe and resilient operation of the network, where the selection of physical notifications would be made on a first come first serve basis.

To implement this lack of a 'ticket to ride' capacity regime, various options could be considered including:

- **Access based on flow:** Access to Project Union could be based on accepted physical notifications for flow
- **Access based on connection contract:** Access to Project Union could be set out within connection contracts between Project Union and connected parties. For example, the connection contract could set out permitted daily flow (on or off Project Union).
  - If additional access were required to the network, market participants could request this on a flexible basis, subject to the ability of Project Union System Operator to accept additional access. This would also be interdependent on the balancing regime and time constraints within a balancing period.

The benefits from this no ticket to ride capacity regime include that it is much simpler to operate than the existing commercial capacity regime, considering the lack of capacity booking auctions. This simple regime would complement the initial limited nature of Project Union and limited Users connected to the network.

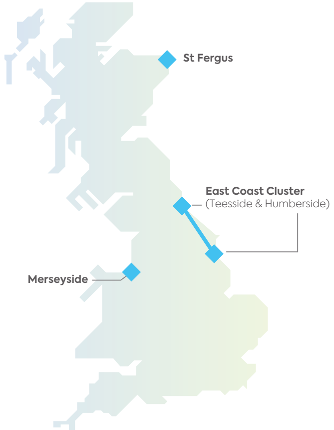
This regime could continue, on an enduring basis, until a trigger is reached requiring the setting up of a commercial capacity regime. For example, a key trigger would be the development of space within the Project Union network becoming a competitive product.

continued >>

Capacity solution options for Project Union (continued)

Solution options for initial connected cluster phase of Project Union:

Phase 1



No ticket to ride capacity regime (continued)

However, there are challenges associated with this non-commercial capacity regime. For example, the existing, mature, integrated NTS generally has enough capacity for all Users intentions to flow on or off the NTS. For Project Union, this may not be the case, considering the limited nature of the network requiring enhance actions from the Project Union System Operator to maintain security of supply and network resilience. This could lead to unpredictability of when DFNs or OPNs were accepted or rejected. In the worst case, this could risk security of supply for connected Users, and at the very least would likely mean Users may be unable to take commercial advantage of accessing the Project Union network due to no means to guarantee access to the network.

A key challenge from this 'no ticket to ride' capacity regime is the lack of visibility for the Project Union System Operator on long term use of the network, and therefore lack of signals for potential investment in the network. Mitigations to this challenge could include; connected Users of Project Union having to provide regular forecasts of future use of the network, and potential Users of Project Union being encouraged to provide advanced indication of potential connection and use of the network.

Finally, decisions on network investment will initially be driven by strategic planning decisions, as there is unlikely to be sufficient market signals and, in this approach no PARCA process or Capacity Regime to send investment signals for additional Project Union capacity until a more mature phase of Project Union is reached.

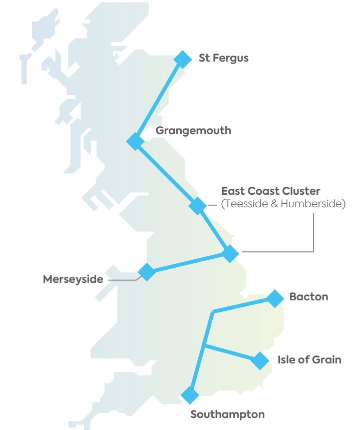
One key thing to note is that in the initial set up of Project Union, there would be no existing linepack and so a volume of hydrogen would need to be purchased and input to the network before flow could commence. Purchase or provision of this gas would need to be explored, costed, and potentially recharged to Users.

A key challenge from this 'no ticket to ride' capacity regime is the lack of visibility for the Project Union System Operator on long term use of the network, and therefore lack of signals for potential investment in the network.

Capacity solution options for Project Union (continued)

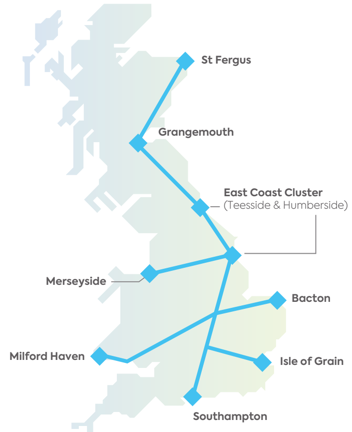
Solution option for regional expansion of Project Union:

Phase 2



Mature phase of Project Union:

Phase 3



Ticket to ride capacity regime

If there is a requirement for a transparent mechanism to allocate space on the network due to increasing competition for space on the network, then a commercial capacity regime will be required to enable Users to pay a premium to guarantee space on the network.

The commercial capacity regime for Project Union could be similar to the existing capacity regime, where a range of capacity products could be designed to meet user needs including:

- Capacity auctions for short term (Entry/Exit) products
- Capacity auctions for long term (Entry/Exit) products
- Firm Entry/Exit capacity
- Interruptible/off peak Entry/Exit capacity

Specific capacity products could be developed to suit the specific needs of Users connected to Project Union. For example, electrolytic hydrogen producers could require a more flexible capacity product to complement intermittent renewable electrolytic hydrogen production. CCUS enabled Methane reformation hydrogen producers would likely favour the ability to book long term firm capacity, considering their baseload production profile.

Potential impact to current legislative hierarchy to enable a capacity regime for Project Union

Below we have articulated an overview of potential changes to the existing legislative framework to enable the solution options we have identified as part of this project to enable a capacity regime for Project Union.

CAM code / European Interconnection Document

- Will need to explore how to implement harmonised 'capacity booking' systems at cross-border hydrogen networks
- It is likely that, at least initially, it will be the role of the strategic planning authority to make decisions on network investment to facilitate additional Project Union capacity/interconnectivity

Gas Act 1986 [underpins all contracts and license obligations – i.e., Transporter and Shipper Licenses - in UK gas industry]:

- In the regime with no "ticket to ride" will Users submitting DFNs/OPNs need to be licensed?
- Which market player/s will be the Users of the network? Depending on level of change, this could require a Hydrogen Act to underpin the commercial relationships between Licensed hydrogen market players.

Gas Transporter License

Gas Transporter License: Standard Conditions

- References works to increase capacity in connection charging methodology

National Gas Transmission plc Gas Transporter License Special Conditions

- Amendments could include developing new section within existing license to ring fence and transfer NTS natural gas entry/ exit locations within the license to Project Union hydrogen points within the license, detailing obligated Project Union capacity.
- If capacity rights are provided as an enduring right and included within Project Union connection contracts, how does this interact with obligated capacity included within license?
- An additional capacity methodology statement would be required for Project Union to outline capacity obligations (this is especially relevant considering most connections to Project Union, initially, will be Entry + Exit sites)
- It is likely that initially, no specific mechanism will be required to send investment signal for additional investment in Project Union. Therefore, it may be the role of a strategic planning authority to make decisions on additional Project Union capacity, it will be important to explore this interaction with the existing Long Term Development Statement obligation.

Uniform Network Code: (UNC is contract between Shippers and Transporters)

- **Section B**: System Use and Capacity
  - Uncertainty on which market players may be the appointed Users to request access to Project Union
  - Section B could be amended, or an addendum attached, outlining the rules for allocation based on physical flow notification (i.e., to enable 'no ticket to ride' capacity regime)
  - Section B could be amended, or an addendum attached, outlining the rules for commercial capacity regime for Project Union (when trigger is reached requiring such a mechanism)

Methodology statements: (Enables changes to capacity rules/processes without lengthy UNC modification process)

- Project Union capacity statement would be required to determine the Entry/Exit capacity available within Project Union to meet obligations in License/UNC.

Section 6: Charging regime

6a. Defining the existing NTS charging regime

For the purpose of this report, our definition of charging relates to the allowed revenue that National Gas Transmission is allowed by Ofgem to earn, at a specified level of return. Our National Gas Transmission plc Transporter License special conditions sets out our allowed revenue, and the charging methodology with the Uniform Network Code Transportation Principal Document (UNC TPD) determines how our allowed revenue is collected.

Please note, while the processes of settlement and billing for consumers is an important part of charging for the gas market, we have excluded those aspects of charging from this particular project.

The cost of building and extending natural gas network assets relates to the capacity they provide. Therefore, we collect most of our allowed revenue from capacity charges. Buying capacity gives Users of the NTS the right to flow gas onto and off the network. One unit of capacity must be bought to flow one unit of energy on or off the NTS. This is known as the 'ticket to ride' principle, where units for NTS capacity are sold in kWh/day.

In the current capacity charging regime, all units of Entry Capacity and all units of Exit Capacity are valued equally, with one price for all Entry Points and one price for all Exit Points. This is referred to as a 'postage stamp' charging regime. The capacity reserve price sets out the minimum price Users can bid in an auction for capacity.

It is key to note that (due to the implementation of the EU Network Code on Gas Tariffs (TAR) within our own UK gas code, the Uniform Network Code (UNC)), there is both a reference price for capacity (i.e. the annual price), and a reserve price for auctions. Under the TAR code there are rules regarding the ability to apply a multiplier to the capacity reference price, however currently the NTS capacity multipliers are set at 1, therefore all the capacity reserve prices are the same as the reference price.

To determine the reserve price for capacity, at the start of each formula year, NGT forecasts the amount of capacity that will likely be sold at Entry and Exit, and divide the Expected Revenue for the formula year, that NGT needs to recover (i.e., our Allowed Transmission Services Revenue with relevant adjustments) by those total volumes. However, challenges can arise from this method, including that our forecast of capacity to be sold will inevitably be different to the amount of capacity actually sold. Therefore, a Revenue Recovery Charge (RRC) can be utilised to make up the deficit to our allowed revenue not collected through Entry and Exit capacity charges, if necessary. The RRC is also applied to capacity bookings, where purchasers of capacity (i.e., Shippers), would be eligible to pay or receive RRC.

The principal types of NTS capacity charges include:

- Transmission Services Charges: This includes capacity reserve prices and revenue recovery charges, it can be referred to the Transmission Owner (TO) charges.
- Revenue Recovery Charge (RRC): This is used to collect revenue not collected via Entry and Exit capacity reserve prices. This charge must be provided two months in advance of payment to industry.

In addition, a flow based charge is used to recover the Non-Transmission Services costs, broadly aligned to our System Operator costs.

- General Non-Transmission Service charge (GNTS): This charge applies to all units of gas that flow on the NTS, it can be referred to as a charge necessary for the gas System Operator (SO) to operate the NTS.

In summary, customers receive charges for the following items: Capacity reserve prices (Entry and Exit), Revenue Recovery Charge (Entry and Exit), and General Non-Transmission Services (GNTS):

ENTRY: Gas enters NTS

- Entry capacity reserve prices = Charge for right to use space on NTS (TO)
- Entry revenue recovery charge = (TO) mechanism to make up allowed revenue
- General non-transmission service charge (GNTS) = Charge to flow gas (SO)

EXIT: Gas exits NTS

- Exit capacity reserve price = Charge for the right to exit gas (TO)
- Exit revenue recovery charge = (TO) mechanism to make up allowed revenue
- General non-transmission service charge (GNTS) = Charge to take gas off NTS (SO)

Some charging discounts are applied, specifically:

- Storage: Currently pay no GNTS (apart from for own-use gas), storage do pay entry and exit capacity reserve prices but with an 80% discount
- Interruptible or Off-Peak capacity: 10% discount
- The Conditional NTS Capacity Charge Discount (CNCCD or "short-haul") provides a discount to users who utilise only a small portion, less than 28km, of the NTS.

Additionally, there are a set of protected price contracts enshrined in GB law following the implementation of EU TAR NC via UNC Modification 0678.

- Existing Contracts, in the form of Existing Available Holdings and Existing Registered Holdings: Capacity booked before 6 April 2017 for gas days after 1st April 2020 has a fixed price (set at the price previously paid in auction bid)

Please see Figure 6 below for an overview of the split between TO and SO allowed revenue charges:

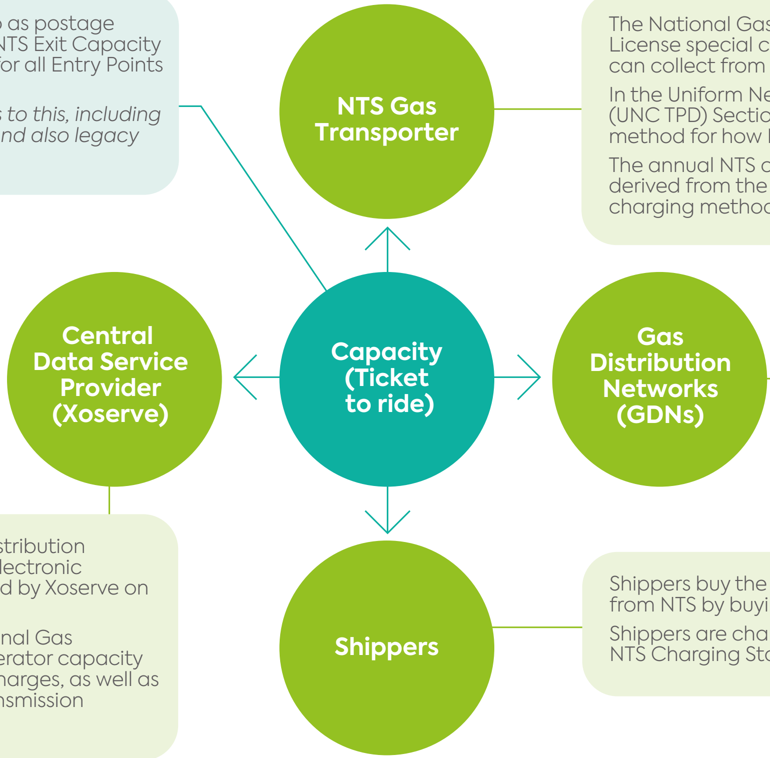
Licence	Transmission Owner (TO) Allowed Revenue	System Operator (SO) Allowed Revenue
UNC	Transmission Services Revenue	Non-Transmission Services Revenue
	• Entry Capacity Charges • Entry Revenue Recovery Charges • Exit Capacity Charges • Exit Revenue Recovery Charges	• General Non-Transmission Entry & Exit Charges • St Fergus Compression • Pensions & Metering Charges

Figure 6

An overview of the key market participants and their roles in the existing NTS charging regime includes:

The current charging regime is referred to as postage stamp, as all NTS Entry Capacity and all NTS Exit Capacity is valued equally, with one* reserve price for all Entry Points and one price for all Exit Points.

* *It is key to note there are some nuances to this, including a discount applied to storage parties, and also legacy charging arrangements in place.*



The National Gas Transmission plc Transmission Transporter License special conditions outlines the allowed revenue that NGT can collect from capacity charges.

In the Uniform Network Code Transporter Principal Document (UNC TPD) Section Y, the Charging methodology determines the method for how NTS charges are collected.

The annual NTS charging statement details the capacity rates derived from the License allowed revenue applied through the charging methodology.

While GDNs do purchase NTS Exit capacity, NTS commodity charges are not applied, and the Transmission Operator capacity charges are passed onto Shippers utilising the GDNs.

Users of the NTS (i.e., Shippers or a Gas Distribution Network (GDN) book NTS through open electronic auctions on the Gemini platform operated by Xoserve on behalf of the NTS.

Xoserve then generates invoices on National Gas Transmission's behalf for Transmission Operator capacity charges, System Operator Commodity Charges, as well as an allowed proportion of Exit overrun Transmission Operator charges.

Shippers buy the commercial right to flow gas into or offtake gas from NTS by buying capacity (ticket to ride principle).

Shippers are charged for NTS capacity charges (subject to the NTS Charging Statement) and are invoiced

The key elements of the current legislative hierarchy that govern the charging regime include:

Network Code on Gas Tariffs (TAR) code – EU Network Code on harmonised transmission tariff structures for gas (incorporated within UK law)

- Covers rules on harmonised transmission structures for gas (i.e., majority of costs should be recovered through Transmission Operator (TO) charges (not System Operator charges) and discounts should be applied to storage operators), including rules on the application of a reference price methodology (TAR code includes option to apply a multiplier to capacity reference prices)
- Includes exceptions for calculation of reserve prices for Interconnector Point (IP) capacity products (i.e., time of auctions, auction process)
- EU network code was incorporated into UK law (not in UNC) (schedule 5 adjustments) as of BREXIT UK does not automatically incorporate EU amendments to TAR code

Gas Act 1986 [underpins all contracts and license obligations – i.e., Transporter and Shipper Licenses - in UK gas industry]:

- Licensees must also become party to and/or comply with certain industry codes (i.e., Network Code).

Gas Transporter License

Gas Transporter License: Standard Conditions

- 4A Obligations for a charging methodology (for the charging of gas Shippers for capacity)
- 4B Connection charging methodology

National Gas Transmission (NGT) plc Gas Transporter License Special Conditions [specifies values to recover allowed revenues]

- Details on NGT recovery of allowed revenue, the amount NGT should aim to recover through transporter charges (includes SO/TO charges)
- License also includes Entry/Exit capacity points where charges are applicable to, and amount of capacity available at those points
- Directly remunerated services are not included in allowed revenue (i.e., connection charges)

Uniform Network Code: (UNC forms the commercial contract between Shippers and Transporters)

- **Section B**: System Use and Capacity [provides overview of types of capacity charges]
  - NTS Entry Capacity (different types of capacity products and charges)
  - NTS Exit Capacity (different types of capacity products and charges)
- **Section E**: Daily quantities, imbalances, and reconciliation [provides overview of the capacity reconciliation charges to Shippers for overruns, scheduling – balancing costs – NGT recovers a percentage of overrun costs as part of allowed revenue]
  - Determination of the daily quantities delivered to and taken off the Total System by each Shipper and the associated imbalance, overrun charges (if User does not have sufficient capacity to cover gas flowed), scheduling charges (incentive for Shippers to match commercial nominations with physical flows, this cost is added to pass through neutrality charge)
- **Section F**: System clearing, balancing charges and neutrality [provides overview of the process for balancing and neutrality charges to Shippers – these are balancing costs and do not impact NGT allowed revenue, but does impact NGT cash flow considering neutrality pot takes ~ 2 months to recover from Users]
  - Clearing of each Shipper's daily imbalances, the calculation and payment of daily imbalance charges and scheduling charges; the calculation and payment of balancing neutrality charges and reconciliation neutrality charges (cost to retain balance on NTS is passed through neutrality pot and smeared back to Shipper community through the cash-out process managed by Xoserve)
- **UNC Section Y**: Charging methodologies [Provides methodology on how to apply the specific values within allowed revenue (taken from the license) to deduce charging rates, i.e., per kWh of capacity]
  - Methodology for how NGT recovers charges, rather than the values themselves (these are included within the license) by providing the methodology for how the specific values are turned into rates (i.e., capacity for Entry/Exit, GNTS), how storage and short haul discount is recovered etc)

The key elements of the current legislative hierarchy that govern the charging regime include: (continued)

NTS transportation charging statements:

- Publish Transmission charges in May
- Publish General Non-Transmission charges in June
- Charging rates applicable from 1st October: Specific values of allowed revenue from license through the charging methodology in UNC Y to provide charging rates
- Details charges that users of the gas National Transmission System have to pay and how they are calculated (required by UNC TPD Section Y). Changes to methodologies must be carried out using UNC governance and change management processes.
- If NGT is significantly over or under recovering, there are a number of mechanisms to mitigate this including:
- Revenue Recovery Charges (RRC) – NGT can apply RRC alongside TS capacity charge within year, but require significant issue to trigger to adjust revenue recovery up or down
- General Non-Transmission Service (GNTS – i.e., commodity charge) - can change throughout year, although NGT required to give 2 months' notice ahead of implementation of change
- Most likely only make changes to charging rates towards end of year to align with allowed revenue
- Charging statements includes the charge for:
- Capacity available at each NTS Entry/Exit site
- Storage/interruptible capacity
- St Fergus compression [only applicable to certain sites]
- CNCCD (Short-haul): When sites apply for short haul discount, the sites are notified of eligibility and receive renumeration based on methodology in Section Y

6b. Challenges to the existing charging regime from the development of Project Union

The key challenges to a charging regime for Project Union, especially significant for the initial and expanding stages of the network, includes the combined market barriers of limited initial user base and thus use of the network, in addition to high costs (in proportion to a small initial user base) to develop Project Union.

The approach of primarily repurposing assets, as is the approach taken by Project Union, is up to five times more cost effective compared to new build (Project Union launch report).

6: Charging regime

In our response to the Government consultation on Hydrogen transport and storage infrastructure business models, we maintained that a Regulated Asset Base (RAB) funding model would be the best option to overcome these market barriers across all stages of hydrogen network evolution. We believe that a hydrogen RAB, as a subset of the existing RIIO (Revenue = Incentives + Innovation + Output) price control, would enable transparent monitoring of investments and investment recovery into Project Union, where the co-management of methane (i.e., existing NTS) and new hydrogen investments (i.e., Project Union) would provide synergistic benefits through planning, financing and operations. This option would also provide the ability to lift out and retarget the cumulative balance of Project Union at a future point.

Although the RAB model would provide a stable and predictable investment recovery trajectory for Project Union, we know there will still be a funding gap (based on limited user base and high costs of developing the network) that will need to be addressed, especially for the early stages of Project Union. There are several options we have considered to address the initial funding gap for Project Union, including:

1. **Deferred revenue:** Allowed revenue collection could be deferred up to a desired point, and then amortised over a specified period, which effectively would move more of the cost onto a future Project Union user base. This option requires investor acceptance of the additional financial risk, for which it is likely a higher level of return would be required, increasing the absolute cost. In addition, there is likely to be a limit to the level of deferral before short term financing becomes an issue.
2. **Price scaling:** A methane network equivalent reference price could be used as the logical starting point for charges associated with accessing Project Union. This would ensure that hydrogen users would pay no more than the natural gas equivalent. Theoretically, the reference price could be scaled to alleviate some of the funding gap, noting that the methane price is not necessarily the maximum affordable price. However, this risks disincentivising uptake where there are already challenging commercial decisions to be made by participants.
3. **Socialisation:** Socialisation involves taking a broader philosophical standpoint on the beneficiaries of decarbonisation, beyond the traditional user pays mindset. There are options for how socialisation could be targeted, but in all cases the need to do this falls away over time as the Project Union user base increases. Possible socialisation options include methane network users, across energy vectors, or at societal level through general taxation.

Our developing view is that socialisation of some costs of Project Union to methane users is the logical option at least as far as the early 2030s. This solution option would allow more time to develop hydrogen specific frameworks, but ensure Project Union could accelerate at pace, facilitated through the existing RIIO regulatory framework. It is key to note that this section reflects our developing view, however a decision on the funding challenge for hydrogen networks has yet to be made, where industry is waiting for a decision on a business model for hydrogen networks in 2025 as per the Government consultation on Hydrogen transport and storage infrastructure business models.

Our developing view is that socialisation of some costs of Project Union to methane users is the logical option at least as far as the early 2030s. This solution option would allow more time to develop hydrogen specific frameworks, but ensure Project Union could accelerate at pace, facilitated through the existing RIIO regulatory framework.

6c. Solution options to enable a charging regime for Project Union

It is key to note that the solution options for charging are interdependent on solution options for capacity (i.e., access to the network), as detailed in the previous section.

Charging solution options for Project Union

Solution options for initial connected cluster phase of Project Union:

Phase 1

Commodity charging regime

In a commodity charging regime, market players would be charged based on their use of the network, with charges applied per kWh of gas flow on or off Project Union. Users would not need to book and pay for capacity in advance of flowing gas on or off Project Union.

To implement this commodity-based charging regime, various options could be considered including:

- **Access based on flow:** Charges to Users would be applied according to their use of the network per kWh of gas flow on or off Project Union.
- **Access based on connection contract:** Charges would be applied to Users based on their use of the network, the maximum use of the network set out in their connection contract to Project Union. Additional charges would apply for any additional flexible use of the network.

Clearly, there are some fundamental questions that will need to be answered to implement a commodity-based charging regime for Project Union. The first key question is of course determining the allowed revenue for Project Union.

Upon determining the allowed revenue, further decisions will need to be made upon utilising options such as price scaling, of deferral of revenues (over an agreed timescale), and decisions on how much of the revenue is targeted to users of Project Union, or socialised more widely to energy users.

Following this, the Project Union System Operator will need to gain an understanding of the use of the network. To understand use of the network, the Project Union System Operator could require connected Users to provide forecasts of their use of the Project Union network.

Answering the fundamental questions of allowed revenue and use of the network will enable charging rates for access to the network to be set (as per the current postage stamp charging regime):

Allowed revenue/Capacity use forecast (kWh) = charging rate per kWh of flow on or off Project Union.

Charging rates for use of the network could be fixed for set time periods, such as a year (the current regime) or for shorter or longer time periods.

If the overall allowed revenue for Project Union were being significantly under or over recovered, then mechanisms will need to be in place to recoup this difference. The revenue could be recouped through a revenue recovery mechanism, or the difference could be bundled into later years of cost recovery, similar to the 'K' factor used in the current charging methodology.

We recognise that in the initial stages of Project Union, forecasts for use of the network are unlikely to be reliable, and therefore tolerances will need to be built into the charging methodology to enable, on aggregate, an accurate forecast of the use of the network to apply charges to. In addition, we have recognised that cost recovery for Project Union will likely include an element of over and/or under recovery with the need to defer costs, until there are greater volumes of flow and use of the network, and also greater accuracy to forecast the use of the network in order to apply charges.

At defined time periods, charges applied to accessing Project Union would need to be reviewed to fine tune the charging rates applied to recover allowed revenues.

This commodity based charging regime could continue on an enduring basis until a trigger is reached requiring the setting up of a more commercial capacity booking and charging regime. For example, a key trigger would be space (i.e., capacity) within the Project Union network becoming an oversubscribed and competitive product.

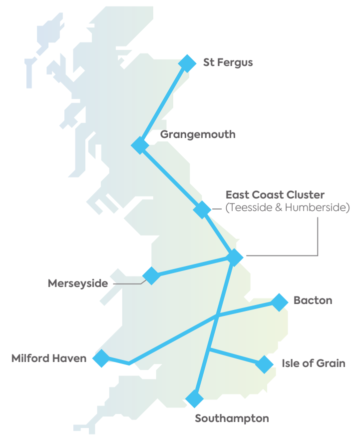
Charging solution options for Project Union (continued)

Solution option for regional expansion of Project Union:

Phase 2

Mature phase of Project Union:

Phase 3



Commercial capacity charging regime

If there is a requirement for a transparent mechanism to allocate space on the network due to increasing competition for space on the network, then a commercial capacity regime will be required to enable Users to pay a premium to guarantee space on the network.

The same fundamental questions would need to be answered as in the above section on solution options for the initial connected cluster phase of Project Union, involving determining the allowed revenue for Project Union and determining the forecast of use of the network to generate charging rates to apply per kWh of gas flow on and off Project Union.

We recommended that if a commercial capacity regime is required for Project Union, then a similar model to the existing charging regime could be applied. These capacity charges could mirror the existing regime and include elements of allowed revenue recovery for Transmission Operator (TO) services and System Operator (SO) services. Naturally, mirroring the existing charging regime for Project Union would require taking lessons learned from the existing natural gas postage stamp capacity charging regime.

To implement a commercial capacity charging regime, various options could be considered including:

- **Ticket to ride:** As in the current regime (i.e., ticket to ride), this would involve Users being required to book and pay for capacity via auctions in advance of flowing gas on or off the network, where flowing without booking capacity will incur charges for Users.
- **Take or pay commitment:** Users would still be required to book and pay for capacity in advance of flowing gas on or off the Project Union network, however, Users would be subject to an additional charge based on their over or under use of their capacity booking, per a percentage of tolerance. This option would incentivise Users of Project Union to book and pay for as much capacity as they intended to use, and would therefore likely provide more certainty on the forecast on the capacity sold on Project Union, and therefore more accuracy on charging rates and more certainty on cost recovery.

Nuances that could be considered for a commercial capacity charging regime for Project Union could include:

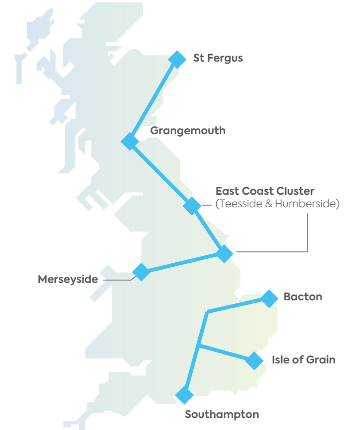
- **Capacity products priced to reflect use of system:** Capacity products could be priced based on User behaviour impact to Project Union network capability. For example, peaking power station Exit connections could be charged a top-up charge in addition to the base capacity charge, due to their reactive and flexible use of capacity on Project Union impacting total system resilience. On the other hand, baseload industrial Exit connections could be charged the base capacity rate or even a discounted rate, considering their likely ability to provide accurate use of the network that the Project Union System Operator can plan to accommodate.

continued >>

Charging solution options for Project Union (continued)

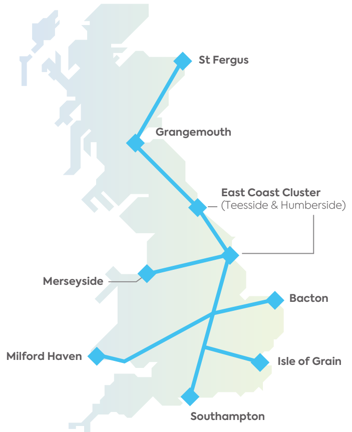
Solution option for regional expansion of Project Union:

Phase 2



Mature phase of Project Union:

Phase 3



Commercial capacity charging regime (continued)

- **Locational or Nodal pricing:** Locational pricing of capacity charges could be used to incentive User behaviour to maximise efficiency of system operation for Project Union, and support efficient network development. For example, Exit capacity could be priced lower in locations of the network experiencing entry constraints, which could incentive exit connections to the network and potentially mitigate the need to invest in network development.
- **Seasonal pricing:** Seasonal pricing could incentivise User behaviour to maximise system operation efficiency for Project Union, and support security of supply. For example, Entry capacity could be priced lower in winter, to incentivise supply to enter the network and therefore contribute to security of supply.
- **Discounts:** Discounts on capacity charges could be offered for a variety of products. In the current regime, discounts are offered for:
  - Interruptible capacity products (currently, there is a 10% discount for interruptible or off-peak capacity)
  - Storage (currently, there is an 80% discount for entry and exit capacity reserve prices and no charge for General Non-Transmission Services for storage)
  - Conditional discount for avoiding inefficient bypass (this discount to Entry and Exit capacity charges is eligible for certain sites, products and routes to avoid inefficient investment in gas networks) (Gas Transmission Transportation Charges, 2022).
- **Amend Entry/Exit split:** Instead of weighting capacity charges the same on Entry and Exit capacity as per the existing regime, capacity charges could be weighted differently to incentivise User behaviour to support system operation of Project Union. For example, charges could be weighted towards Exit to incentivise additional gas imports and support security of supply on Project Union.

If capacity products were to be oversubscribed on Project Union, Users could either bid more than the capacity reserve price, or price steps could be implemented. Price steps are implemented by applying a multiplier to the capacity reference price, to generate different prices to the reserve price at capacity auctions. Implementing price steps, as currently used for interconnection point capacity auctions, would enable capacity on Project Union to be sold to Users at the market premium.

It is key to note that this solution option of implementing a commercial capacity charging regime, mirroring the existing charging regime, is predicated on the assumption of a daily balancing regime, where capacity is sold via auction as a daily product. If the balancing regime were to be changed to a more granular period, such as every 12 hours to ensure system resilience, then further consideration on capacity products and associated charges would be needed.

Potential impact to current legislative hierarchy to enable a charging regime for Project Union

Network Code on Gas Transmission Tariff Structures (TAR) code – EU Network Code on harmonised transmission tariff structures for gas

- Need to ensure harmonised 'capacity booking'/charging arrangements for cross-border hydrogen pipelines
- Will hydrogen pipelines/ networks be subject to TAR, or will a separate hydrogen tariff framework be developed?
- Could an amendment to the European Interconnection Document facilitate potential commodity based charges (which are not permitted to recover the majority of revenues under TAR)?

Gas Act 1986 underpins all contracts and license obligations – i.e., Transporter and Shipper Licenses – in UK gas industry:

- Will there be a role for hydrogen Shippers? If there are no Shippers this could potentially drive the need for a new hydrogen Act to underpin the commercial relationships between the appropriate hydrogen market players, which may dive the need to license additional market players.

Gas Transporter License

Gas Transporter License: Standard Conditions

- There will need to be inclusion of new obligation to develop hydrogen charging methodology
- New obligation for hydrogen network connection charging methodology
- It is uncertain on whom network charges (i.e., charges for flowing gas on or off Project Union) will be applied to (i.e., potentially not shippers but different market player(s) will be paying for access to network)

National Gas Transmission plc Gas Transporter License Special Conditions [specifies values to recover allowed revenues]

- Requirement to clearly demarcate the license entry and exit points where charges for Project Union apply, this can either be included within the existing NGT license, or within a newly developed Project Union License
- Requirement to outline allowed revenue for Project Union (there are various charging options that could be taken forward, including targeted charging towards Project Union users, there could be an element of socialisation of costs with methane users etc), the allowed revenue for Project Union could be included within the existing NTS license or within a newly developed Project Union license.

Uniform Network Code:

- **Section B**: System Use and Capacity
  - Requirement to include separate charges for access to Project Union (pending decision on charges, i.e. commodity based, capacity charging regime or commercial capacity charging regime) capacity products and types of charges
- **Section E**: Daily quantities, imbalances, and reconciliation
  - Requirement to include separate charges for reconciliation charges for access to Project Union
  - Could consider whether penalties for reconciliation charges lie in code or within connection agreement
- **Section F**: System Clearing, Balancing Charges and neutrality
- – Requirement to include separate balancing and neutrality process for balancing charges associated to Project Union, which could involve new mechanisms such as separate neutrality pot
- **Section Y**: Charging methodologies
  - Requirement to set out separate methodology for recovery of Project Union allowed revenue, to detail how the allowed revenue for Project Union is turned into rates to apply to charges for access to the network
  - Requirement for UNC Section Y to include section to avoid cross subsidy between allowed revenue for Project Union vs allowed revenue for natural gas NTS

NTS Transportation charging statements:

- Requirement to develop separate charging statement for Project Union, that puts the specific values of Project Union allowed Revenue from licence through the charging methodology to provide rates for access to Project Union.

Conclusion and next steps

To develop this project, National Gas Transmission worked in collaboration with an expert industry working group to explore how the existing gas market commercial framework may need to evolve to accommodate the growth phase and steady state phase of Project Union.

To deliver a commercial framework that is suitable for both the growth and steady state phases of the Project Union hydrogen transportation infrastructure, options we explored included:

1. Continue to develop existing market frameworks

Existing market frameworks could be developed to accommodate a hydrogen transition within the UK.

✓ ***Benefits include*** that a known framework would be used as the basis for hydrogen market frameworks, enabling enduring principles to be carried through the hydrogen transition. This option could also deliver a framework for initial hydrogen infrastructure at pace.

✗ ***Risks include*** potentially reaching a tipping point where it may be no longer relevant or suitable to continue to develop existing market frameworks to accommodate hydrogen.

2. Add hydrogen specific sections to the existing market frameworks

New chapters or sections specific to hydrogen could be added to existing market frameworks.

✓ ***Benefits include*** the ability to take forwards enduring, appropriate principles from the existing natural gas market framework to a hydrogen market framework, in a process that may be more efficient depending on how complex or timely the process could be to continue developing existing market frameworks.

✗ ***Risks include*** compounding complex interactions between existing natural gas market frameworks and hydrogen specific additions.

3. Generate new hydrogen market framework

In the event of significant changes to current natural gas market participants, or the development of new market roles in a hydrogen transition, it may be necessary to generate new, fit for purpose market frameworks for hydrogen. Recognising this should not preclude acknowledgement that the existing market frameworks, in particular the commercial framework principles, are suitable as the basis for supporting the development of hydrogen transportation networks.

✓ ***Benefits*** to this approach include the ability to develop a simple market framework to support initial hydrogen transportation infrastructure, built on existing market frameworks.

✗ ***Risks include*** that due to hydrogen being an emerging market, generating new market frameworks does not guarantee developing the optimal framework.

It is key to note these market framework options require further industry and decision maker consideration and evaluation, and these options are not mutually exclusive.

We recommend that it will be essential to be clear on what is required to be delivered or facilitated by the hydrogen market before any changes to existing commercial frameworks are made. Therefore, urgency is needed on understanding the role of hydrogen market players, including any amendments to the roles of existing market players. For example, currently, the Hydrogen Production Business Model does not permit for the role of 'risk taking intermediaries', including shippers and suppliers. Further clarity is needed on the role of market players and whether additional market players need to be licensed and be party to a hydrogen code, such as hydrogen producers and storage facilities.

Finally, we recognised that while amending existing frameworks could be quicker to implement, the existing commercial frameworks will not always represent the right solution. Depending on whether hydrogen commercial framework changes are evolutionary or revolutionary, this may require the development of a new and separate hydrogen commercial framework, including the development of a Hydrogen Act, secondary legislative measures such as a Hydrogen Gas Safety Management Regulations and a Hydrogen Code.

Our key overarching recommendation is that it will be essential to reduce transitional issues and mitigate the risk of potentially time consuming and costly unpicking of market frameworks between hydrogen market phases, considering the vision to develop a large, integrated, and resilient hydrogen transportation network to support the UK's hydrogen economy.

Progress, simplicity, and compatibility should be key drivers when developing the commercial framework to support hydrogen transportation infrastructure. We believe this can be effectively realised by the appropriate and proportionate application or amendment of the existing gas commercial framework in the initial phase of Project Union, however, this does not preclude a long-term movement to a hydrogen specific hydrogen Act, licensing, or secondary measures, should it prove beneficial to do so in the longer term, especially considering any potential changes to the long-term role of hydrogen market players.

As asserted by Government in the consultation on Business Models for Hydrogen Transportation and Storage infrastructure, there is a need for hydrogen transmission infrastructure, regardless of policy decisions on the role of hydrogen for heating. Considering this need, there is a clear requirement for urgency and pace on developing commercial frameworks to enable the development of hydrogen transportation infrastructure. We know that changes to commercial frameworks are complicated and lengthy processes, therefore it is essential to continue to progress this work at pace in alignment with technical work on Project Union.

Our next steps from this project include developing additional granularity of detail on the commercial framework solution options we have proposed during this project.

It will be essential to reduce transitional issues and mitigate the risk of potentially time consuming and costly unpicking of market frameworks between hydrogen market phases.

Progress, simplicity, and compatibility should be key drivers when developing the commercial framework.

Appendix 1: Overview of the current gas market design

The existing mature gas market framework has been designed in the context of delivering natural gas to end users. Considering a 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.

Gas market framework

For the purposes 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.***

Our current gas market 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 the existing gas market framework in Figure 7.

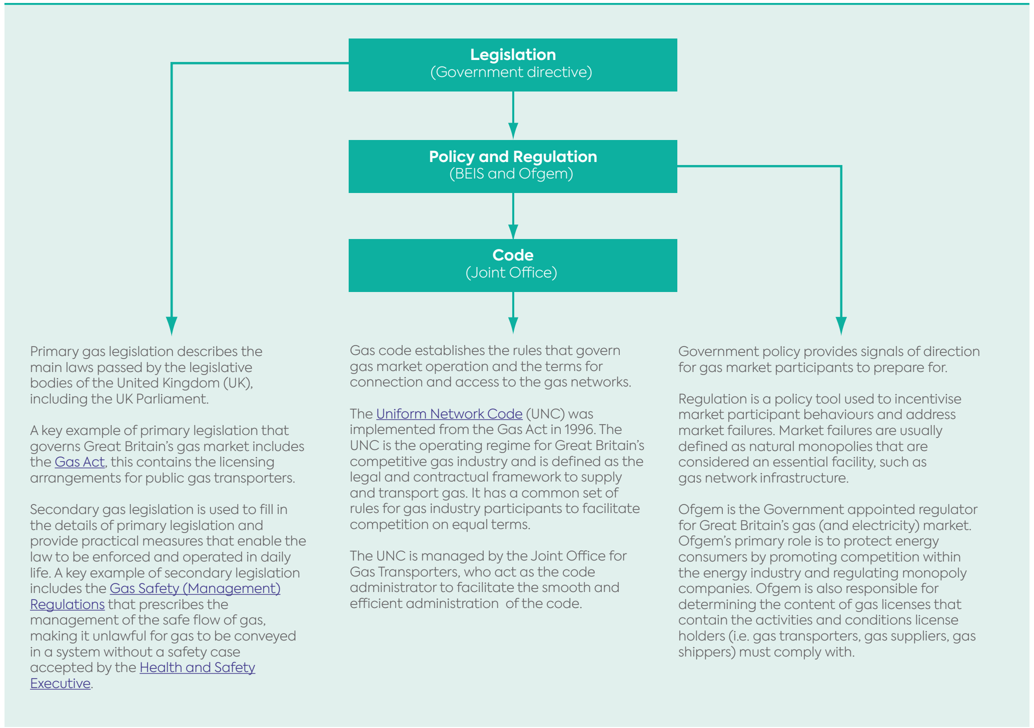


Figure 7: Gas market frameworks

Gas market players

The flow diagram in Figure 8 illustrates a high-level overview of current gas market players and their interactions, as well as the direction of payments, based on the current gas market value chain.

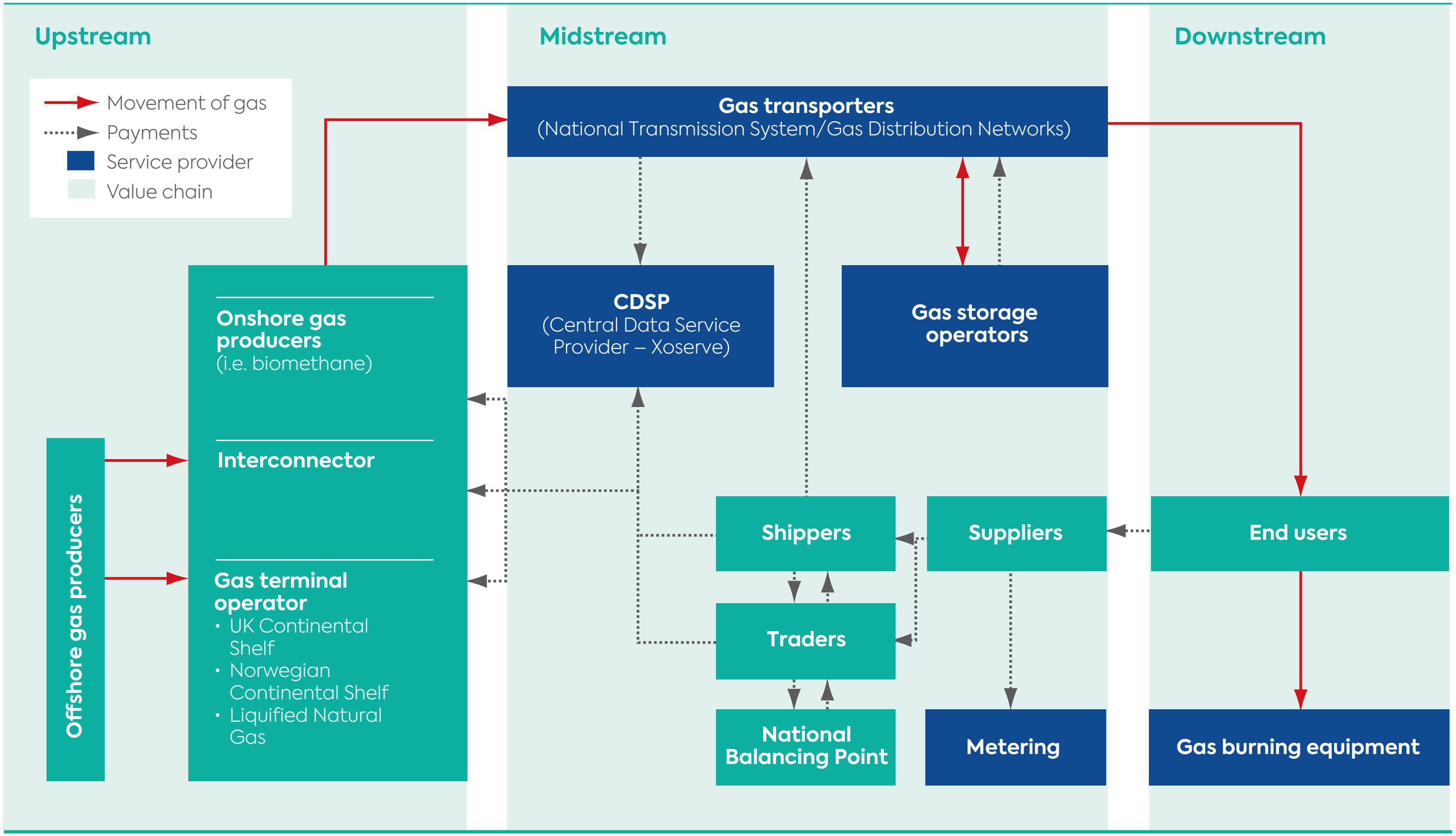


Figure 8: Gas market players

Gas market principles

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

For the purposes of this project, we have focused on seven market principles and outlined these in context of the existing gas market in Figure 9.

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 theirportfolios.

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 Gas Transmission makes entry and exit capacityavailable 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 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.

Figure 9: Gas market principles

Gas market fundamentals

Finally, in Figure 10 we have outlined some of the key market fundamentals within each of the above market principles. We defined the market fundamentals as the functions within each market principle that contribute towards the operation of the current liquid, liberalised and competitive gas market.

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

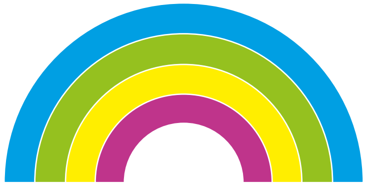
- Settlement process
- Consumer billing
- (NTS) Commodity charges
- (NTS) Capacity charges
- (GDN*) Local Distribution Charges

Connections

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

Figure 10: Gas market fundamentals

Appendix 2: Hydrogen Rainbow



Blue hydrogen Natural gas reformation with Carbon Capture Usage and Storage
Green hydrogen Electrolysis of water, powered by wind energy
Yellow hydrogen Electrolysis of water, powered by solar energy
Pink hydrogen Nuclear power driven hydrogen production

Figure 11: Hydrogen production methods

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