Department for
Energy Security
& Net Zero

Hydrogen transport and storage infrastructure: government response to consultation

Summary of responses received and government response to consultation on business model designs, regulatory arrangements, strategic planning and the role of blending

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General information

Government response structure

In this document we summarise the responses received to each of the 63 questions in our consultation on hydrogen transport and storage infrastructure.

The consultation was open from 22 August 2022 to 31 November 2022. We received 90 responses from stakeholders by email and follow up discussions. We held stakeholder briefing events and workshops and had continuous engagement with stakeholders through working groups and bilateral meetings where requested. We are publishing our government response alongside a separate document setting out our minded to position for chapters in the consultation. Our minded to positions set out our proposed policy, current thinking and next steps in each area and we intend for it to be read alongside this document.

Analysis of responses received to the consultation

In reporting the overall responses to each question, we have used a number of terms:

- 'majority' indicates the clear view of more than half of respondents to that question.
- 'minority' indicates the clear view of fewer than half of respondents to that question.

The following terms have been used in summarising additional points raised in the responses:

- 'some respondents' indicates any number between 3 and 15 respondents.
- 'many respondents' indicates any number 15 and 45 respondents have shared this view.
- 'strong agreement' indicates that upwards of 45 respondents have shared this view.

We have thematically analysed each response as a whole based on the themes set out in the consultation and identified via stakeholder engagement. Responses which did not explicitly express their support or disapproval for the specific question were logged but classified as neither supportive nor non-supportive. When summarising responses to the consultation, all accompanying written text was analysed for each question. Where information provided by a respondent related to a different question, we have summarised it under that other question.

Chapter 1: General considerations (Q1 – 2)

Vision for hydrogen network evolution

Question 1: Do you agree with Government's analysis and vision for hydrogen network evolution through the different phases as described? Please explain your answer and provide any relevant evidence.

Consultation position

In chapter 2 of the consultation, we set out a vision for how hydrogen networks may evolve. We set out our 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. This may begin to materialise from the mid-2030s and beyond. In time, we expect the market to be able to operate free of subsidy, although likely not free of regulation (much like the existing gas networks today).

We consider business models for both hydrogen transport and storage are required to remove market barriers and stimulate private investment in the necessary supporting infrastructure, to deliver this vision of how hydrogen can play its full role in decarbonising the UK economy.

Summary of stakeholder responses

Response	Number of responses
Strongly agree	4
Agree	51
Neither agree nor disagree	5
Disagree	5
Strongly disagree	1

A majority of respondents agreed with the vision set out in the consultation and government's analysis of hydrogen network evolution, although many respondents had additional considerations they felt the vision needed to take into account.

Many respondents found the road map ambitious but plausible and achievable, while noting the uncertainties in how the hydrogen economy might grow, in particular in response to policy decisions not yet taken, such as the use of hydrogen for domestic heating. Some respondents agreed with the overall vision but disagreed with the phases, especially the timing of the mid 2030s for regional/national scale networks with some seeing this as too ambitious and too focused on a backbone, and others seeing this as too late and envisaging development of a hydrogen backbone and of large-scale storage in the early 2030s.

Additional considerations included:

- Business models for transport and storage are required sooner than the target date of 2025 set out in the British Energy Security Strategy,
- Bespoke interim mechanisms are needed to support current and near-term projects,
- There is a need for oversizing during the early phases to ensure undersized infrastructure does not limit the market later,
- The decision on hydrogen for heating should be brought forward,
- The importance of blending as a transitional end use could have been brought out more in the vision,
- The requirements of industry, dispersed as well as located in clusters, and transport applications, including rail and air, as key off-takers need to be further considered,
- Vehicular transport was not sufficiently considered in the vision,
- Small scale liquid hydrogen network development could be supported by supply chains for the existing helium industry,
- Hydrogen carriers could be especially useful for remote areas, but safety risks that need to be taken into account.

Government response

Given the broad agreement amongst stakeholders with government's vision for the evolution of hydrogen networks, we plan to move forward on this basis.

Following the recommendation in the Independent Review of Net Zero we announced our intention to work with industry with a view to developing a hydrogen production delivery roadmap by the end of 2023. Alongside that, we will look to publish a 'hydrogen networks pathway', to set out the next steps in our vision for the development of hydrogen transport and storage in the UK. One of the key objectives will be overcoming some of the barriers stakeholders have identified to the early growth of hydrogen transport and storage.

We are committed to continuing to support early projects, unlocking the potential advantages that respondents have highlighted, as demonstrated by recent announcements on the progress of the Hydrogen Allocation Round and the Track 1 Cluster Sequencing Process.

As well as these forms of support, we are developing our approach to strategic planning for hydrogen transport infrastructure at pace to help identify and prioritise early strategically significant projects. This strategic planning will form the basis of the business model allocation processes and their interaction with the nature and timing of support for early hydrogen transport projects. As set out in Chapter 4, the 'hydrogen networks pathway' will set out a strategic framework for hydrogen network planning and a vision for the build-out of hydrogen T&S infrastructure ahead of the business models being available.

Key design principles

Question 2: Do you agree with these key design principles for the transport and storage business models? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we set out key design principles (see below) for considering the advantages and disadvantages of each business model design, and how well it meets government objectives.

- Investable
- Promotes market development
- Compatible
- Avoids unnecessary complexity
- Reduces support over time
- Suitable for future pipeline
- Value for money

Summary of stakeholder responses to consultation

Response	Number of responses
Strongly agree	2
Agree	52
Neither agree nor disagree	8
Disagree	2
Strongly disagree	2

Out of the 90 respondents that responded to the consultation, 66 responses were received for this question. The majority of respondents 'agreed' that the key principles outlined were the key principles for the design of the business models. A further 2 'strongly agreed' that this was the case. Two respondents 'disagreed' that these would be the key design principles, and a further 2 respondents 'strongly disagreed'. Eight respondents 'neither agreed nor disagreed'.

Respondents also provided feedback on the suggested design principles or suggested additional principles for consideration, including:

Kept Under Review

- Some respondents suggested the design principles need to be kept under review. As the hydrogen economy evolves, priorities may change, and the principles may need to be weighted differently over time to reflect these changing priorities. Respondents saw review points as critical to allow for adaptation as more knowledge on the hydrogen economy is gained.

Promoting market development

- Some respondents suggested a different focus for the ‘promoting market development’ principle, with two respondents suggesting it should emphasise developing a market that does not require external support in the long term.

Transparency

- Some respondents noted that the principle of ‘reduce support over time’ needs to be transparent and predictable so it does not create additional revenue risk and make investing in the infrastructure less desirable.
- Some respondents wanted clarity around how support may evolve over time.

Flexibility

- Flexibility was suggested by many respondents as an additional key design principle.
- A business model that works for first of a kind (FOAK) projects, may not be suitable for nth of a kind (NOAK) projects.
- Respondents felt that the business models need to be able to cater for different priorities as the hydrogen economy evolves, allowing for lessons to be learned from FOAK projects to then be incorporated into design for NOAK projects.

Anticipatory investment

- Some respondents noted the need to ‘futureproof’ the investment so it could cater towards future need rather than current known users of the network. This could result in higher upfront costs but could reduce costs over the longer term, and result in a more resilient and accessible network.

Strategic approach to hydrogen transport and storage infrastructure development

- Linked to the need for anticipatory investment, some respondents set out the need for strategic planning to ensure that infrastructure is built in the right places and at the right size.
- Respondents suggested a holistic approach to network development, ensuring that infrastructure is built in a coordinated way, reducing the need for future reinforcement or duplication. This includes the re-purposing of existing infrastructure and co-location with carbon dioxide transport and storage infrastructure.

Timelines

- Some respondents suggested that key decisions on the business models be made as soon as possible to ensure projects can continue to progress and to support government's hydrogen economy ambitions.

The minority of respondents who disagreed with the key principles suggested that the overall goals of the business models are missing. These respondents recommended we include a net zero aim, driving the lowest emissions options and that any profits should be capped by government.

Another respondent took issue with 'nationally significant infrastructure' and disagreed with hydrogen transport and storage being framed in terms of business models. This respondent suggested the key principles should be focused on security, sustainability, long-termism and flexibility.

Government response

Given the consensus established for the key design principles, we will continue with this approach for developing hydrogen T&S business models.

We have however used the feedback provided by respondents to further inform our thinking on design principles for each business model.

An updated set of design principles for the hydrogen transport business model is provided in Chapter 2, and an updated set of design principles for the hydrogen storage business model is provided in Chapter 3.

Some of the considerations suggested by stakeholders, most notably strategic planning, do not fit into our design principles but are important consideration that will be reflected elsewhere.

Our work on strategic planning (see Chapter 5) will likely inform the allocation criteria and process for both business models, and location and sizing will be an important factor in this.

Chapter 2: Hydrogen transport infrastructure (Q3 – 20)

Market barriers

Question 3: In your view, do you agree we have correctly identified and characterised the market barriers facing the development and operation of hydrogen pipelines and a hydrogen network? Are there any other market barriers we should be considering?

Consultation position

In the consultation, we set out what we believe to be the main market barriers that prevent final investment decisions (FIDs) from being taken with respect to the development, construction, and operation of hydrogen pipelines and networks. This included: demand and supply uncertainty; limited consumer base to cover costs; high cost; and market barriers associated with a natural monopoly.

Summary of stakeholder responses

Response	Number of responses
Strongly agree	5
Agree	49
Neither agree nor disagree	4
Disagree	3
Strongly disagree	0

Out of the 90 respondents that responded to the consultation, 61 responses were received for this question. The majority of respondents agreed or strongly agreed that we had correctly identified and characterised the market barriers facing the development and operation of hydrogen pipelines and/or networks. Some respondents answered 'neither agree nor disagree', while some disagreed that we had correctly identified and characterised the market barriers.

Additional marker barriers

Respondents provided several additional factors which they believed to be market barriers. Some highlighted that the time taken to secure planning permission to deliver large scale infrastructure projects can lead to additional project delays as well as financial risk. One respondent highlighted the shortage of skilled workers paired with high labour demand may lead to increased costs and delays for projects.

In other views to this question, some respondents highlighted the lack of private insurers and reinsurers willing to offer hydrogen-insurance products to small scale projects, as well as the higher level of capex and opex risks for new, and smaller, entrants compared to existing networks.

One respondent highlighted that the purity of hydrogen transported at a national level may not be suitable for all user cases curtailing demand, while another highlighted the impact of negative public perception of hydrogen projects may result in significant delays to projects, or in some cases, prevent demand user cases materialising, ultimately disincentivising supply and transport participants from investing.

Government response

Notwithstanding the broad agreement on the main market barriers identified, the government recognises that there may be others, similar to those raised by a number of respondents, that government will need to address as we progress with the delivery of the hydrogen economy.

Ensuring that the UK has the right skills and capabilities will be critical to achieving our hydrogen ambition. Government have published the Hydrogen Sector Development Action Plan (SDAP), a key commitment made in the UK Hydrogen Strategy. The SDAP sets out what we have learned about key areas of sector development since publication of the Hydrogen Strategy and actions that government and industry are taking to maximise economic opportunities in UK hydrogen. The document covers investment, supply chains, jobs and skills, and trade and exports. Additionally, through forums such as the newly established Jobs Skills and Supply Chain working group under the Hydrogen Delivery Council, we are continuing to engage with partners across industry, and through the Green Jobs Delivery Group, this engagement extends to devolved administrations, local authorities and enterprise agencies, as well as industry, to drive forward collaborative action and ensure there is effective and targeted investment in relevant skills.

The regulatory framework as it relates to hydrogen is broad and complex, including rules and regulations relating to the environment, safety, markets, competition, planning and specific end uses. We recognise that new rules and regulations may be required to facilitate the further expansion of the market and maintain competitive pressure over the course of the 2020s and beyond, especially should hydrogen networks connect to the existing gas network in the future, for instance, to enable blending or grid conversion. Government is working with regulators and industry to develop a common understanding of how current regulation supports or impedes the development of a hydrogen economy, and where necessary, we will make changes to facilitate delivery.

Government also recognises that industry needs certainty for those projects already in the development pipeline. Therefore, in the interim, we are working with Ofgem and industry to enable early projects to operate within the existing regulatory regimes.

Business model design options

Question 4: In your view, have we set out the main business model design options, or are there others that should be considered?

Consultation position

The consultation document sought to outline, at a high level, the main business model design options available for hydrogen transport infrastructure in order to overcome the market barriers previously identified in the consultation, as well as to bring forward investment and the development of hydrogen pipelines and networks. The UK Government has previously worked with industry to design business models that encourage investment and the construction of infrastructure across the energy sector and beyond.

Summary of stakeholder responses

Response	Number of responses
Yes	47
No	3

Of the 90 responses received, 50 responses were received for this question. There was strong agreement from respondents stating that we had identified the main business model options. Some respondents answered that we had not identified the main business model options. Many respondents either did not answer the question, either directly or indirectly, or set out in the answer that they were unsure if we had identified the main business models.

Further explanation

Of the respondents that provided further explanation for their answer, there were some common areas raised in their responses which have been outlined below in further detail.

Flexibility/adaptability/evolution of business model design

The most commonly mentioned theme in the responses to this question were around the need for any business model design to be flexible and adaptable. Both in terms of its applicability to different types of projects (for example, a multi-point transport network compared to a point-to-point project) and its ability to adapt over time and phases of the hydrogen economies development.

RAB as the preferred business model

Even prior to the questions on the most suitable business model options in a growth of steady phase, there were some respondents that stated that of the business models identified in the consultation, the preferred option would be a RAB model. The main reasons for this were that a RAB model has been previously used in similar sectors and scenarios, meaning it is well understood and can help improve investor confidence.

Local or regional focus in business model

Some respondents noted that in the early stages of the hydrogen economy, the focus for support and initial investments should be done on regional basis. The reasoning for this was to consolidate the industry in regional clusters with early adopters that could then be quickly expanded from as opposed to a slower progression across the whole of the UK. There was also a respondent that stated that for local or point-to-point hydrogen projects, a merchant-based model could be more suitable provided any such project could prove commercial viability.

Different business model designs for different stakeholders

Some stakeholders pointed out the possibility of utilising different business models for different types of projects, infrastructure, stakeholders or parts of the hydrogen value chain, and even a hybridisation of business models depending on those factors.

Regulatory framework is required alongside a business model

A couple of stakeholders noted the need for a regulatory framework alongside any business model design to address market barriers and uncertainty.

Additional business models to consider

A further two respondents provided examples of additional business models that had not been stated in the consultation, including a 'Built-Own-Operate-Transfer' model and a 'Mutualisation' business model.

Government response

Government acknowledges the additional considerations from stakeholders regarding the main business model design options. We agree with the majority of respondents that the business model design options identified in the consultation are the main options that should be considered for a hydrogen transport business model. The responses will continue to be considered through the detailed business model design process to ensure the final business model can account for areas raised by stakeholders.

Predominant market barriers in a growth phase

Question 5: In your view, do you agree that uncertain demand and supply and limited user base will be the predominant barriers in a growth phase of hydrogen network development? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we differentiate between a growth phase of network development and a steady state phase of network development. A growth phase being the construction (including repurposing) of new hydrogen pipelines to connect producers and end-users, storage facilities and import/export terminals, within and beyond clusters. A steady state phase is the maintenance of one or several networks with multiple entry and exit point, with furth investment based on an incremental basis rather than transformational. The consultation set out that in a growth phase it was likely that the predominant market barriers to developing hydrogen transport infrastructure would be uncertain demand and supply and limited user base.

Summary of stakeholder responses

Response	Number of responses
Strongly agree	9
Agree	46
Neither agree nor disagree	1
Disagree	4
Strongly disagree	0

Out of the 90 respondents that responded to the consultation, 60 responses were received for this question. The majority of respondents agreed or strongly agreed that uncertain demand and supply and a limited user base would be the predominant barriers in a growth phase. Some respondents disagreed that these would be the predominant barriers in a growth phase, although no respondents ‘strongly disagreed’. One respondent was unsure, so was tallied as ‘neither agreed nor disagreed’.

In aggregate, these responses suggest that there is consensus amongst respondents that uncertain demand and supply and a limited user base would be the predominant barriers in a growth phase.

Additional barriers

Although there was consensus, respondents did note other barriers that could arise in a growth phase. The additional barriers that attracted the greatest amount of attention from respondents are summarised below:

Uncertainty over location and sizing

Associated with uncertain demand and supply, some respondents noted that location and sizing requirements for hydrogen transport infrastructure were also uncertain, which created a barrier to hydrogen transport infrastructure development in a growth phase. A potential transport provider will need certainty over the location and the sizing of the network to manage risks of stranded assets and/or non-allowable costs. Without this certainty, a transport provider may be unwilling to invest or develop infrastructure, or alternatively may invest or develop infrastructure in the wrong location and/or at the wrong size. An issue a provider will want to try and avoid. Although, initial users of this infrastructure will likely be cluster based, beyond that there is little certainty as to where these users will be located.

This uncertainty over location and sizing is further brought about through the absence of a decision on blending or hydrogen for heating. This is highlighted by the large gap between 2050 hydrogen demand estimation in the National Grid's Future Energy Scenarios, with hydrogen demand for residential heat varying between 0TWh and 145TWh depending on the decarbonisation scenario HMG decides.

Environmental and planning regulation

Some respondents noted that environmental regulation and planning regulation could also act as a barrier in a growth phase. Both environmental and planning regulation would need to be overcome if hydrogen transport infrastructure is to get built. A respondent citing that environmental and planning regulation could be the biggest barrier after an investment decision has been made. A couple of respondents noted that water abstraction would likely be an environmental consideration. Two respondents set out that uncertainty associated with the planning process and the timescales for getting the consents could act as a barrier. One of these respondents suggested that support from government would be needed to overcome barriers associated with planning consents whilst there is demand and supply uncertainty.

Overcoming these barriers

As well as commenting on the barriers, many respondents also noted ways in which these predominant market barriers could be reduced, alongside a business model. The additional measures that attracted the greatest amount of attention from respondents are summarised below.

Clarity on strategic approach to hydrogen transport infrastructure development

To overcome these barriers, most notably uncertainty demand and supply, respondents suggested that greater clarity on the strategic approach to the development hydrogen transport infrastructure was needed. This will help ensure that this infrastructure is built where and when it is needed, as well as at the right size, to support the wider hydrogen economy. This should encourage the development of one network developing holistically rather than smaller networks developing in a piecemeal fashion. This holistic development will give further confidence to demand and supply. Coordination and a clear commitment as to the hydrogen transport infrastructure requirements to support the hydrogen economy will help overcome these barriers. This transparency will also allow production and demand to evolve with confidence, further supporting the hydrogen economy.

Support for demand

Some respondents noted that better supporting demand would also help mitigate barriers for hydrogen transport infrastructure in a growth phase. Once demand is better articulated, supply will become easier through the provision of a marketplace. Thus, helping overcome uncertain demand and supply and a limited initial user base. More comprehensive policy on end-use may help stimulate demand, as it becomes easier for industry to evaluate the cost and benefits of switching to hydrogen.

Respondents that disagreed

Some respondents disagreed that these were the most prominent market barriers in a growth phase. For those disagreeing, a mix of reasons were given however most centred around the fact that these market barriers could be removed by ensuring demand by optimally locating the infrastructure or more comprehensive government policy on demand.

Government response

Given the consensus established for the market barriers outlined in a growth phase, these will remain a key barrier to focus on as the hydrogen transport business model is designed. The other barriers raised will remain a consideration as the hydrogen transport business model is designed.

Other recommendations to remove these market barriers will also be considered. Our work on strategic planning (see Chapter 4) will likely inform the allocation criteria and process for both business models, and location and sizing will be an important factor in this.

Business model in a growth phase

Question 6: In your view, which business model design options do you consider may be suited to address the barriers in a growth phase?

Consultation position

The consultation stated that the development of hydrogen transport pipelines and the eventual network, will take place in two main phases - a growth phase and a steady state phase - which will need to be considered throughout the business model design process. These phases may overlap or co-exist in practice, for instance where one region in the UK has a hydrogen network in the growth phase while another region is already in an initial steady state phase.

The consultation acknowledged that hydrogen is subject to new and distinct challenges and market barriers that need to be overcome in order to drive initial pipeline and subsequent network development. Further, the market barriers faced during a growth phase are likely to be different to the ones faced in a steady state phase. Given these new and potentially phase specific challenges, designing a business model for hydrogen transport from the existing framework for natural gas may not be appropriate.

Summary of stakeholder responses

Response	Number of responses
RAB	34
Cap and floor	1
Contracts for difference	3
Government as long-term capacity booker	1
Capacity availability	1
Co-investment by government	3
Merchant model	0
Other	4

Of the 90 respondents that responded to the consultation, 47 responses were received for this question (this includes multiple responses from the same respondent). The majority of respondents preferred a RAB business model design. Some responses were received for an alternative ‘Other’ business model design. This ‘Other’ business model design consisted of a combination of the business model designs outlined and one new business model – ‘Mutualisation’. All the other business model design options in the consultation were preferred by between one and three responses.

There were some common additional considerations raised by respondents which have been outlined below.

Avoid initial costs falling on small user base

Many responses stated that the importance of avoiding any initial costs falling exclusively on an initially limited user base for hydrogen, which will potentially damage the confidence of investors during a growth phase. This was identified by some respondents as one of the major market barriers during the growth phase.

External funding mechanism required alongside business model

Many respondents also noted that the final business model would need an external funding mechanism to ensure investor confidence during a growth phase as well as avoiding costs falling exclusively on an initially limited user base.

Flexibility in business model through phases and over time

Some respondents stated that the business model would need to be flexible over time and between the growth and steady state phases. Several of these respondents specifically commented that a RAB business model would be preferable as it offers that flexibility.

RAB established & familiar model

There were also some respondents that stated a RAB was the preferred business model during a growth phase as it is an established, familiar and well understood business model for the industry to follow and increase investment confidence.

Other business models

Some respondents answered question 6 with a preferred business model that was not explicitly mentioned in the consultation. For example, using a hybrid approach of different business models presented.

Commercial viability should allow for merchant style model

Some respondents commented that where a hydrogen project can demonstrate commercial viability, the business model and any associated regulations should allow for the use of a merchant or market-based model.

Transition between growth & steady phases

Some respondents noted that consideration should be made in the business model design to the transition between a growth and steady state phase. Specifically, respondents noted the different market barriers in a growth and steady state phase and that although a RAB model may not address all of these barriers during both phases, it does offer flexibility in that transition phase.

Government response

Given the volume of responses to this question that directly stated a RAB business model as the preferred design, government agrees that a RAB model would be best suited to address the identified market barriers in a growth phase. As noted in the consultation, and by several respondents, an external funding mechanism will be required to avoid excessive costs being passed onto an initially limited user base while also ensuring a steady and predictable revenue stream for developers. We are particularly minded to utilise a RAB business model, as noted in many of the consultation responses, because it is a well-established and familiar model that is understood by the industry and means we can build on existing model examples to take into account the additional considerations raised in the responses to the consultation.

However, we will take note of the other considerations and points raised in the consultation responses regarding business model design in a growth phase, for example, considering the transition between growth and steady state phases in the business model design, and the potential for commercially viable projects to utilise a merchant business model as opposed to a RAB model.

Interim measures

Question 7: In your view, are there any interim measures that we should be exploring to support the development of early hydrogen pipelines ahead of a hydrogen transport infrastructure business model being available? Please explain your answer and provide any relevant evidence.

Consultation position

The consultation acknowledged that a business model for hydrogen transport infrastructure specifically is not currently available to allow for the development of pipelines in these early stages. However, it suggested that some support may be available to encourage investment in and development of initial pipelines through other means. For example, some costs incurred by existing natural gas network operators may be recoverable on a case-by-case basis under the current RIIO framework. For example, Ofgem has previously allowed some funding for hydrogen transport infrastructure feasibility studies through RIIO. In addition, hydrogen production business model contracts may fund some limited transport infrastructure directly linked to production projects and necessary for those projects to access their initial consumers.

Early projects may need to use this support to start or continue to progress the development of transport infrastructure to meet initial demand. The consultation asked whether any specific measures should be explored that might be necessary to allow projects to continue in the interim before a hydrogen transport infrastructure business model is available.

Summary of stakeholder responses

Out of the 90 respondents that responded to the consultation, 53 responses were received for this question. There was strong agreement from respondents that some form of interim support mechanism would be needed ahead of the business models being designed. The key benefits of providing interim support mechanisms were identified as allowing strategically important projects to reach FID before 2025 and demonstrating the technology and its benefits at a larger scale.

Potential avenues for interim funding

Respondents picked up on two existing support mechanisms referenced in the consultation – the RIIO Price Control framework for owners and operators of natural gas networks, and the hydrogen production business model. Many respondents suggested that the existing RIIO-2 framework, a RAB business model design, could be expanded to include early hydrogen projects. Some respondents also suggested taking a pragmatic and flexible approach to the types and scale of transport projects that could be supported under the hydrogen production business model.

Other interim support

The majority of respondents focused on funding or revenue support options, but some respondents also suggested other interim support measures: streamlining the planning process, setting a quality standard for Liquid Organic Hydrogen Carriers (LOHC) and accelerating policy decisions on blending, hydrogen-ready boilers, and hydrogen for heating.

Many respondents also indicated that clear policy direction on a transparent transport infrastructure road map is needed, not just to identify early strategically important or low regrets transport projects that might require support, but also to help both Government and industry coordinate projects and identify synergies that would allow for cost and efficiency savings and minimise construction impacts.

Support for vehicular transport

Other issues raised by respondents included the potential need to consider support for relevant supply chains, and that the transport strategy set out is too focused on pipeline infrastructure over vehicular transport of hydrogen, which should also be supported.

Risks

Respondents also highlighted the risks as a result of not providing interim support:

- Missed opportunities to save costs and disruption by pursuing parallel construction with other projects, e.g. where hydrogen pipelines can be sited with already planned carbon dioxide pipelines,
- Excess costs as a result of early small-scale construction precluding more efficient larger-scale projects in a more mature market,
- Rendering strategically important projects unable to reach FID in line with partnership projects, and
- A risk of undermining the ability of the UK hydrogen market to reach the Hydrogen Strategy goal of 10GW of hydrogen production by 2030.

Some respondents were more ambivalent over the need for interim measures ahead of business model availability. The risks of providing an interim support mechanism were identified by some respondents as potentially disadvantaging first adopters who only get limited support versus second entry players who enter the market with full business model support after 2025, or that the mechanism could be too complex or over-engineered. Others recommended prioritising support for production and ensuring that the supply chain was developed in parallel. Some pointed out the risk that projects developed too early in the growth of the hydrogen economy stand a high risk of being under-sized, and that future T&S requirements should be assessed in more detail as part of development of the business models.

Government response

Our commitment to design the hydrogen transport business model by 2025 is ambitious and challenging, and will provide the enduring framework for transport projects, with an initial focus on gaseous hydrogen pipelines. Many respondents have suggested that prior to 2025, additional measures may be necessary to support early projects. As noted in Chapter 2, an interim business model would not be ready any sooner than 2025 and could cause complications with the enduring model.

Some measures are, however, already available and are supporting early projects through innovation funding, funding for feasibility studies, and support for the transport infrastructure required as part of production projects supported through the hydrogen production business model.

We are committed to continuing to support early projects, unlocking the potential advantages that respondents have highlighted. For example, in March 2023, 20 production projects were shortlisted through the Hydrogen Allocation Round process, and many included some early transport infrastructure. The transport infrastructure necessary for the first hydrogen production projects in the Clusters is also being taken forward as part of Track 1 of the Cluster Sequencing process. Additionally, DEVEX for some hydrogen projects by existing natural gas network operators may be supported under Ofgem's RIIO mechanism, where these projects provide clear benefits to natural gas consumers, as evidenced by their recent approval of DEVEX funding for the feasibility stage of National Gas's 'Project Union'.

As well as these forms of support, we are developing our approach to strategic planning for hydrogen transport infrastructure at pace to help identify and prioritise early strategically significant projects. This strategic planning will form the basis of the hydrogen transport business model allocation process and its interaction with the nature and timing of support for early hydrogen transport projects. As set out in the Strategic Planning chapter (Chapter 4), we will publish a 'hydrogen networks pathway' that will set out a strategic framework for hydrogen network planning and a vision for the build-out of hydrogen T&S infrastructure ahead of the business models being available.

Business model in a steady state

Question 8: In your view, is a RAB model, based on the natural gas RAB design, likely to be the most suitable business model during a steady state, or would another business model design be more appropriate? Explain your answer.

Consultation position

The vision of UK Government for hydrogen transport is of a large, integrated and resilient network with multiple entry and exit points across regions or even nationally. Although a subsidy might be required during a growth phase, we would expect a hydrogen network to operate without any subsidies but with regulations in place, much like the existing gas networks.

In a steady state phase, the UK Government believes that the predominant market barrier is likely to be that associated with a natural monopoly. Therefore, a RAB may be the most appropriate business model design as it is the model typically used in the UK for monopoly infrastructure such as gas, electricity and water networks.

Summary of stakeholder responses

Response	Number of responses
Yes	47
No	2

Out of the 90 respondents to the consultation, 49 responses were received for this question. The majority of responses agreed that a RAB business model design would be the most appropriate during a steady state. Only two respondents did not agree that a RAB business model design would be the most appropriate, and another business model design would likely be more appropriate. A further 41 respondents either did not answer the question, both directly or indirectly, or were not sure.

Of the respondents who provided further explanation to their answers, the recurring topics and themes were similar to those in response to question 6, and have been outlined further below:

RAB established & familiar model

Some respondents again stated that a RAB business model would be preferable as it is a well-established model used in other similar industries, so stakeholders are familiar with its use. Further, respondents noted given it previous usage and familiarity, a RAB model could provide further investor clarity and confidence to help grow the hydrogen economy.

Funding mechanism required alongside business model to ensure stability and avoid costs falling on initially small user base

Some respondents again reiterated the need for an external funding mechanism alongside a final business model. Respondents that commented on this in question 8 were mostly referring to the use of an external funding mechanism in a growth phase and thus reiterating an answer to question 6. However, there were respondents that stated a desire for an external funding mechanism in a steady state phase as well to boost investor confidence and ensure revenue predictability.

Localised/Point-to-Point models would favour merchant model if commercially viable

Some respondents stated in part of their answer that where a hydrogen project could demonstrate commercial viability, then the regulations and business model should allow for a merchant model to be used instead of the final business model design, as this would allow a fast stream of potential projects to be completed quickly with a less complex revenue stream.

Respondents that answered 'No'

Two respondents answered 'No'. Both of these respondents noted that a RAB model could still be utilised if it is either for hydrogen transport in gas pipelines as opposed to vehicular or LOHC transport, or if the RAB is used to underpin the investment of hydrogen assets within a competitive regime.

Government response

Government agrees with the majority of respondents that a RAB model based on the natural gas RAB design is likely to be the most suitable business model during a steady state. Similarly, in our response to question 6, we acknowledge that a RAB model is well established and understood by the industry, as well as allowing for a degree of flexibility and adaptation when considering specific projects and regions. As part of the flexibility afforded by a RAB model, we can consider building into the model the ability for commercially viable projects (particularly localised or point-to-point models) to utilise a merchant business model.

We note that some respondents stated the need for an external funding mechanism in response to this question, however, as stated in the consultation, it is our vision for a hydrogen network to operate free from subsidies in a steady state phase and so we intend to phase out any external funding between a growth phase and steady state.

Compatibility between growth phase and steady state

Question 9: In your view, is there a need for compatibility between a business model for a growth phase and a business model for a steady state, and how should this be managed?

Consultation position

In the consultation, we acknowledged that additional factors may need to be taken into account when designing the business model so as to drive network development in the growth and steady state phases. We asked respondents to consider issues around compatibility between a business model in a growth phase and a business model in a steady state phase.

Summary of stakeholder responses

Response	Number of responses
Yes	44
No	1
Not sure	4

Of the total 90 respondents that responded to the consultation, 49 responses were received for this question. The majority of responses felt that compatibility is needed for business models for a growth phase and a steady state. One respondent did not feel compatibility is needed, while some respondents were not sure.

Reasons for compatibility

Respondents gave a range of reasons for believing compatibility is needed. This included the provision of a steady regulatory regime through compatibility, associated boosts to investor confidence, a reduction in policy uncertainty and increases in certainty for users, and a reduction in policy complexity. A smooth transition enabled by compatibility was also cited as a stimulant for the hydrogen economy.

Other priorities

Some respondents also identified priorities ahead of compatibility between business models for growth and steady state phases. The included a focus on investor confidence, synergy between the hydrogen production business model for electrolytic hydrogen and the hydrogen transport business model, and a focus on the speed of delivery of the business model.

Other considerations

In answers to this question, some respondents set out that a RAB should be used in both a growth phase and a steady state phase, therefore commenting on both questions 6 and 8. By contrast, some respondents felt a different business model could be used but compatibility still would be needed. Some respondents felt clarity is needed on the transition from a growth phase to a steady state phase in any situation.

The existing RIIO regulatory regime for natural gas, which is a RAB-style price control, was mentioned as a potential business model. It was suggested that a RAB could be flexible and so be amended to be more bespoke in a growth phase to allow for a more suitable framework. However, in a steady state phase, it could resemble more the existing regulatory regime for natural gas.

Finally, it was also suggested that a RAB can address market barriers in both a growth phase and a steady state phase.

Government response

Government acknowledges the responses on the subject of compatibility between a growth phase and a steady state phase for the hydrogen transport business model, noting that the large majority of those answering the question are in favour of compatibility, with justifications provided including boosts to investor confidence, reduced complexity, and policy uncertainty for developers.

Given government's intention to stimulate the hydrogen economy and encourage its progress towards a steady state, mature market, and noting the benefits of doing so cited by respondents, government will aim to develop compatibility between the growth and steady state phases where appropriate when designing the hydrogen transport business model, recognising that the model will evolve over time as the hydrogen economy matures.

Government agrees that a RAB is likely to be the most suitable high-level design for the hydrogen transport business model. This can be applied to both the growth and steady state phases of the hydrogen transport business model, which should boost compatibility between them. However, government also notes the other principles and suggestions raised by respondents, namely flexibility of the hydrogen transport business model as regards existing regulatory regimes for natural gas, a focus on investor confidence, emphasising speed of development, and synergy between the hydrogen transport business model and the hydrogen production business model.

Compatibility between hydrogen and natural gas business models

Question 10: In your view, is there a need for compatibility between a business model for hydrogen and a business model for natural gas, and how should this be managed?

Consultation position

In the consultation, we acknowledged that additional factors may need to be taken into account when designing the business model so as to drive network development in the growth and steady state phases. We asked respondents to consider issues around compatibility between a hydrogen transport business model and the natural gas business model (the future natural gas network price control).

Summary of stakeholder responses

Response	Number of responses
Yes	46
No	6

Not sure	1

Of the total 90 respondents that responded to the consultation, 53 responses were received for this question. The majority of responses stated that compatibility between business models for hydrogen and natural gas is necessary. Some respondents stated that there is no need for compatibility, while one respondent was not sure.

Out of those respondents not feeling compatibility was needed, some argued that the hydrogen business model should not resemble the gas business model given the different levels of market maturity for hydrogen and gas, and the different market barriers they face.

Why compatibility was needed

Many respondents stated that compatibility would aid the transition from natural gas to hydrogen and noted the role of blending in achieving this; one respondent also called for blending volumes to be factored into the awarding of contracts for the external subsidy mechanism.

Respondents gave a range of explanations as to why they felt compatibility would be beneficial. Some stated that compatibility would allow for the evasion of high up-front costs, long lead-in times, and additional disruption for developers. Some also stated that compatibility in the form of similar market arrangements would provide familiarity for operators and would boost investor confidence for market participants. Some stated that compatibility would help with the re-purposing of existing gas infrastructure specifically, with three respondents stating that re-purposing requires targeted support. Some respondents also stated that double subsidies must be avoided when providing support for re-purposing.

Length of compatibility

With regards to the scale of compatibility, some respondents stated that compatibility between the business models would only be needed in the short-term, focusing on re-purposing and blending, but that in the long-term, the business models should be distinct. A couple of respondents stated that compatibility would be especially important in the growth phase given the expected high market share of grey hydrogen, and the consequential effect of gas prices on hydrogen prices. Some respondents also emphasised the need for alignment across the UK's regional clusters with regard to compatibility between the business models for gas and hydrogen, so as to provide common market arrangements. Two respondents stated that the scale of compatibility required would depend on the size of the UK's hydrogen economy, with a greater size requiring greater levels of compatibility.

Additional features

Some respondents called on the government to bring forward its decision on hydrogen home heating from 2026 to 2023 in order to give greater confidence to the hydrogen T&S sectors.

A couple of respondents that emphasised the need for the economic regulator within the hydrogen business model to allow for the transfer of assets from gas to hydrogen by assigning them fair values in order to reduce the risk of stranded assets. One of these called for the regulator to be Ofgem, and for it to develop a specific methodology to determine these fair values.

There were two respondents that also stated that risk to hydrogen investment could be reduced by the provision of cross-subsidies between natural gas and hydrogen.

Government response

Government acknowledges the responses on the subject of the hydrogen transport business model's compatibility with the natural gas business model, noting that the large majority of those answering the question are in favour of compatibility, with justifications provided including the importance of supporting repurposing of existing gas infrastructure, and benefits to investors from familiarity with the existing natural gas business model.

As such, we will aim to develop compatibility between the hydrogen transport business model and the natural gas business model where appropriate. Government expects the design of the hydrogen transport business model to be based on the RAB model. As the existing natural gas business model also functions on the basis of this model, this should allow for compatibility between the hydrogen transport business model and the natural gas business model. However, government also notes the other principles and suggestions raised by respondents, such as flexibility of the hydrogen transport business model across different timescales, and so these will also need to be factored into its design.

Other considerations

Question 11: In your view, are there any other considerations we should take into account?

Consultation position

In the consultation, we acknowledged that additional factors may need to be taken into account when designing the business model so as to drive network development in the growth and steady state phases.

Summary of stakeholder responses

Response	Number of responses
Yes	25
No	13
Not sure	5

Of the total 90 respondents that responded to the consultation, 43 responses were received for this question. The majority of respondents were of the view that other considerations need to be taken into account. Additionally, some respondents stated that there are no other required considerations. Out of those answering the question, the lowest number of respondents were not sure.

Additional considerations

Respondents provided a range of additional suggestions on what should be taken into account. Some respondents highlighted the necessity of compatibility between the hydrogen business models for the UK and the EU, while some emphasised the need for the hydrogen business model to be flexible, given the level of uncertainty within the UK's hydrogen economy at present.

Some respondents stated that the external subsidy mechanism must be in place in the long-term so as to protect hydrogen users from the impacts of other users defaulting. Some also stated that there must be consistency between the business models for hydrogen and CCUS.

Some respondents called for the rapid development of interim arrangements for the timely delivery of necessary hydrogen infrastructure, while three others called for clarification on how existing natural gas pipelines will be treated and regulated.

Some respondents stated that there should be a requirement for a credible needs case and strong evidence of demand for each RAB application to be deemed successful, and three others stated that the business model should not penalise the first connecting projects.

Finally, a few respondents stated that local authorities should be supported to ensure the timely processing of planning applications for hydrogen infrastructure, while two respondents suggested that the hydrogen market should be scaled in line with the offshore wind market.

Additional features

Numerous other suggestions were made by one respondent each. It was suggested that the hydrogen business model give consideration to:

- The certainty of the funding envelope,
- Co-ordination of projects across the value chain,
- The Development Consent Order process,
- Combining hydrogen and CCUS transport infrastructure (e.g. terminals),
- The development of a business model for LOHCs,
- Enabling collectively-owned assets for early projects (i.e. "virtual pipelines"),
- Additions of fuel cells & energy storage facilities along pipelines to boost safety & accessibility,
- The development of a specific plan for the overuse & underuse of pipelines,

- Issues around hydrogen compression, as reciprocal technology has associated reliability & land use issues,
- Incentives for owners/operators for efficient & timely project delivery,
- Provisions to ensure the cost of hydrogen use remains stable,
- Risk sharing during the construction phase for hydrogen infrastructure,
- Centralisation of strategic assessment to enhance co-ordination,
- In-tandem construction of hydrogen & CCUS infrastructure,
- Development of effective leak detection practices,
- Encouraging localised hydrogen production to capture surplus electricity,
- Ensuring policies are time-dependent to allow strategies to evolve according to the uncertain hydrogen landscape,
- Additional natural gas storage to address peak gas demand during periods of low wind & sunlight (i.e. low renewable energy generation),
- Development of a network code document to develop the hydrogen market, with the possible adoption of the gas network code for blending gas & hydrogen.

Government response

Government received a wide range of additional suggestions on the subject of the hydrogen transport business model's compatibility with a business model for natural gas, and compatibility between different phases of the HTBM. Government takes note and will consider these suggestions, such as clarity for questions raised around the hydrogen transport business models flexibility, consistency with the EU's hydrogen business model and the CCUS business model, and any interim arrangements to be developed before the launch of the hydrogen transport business model.

Ownership arrangements

Question 12: In your view, what ownership arrangements do you think are likely to be suitable for hydrogen networks? Does this depend on the chosen business model and/or phase of network evolution?

Consultation position

In the consultation we recognised that there are a variety of ownership models that could work within the business model design options detailed, including government owned, privately owned, or a combination. For infrastructure under a regulated business model, such as a RAB or a cap and floor, it can be either privately owned or government owned (or a mix of both). Under a contractual business model, infrastructure tends to be privately owned. Through government co-funding, infrastructure can be privately owned or co-owned.

Summary of stakeholder responses

Response	Number of responses
Private ownership	36
Co-ownership with government	10
Public ownership	2
No preference	3

Out of the 90 respondents that responded to the consultation, 51 responses were received for this question. The majority of responses supported “private ownership” of which some noted that “co-ownership” was an option for strategically important projects in their growth phase. Further responses were received for “co-ownership”. A further two respondents identified public ownership being the most suitable for hydrogen networks, while some respondents gave no preference.

Reasoning for private ownership

The predominant rationale provided by those who supported “private ownership” was that regulated private ownership, similar to the existing ownership structure of the natural gas transportation network, had demonstrated the value and benefits of private investment, operating within a stable regulatory framework, overseen by a competent government appointed sector regulator.

One respondent who supported “private ownership” also put forward the idea that a consortium of large (private) organisations with common interests in key regions (comprised of companies producing, transporting and consuming hydrogen) could act as a temporary (or permanent) bridge to an alternative owner such as a gas network or the gas transmission system operator.

Other considerations

Of those who had no preference, one respondent argued for effective separation of network operators from activities of production, supply and storage, i.e. vertical unbundling, in order to avoid conflicts of interest and ensure fair competitive access to networks. They did note however that this may not be practical in the very early days of network development, and, in advance of market maturity, it may be reasonable to make exceptions for geographically confined industrial or commercial areas, such as intra-cluster pipelines, or for existing hydrogen networks, for a time limited period.

Government response

The government recognises that private ownership, in conjunction with stable regulatory frameworks administered by an independent regulator, has facilitated efficiency and stability across the existing natural gas network. As we progress the business model design, we will take this, and the remaining feedback, into account, when making the final design decisions.

We also acknowledge the challenges posed by natural monopolies and the importance of unbundling in facilitating market competition. Given that regional networks, such as those that might emerge in and around the CCUS clusters, could potentially interconnect with one another, and might even connect with networks further afield, the end-state could be an integrated national network that has characteristics similar to the existing natural gas networks. Consequently, the market framework that currently supports the natural gas system (Gas Act; licencing arrangements; Uniform Network Code etc) might be appropriate for underpinning such an end state. However, questions remain as to its suitability during the growth phase of the hydrogen economy when the landscape will look very different, e.g. there will be a much smaller number of market participants, much less interconnectivity, and a series of non-networked pipelines connecting some producers with one or a few end-users. There is a risk that unnecessarily burdensome regulatory arrangements during the growth phase could present a barrier to investment in such infrastructure. Consequently, it is government's intention to keep the market framework (as it applies to the conveyance of hydrogen) under review as it progresses the design of the hydrogen transport business model.

External funding mechanism in a growth phase

Question 13: In your view, is an external funding mechanism needed in a growth phase of network evolution? If so, at what stage of market and network evolution might it no longer be required? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation we put forward the idea that a business model may need an external funding mechanism to help overcome the market barriers identified, especially in a growth phase of network evolution.

Summary of stakeholder responses

Response	Number of responses
Yes	51
No	1
No clear preference	14

Out of the 90 respondents that responded to the consultation, 66 responses were received for this question. There was strong agreement from the responses that believed an external funding mechanism is needed during the growth phase of network evolution. One respondent believed an external funding mechanism was not required, while some respondents showed no clear preference.

Reason for an external funding mechanism

Amongst those who agreed that an external funding mechanism was required it was argued that it would be needed from the beginning of the growth phase until such time as the market becomes self-sufficient, that is, when the market price of hydrogen is established by demand and supply forces which can cover/absorb the relevant transportation and storage costs. It was also noted that such a funding mechanism would not only to reduce volume risks for the pipeline infrastructure provider (thereby securing investment and reducing cost of capital) but also would protect the low number of initial consumers from bearing disproportionately high costs in the infancy period, thereby avoiding distorting the economics of early projects.

Of the respondents that showed no preference, one stated that any support provided should only be on the basis that it warrants value for money, attracts and accelerates private investment, and facilitates its own removal as early as possible.

The one respondent who was against an external funding mechanism argued that the UK already has a significant cost base, including the impact of the UK ETS, and a further increase in costs risks investment in UK industry, including in the energy transition.

Government response

The government, in line with the prevailing opinion from the consultation responses, believes an external funding mechanism is required to help overcome the associated market barriers with large scale infrastructure, especially in a growth phase of network evolution. The limited initial user base may require an external funding mechanism to increase revenues while keeping user costs affordable, whilst uncertain revenues may require an external funding mechanism to provide some predictability to revenues.

Furthermore, the government agrees with the principle that any external funding mechanism should not only represent value for money, but attract and accelerate private investment, facilitating its own removal as early as possible.

External subsidy mechanism funding

Question 14: In your view, if needed, what are your views on possible approaches to funding a potential external subsidy mechanism?

Consultation position

In the consultation we recognised that the funding of the business model for hydrogen may have to be different to what is already applied to natural gas as a new hydrogen network will not have established economies of scale that can provide services at an affordable rate for users. Instead, an external funding mechanism, potentially through a levy or other kind of formalised cross-subsidy from other energy consumers or via another means, such as directly through central government, may be needed to support the development of new pipelines, and a subsequent network.

Summary of stakeholder responses

Response	Number of responses
Socialisation costs across all gas users	16
General taxation	15
Levy across all energy users	2
Levy on oil and gas profits	4
No clear preference	6
No clear answer	16

Out of the 90 respondents that responded to the consultation, 59 responses were received for this question. Many respondents believed that an external funding mechanism should be funded by socialising the cost across all gas users. Many respondents also supported funding via general taxation, of which two also supported a levy across all energy users in addition. A levy on oil and gas profits as the funding source was advocated for by some respondents, while some respondents indicated no clear preference.

Of those who supported socialising the cost across all gas users, the main argument was that due to the number of UK gas users, circa 22 million, socialising the costs would be both expedient and have no visible impact in any UK gas customer bill when collected via the transmission operator.

The consensus of those who supported general taxation was that such a policy would avoid hydrogen users being penalised or placing an undue burden on natural gas and/or electricity consumers.

Respondents who supported a levy on oil and gas profits argued that on expiry of the current Energy Profits Levy, the government could consider a general levy on upstream oil and gas profits to fund an external subsidy mechanism. Alternatively, it put forward that the government could enable oil and gas companies to offset investments in hydrogen infrastructure against the Energy Profits Levy to help stimulate the hydrogen sector.

One respondent suggested that the funding approach could be a hybrid approach with funding from both taxation and energy network users. Subsequently, once the hydrogen market had matured sufficiently, the network users would pick up the remainder allowing the taxation element to be turned down to zero.

The respondents who supported a levy on all energy users argued that hydrogen infrastructure could provide flexibility and resilience to the whole energy system, thus benefits both gas and electricity users.

Government response

The government welcomes the views of respondents on how to fund an external subsidy mechanism. Unlike the natural gas business model, which is paid for through users of the natural gas networks, a nascent hydrogen network will not have established economies of scale that can provide service at an affordable rate for users. As such we believe a form of revenue raising either through a levy, formalised cross-subsidy from other energy consumers, direct central government support, or a combination of such mechanisms is necessary.

The government recognises many of the arguments raised in the responses to the consultation and will work to ensure that whatever the final decision, it is cost-efficient, fair, and provides value for money for taxpayers, energy consumers and users of hydrogen.

Developing other hydrogen pipelines in the UK

Question 15: In your view, how might other onshore hydrogen pipelines, including pipelines transporting hydrogen through a carrier, develop in the UK? Please explain your answer and provide any relevant evidence.

Consultation position

This chapter set out that the initial focus for the hydrogen transport business model would be on onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback suggested this form of transport is the most suitable for early hydrogen producers and end-users.

However, it is likely that other pipelines may be needed to support the hydrogen economy, such as those transporting hydrogen through a carrier (for example, ammonia). We asked stakeholders how this infrastructure may develop.

Summary of stakeholder responses

Response	Number of responses
Hydrogen gas transportation	20
Hydrogen liquid transportation	2
Ammonia	14
Methanol	4
LOHCs	5

Out of the 90 respondents that responded to the consultation, 39 responses were received for this question. Out of the 39 responses received, 30 provided specific views on how other onshore pipelines would likely develop, or not, including views on the use of energy carriers. Out of the 30 responses, some respondents provided multiple views on the likely development of other onshore pipelines.

Many respondents believed hydrogen would be transported by gas in onshore pipelines and two respondents supported liquid transportation. Some noted gas would be the predominant method of transport in the early years of the hydrogen economy (with some respondents noting up to 2030) but as noted below, additional energy carriers may become more viable in future years. Liquid hydrogen was noted as potentially being of benefit to the aviation industry for use as a transport fuel.

Alternative energy carriers were also envisaged as potentially being able to transport hydrogen. Some respondents discussed ammonia, with some noting that it could be used as an alternative to gaseous hydrogen in transport and one noting it as a potential direct fuel in maritime. Most respondents noted ammonia would likely be used in the longer term via end-to-end pipelines, as opposed to networks, to serve specific end-users like maritime and aviation.

One respondent was against ammonia due to inefficiency and costs concerns, one respondent noted it would be unlikely needed in the future, excluding specific end-use purposes. Another respondent (whilst foreseeing a future use of ammonia) noted toxicity and safety concerns surrounding the use of ammonia.

Some respondents identified methanol specifically as a carrier, based on the same reasoning as ammonia, as well as noting its potential use in aviation. Non-specific LOHCs were mentioned by some respondents, with two noting that existing oil and gas transport and storage facilities can be used for transporting and/or storing LOHCs. One respondent was against LOHCs because of inefficiency and cost concerns. One respondent noted carriers may be needed in future, but the focus should remain on hydrogen gas transport initially and to not get distracted by other means.

Government response

The majority of stakeholders noted the view that hydrogen will be transported as a gas, particularly in the early stages of the hydrogen economy. This aligns with our initial expectation detailed in our consultation. A small number of respondents suggested liquid hydrogen as a potential alternative.

Several LOHCs were also highlighted in responses, with most stating ammonia as well as methanol as potential options. This feedback has been useful for widening our understanding of how hydrogen transport infrastructure may develop in the coming years. We will continue to feed this into our policies. We will also make use of this in our strategic planning workstream.

Business model for other onshore pipelines

Question 16: In your view, is a business model required for the development of other onshore pipelines for hydrogen and, if so, how might a business model for onshore pipelines transporting hydrogen as a gas be adapted for this?

Consultation position

This chapter set out that the initial focus for the hydrogen transport business model would be onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback suggested this form of transport being the most suitable for early hydrogen producers and end-users.

However, it is likely that other pipelines may be needed to support the hydrogen economy, such as those transporting hydrogen through a carrier (for example, ammonia). We set out a question asking stakeholders how a business model for onshore pipelines transporting hydrogen as a gas could be adapted for other onshore pipelines.

Summary of stakeholder responses

Is a business model required for the development of other onshore pipelines for hydrogen?

Response	Number of responses
Yes	23
Undecided	8
No	3

Out of the 90 responses to the consultation, 39 responses were received for this question. Of the 39 responses received, 34 provided a specific view on whether business model support is needed.

Business model needed

Many responses noted that business model support will be required for developing other onshore pipelines. Supporting reasons included that it reduced risk and provided certainty for investors, and it would accelerate the transition to hydrogen from natural gas. Some respondents did not signal support for or against the need for business models. Some respondents were against business model support, with one noting that this was not a priority and one noting that it would be better delivered on a merchant basis.

Adapting the business model

In terms of how a business model may be adapted for other onshore pipelines, some respondents signalled support for using existing RAB-style business models, with the main reason being to maintain compatibility with existing models which are already tried and tested. Some respondents signalled support for expanding existing business models to accommodate new other onshore pipelines, and some respondents noted specifically that future business models should be accommodate pipelines transporting hydrogen carriers like ammonia.

Government response

A majority of the responses received noted that a business model would be required to aid the development of the onshore transport pipelines. Government is minded to provide support via the hydrogen transport business model. A RAB will form the basis of the hydrogen transport business model, along with an external subsidy mechanism.

To note, this will be a separate business model from the hydrogen production business model and the hydrogen storage business model.

UK government plan to support transportation of hydrogen as a gas through pipelines initially, aligning with the stakeholder feedback received that this will be the main method of transporting hydrogen during the early stages of the hydrogen economy. Carriers will not initially be supported, as technology is still being developed and further assessment is needed of their technical and economic suitability, but this will be kept under review.

Developing offshore hydrogen pipelines in the UK

Question 17: In your view, how might offshore hydrogen pipelines develop in the UK? Please explain your answer and provide any relevant evidence.

Consultation position

This chapter set out that the initial focus for the hydrogen transport business model will be on onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback suggested this means of transport is the most suitable for early hydrogen producers and end-users.

However, it is likely that offshore pipelines may be needed to support the hydrogen economy, to allow connections to offshore storage or production facilities. We asked stakeholders how offshore pipelines may develop.

Summary of stakeholder responses

Response	Number of responses
Develop alongside cross-border import/export pipelines	12
Develop alongside offshore storage	11
Develop alongside offshore wind generation	10
Repurposing existing natural gas pipelines	6
Develop alongside offshore hydrogen production	6

Out of the 41 responses received for this question, 31 provided specific views on how offshore pipelines may develop. Some respondents provided multiple views on how offshore pipelines could develop.

Need for offshore pipelines

Some respondents expect offshore pipelines to develop alongside offshore storage capability, with offshore pipelines connecting offshore storage to onshore demand centres/production sites. Some respondents expect offshore pipelines to develop alongside offshore wind generation installations. Some respondents specifically noted that pipelines will likely develop alongside offshore electrolytic hydrogen generation because of cost savings associated with site integration of electricity generation (from wind) and hydrogen production as well as the balancing benefits offered by electrolytic hydrogen, helping avoid grid congestion. Two respondents noted that development must consider marine spatial planning requirements, as space will need to be balanced with other offshore assets such as CCUS pipelines.

Some respondents noted that repurposing of existing offshore oil and gas pipelines could provide a route for transporting hydrogen, but one respondent flagged that this may require hydrogen transportation at a lower pressure and/or with new internal coatings in the pipelines, with embrittlement noted as a concern when transporting hydrogen in these pipelines. Two respondents noted that radial connections should be reviewed, and potentially avoided, based on learnings from previous pipeline developments.

Initial focus onshore

Some respondents specifically noted that onshore pipeline development should be the focus in the short-term. In the longer term, some respondents stated that offshore pipelines are likely to develop alongside cross-border import/export pipelines, particularly to continental Europe, but the focus should remain on onshore in the interim.

Government response

A varied view of how offshore transport pipelines would develop was offered by the respondents to this question. Some respondents expect offshore pipelines to develop alongside offshore storage capability, with offshore lines connecting offshore storage to onshore demand centres/production sites. Respondents also expect development alongside offshore wind generation installations, with some respondents specifically noting that pipework will likely develop alongside offshore electrolytic hydrogen generation. This aligned with the assumptions in the consultation.

Repurposing of existing offshore oil and gas pipelines was flagged as a potential route for providing transport for hydrogen, but one respondent noted this may require hydrogen transportation at a lower pressure and/or with new internal coatings in the pipelines, with embrittlement noted as a concern when transporting hydrogen in these pipelines.

Whilst we initially understand the need to support onshore pipelines for transporting hydrogen gas, we will keep these insights in mind during the introduction of our future hydrogen transport business model.

Business model requirement for offshore hydrogen pipelines

Question 18: In your view, is a business model required for the development of offshore hydrogen pipelines and, if so, how might a business model for onshore pipelines transporting hydrogen as a gas be adapted for this? Please explain your answer and set out the specific market barriers that a business model would be required to address as well as providing any relevant evidence.

Consultation position

This chapter set out that the initial focus for the hydrogen transport business model will be on onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback has suggested this means of transport is the most suitable for early hydrogen producers and end-users.

However, it is likely that offshore pipelines may be needed to support the hydrogen economy, connecting offshore storage or production facilities to onshore sites. We set out a question asking stakeholders how a business model for offshore pipelines transporting hydrogen as a gas might be adapted for offshore pipelines.

Summary of stakeholder responses

Is a business model required for the development of offshore hydrogen pipelines?	
Response	**Number of responses**
Yes	26
Undecided	3
No	0

Out of the 39 responses received, 29 provided a view on whether business model support would be needed for offshore pipelines.

Reasons for a business model

Many responses stated business model support would be required for developing offshore pipelines. Their reasons included that business models help to overcome large upfront financial barriers and encourage investment. Some respondents did not signal support for or against the need for business models and no respondents were against having business models.

Adapting business models

Regarding how a business model may be adapted for offshore pipelines, some respondents signalled support for using existing RAB-style business models. Some respondents signalled support for expanding existing or new business models to accommodate new pipelines, with the majority of these noting that the same business model should be used for onshore and offshore pipelines. Two respondents suggested that it would be best to create separate onshore and offshore business models.

Two respondents also mentioned the possibility of using a cap and floor business model as opposed to a RAB. Three respondents specifically highlighted the Offshore Transmission Owner (OFTO) as a model either not to follow or to learn from, noting issues with it when used previously.

Government response

The majority of respondents noted that business model support will be required for developing offshore hydrogen transport pipelines. Differing views were offered as to how this could be facilitated, with a RAB highlighted in particular, as well as expanding other business models. The potential of merging onshore and offshore business model support was highlighted several times, but a small number of respondents emphasised keeping support separate. Some respondents also stressed that lessons should be learned from the OFTO model.

Currently, government understands there is a need to focus support on onshore pipelines as this seems to be the most pressing need in the short term. However, our position will be kept under review, as we recognise the need for offshore pipeline development.

Developing vehicular transport for hydrogen in the UK

Question 19: In your view, how might vehicular transport for hydrogen develop in the UK? Please do include any other vehicular transport we may have missed. Please explain your answer and provide any relevant evidence.

Consultation position

This chapter set out that the initial focus for the hydrogen transport business model will be on onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback has suggested this means of transport is the most suitable for early hydrogen producers and end-users.

However, it is likely that vehicular transport may be needed to support the hydrogen economy in the short term and long term. We asked stakeholders how this infrastructure may develop.

Summary of stakeholder responses

Response	Number of responses
Expecting use for hydrogen refuelling stations	8
Expecting use for supplying dispersed sites	8
Expecting use in high pressure containers	5
Concern relating to high cost	7
Concern relating to safety	2

Out of the 45 responses received, 36 provided specific views on how vehicular transport of hydrogen would likely develop. Some respondents provided multiple views on how vehicular transport could develop.

Many respondents noted that they expected a need for road transport of hydrogen. Most of these respondents noted that it provided supply of hydrogen to geographically dispersed locations that may otherwise not have access, at least for a limited period. Some of these respondents also suggested this could be used to supply refuelling stations.

Some respondents see a long-term role for vehicular transport of hydrogen, with three respondents noting that transport offers higher purity hydrogen compared with hydrogen transported by pipeline which offers an advantage in some specific end-users (for example in transport applications). One respondent noted this as a cost competitive solution at short distances.

Some respondents noted increasing the pressure of hydrogen that could be stored in transport vehicles would allow more to be transported in each truck, making this method more economical. Some respondents also noted that allowing hydrogen to be used as a transport fuel in dangerous goods vehicles would increase demand for hydrogen fuel in vehicles, driving the need for refuelling stations and subsequently, demand for vehicular transport of hydrogen.

Whilst some respondents envisaged a short and long-term role for hydrogen road transport, some only viewed it as a short-term solution whilst pipelines develop. Some respondents raised cost concerns with road and vehicular transport generally.

Some respondents provided views on rail transport, with most of these expecting there to be a role in providing hydrogen to decentralised locations. Two respondents noted it would be unlikely to gain traction because of safety and cost concerns.

Some respondents discussed the expected uptake of maritime transport, with most of these expecting it to be used to transport hydrogen between countries. One respondent noted concern with the cost of setting up port facilities to accommodate this and stated that this represents a significant barrier. Several respondents noted that hydrogen may be transported as part of a carrier rather than as pure hydrogen.

Government response

A varied range of views was received on how vehicular transport may develop. Road transport was discussed most frequently, with respondents noting this has the potential to bridge the gap between pipeline access and dispersed end users, particularly in the early stages of the hydrogen economy. This aligns with government’s current view.

Some respondents stated that they see a long-term role for road transport, particularly for delivering hydrogen to refuelling stations. The higher purity of hydrogen offered via road transport compared with pipe transfer was also noted as a benefit. Whilst respondents mentioned a long-term role, some respondents shared an expectation that this technology would only be suitable in the short-term and they cited cost concerns as a particular limiting factor.

Some respondents highlighted measures to improve the economic viability of road transport and the demand for road transport of hydrogen, such as increasing the pressure of hydrogen stored in transport vessels and allowing hydrogen to be used as a fuel in dangerous goods vehicles (driving up demand). These points have been noted.

Some respondents view a role for rail transport of hydrogen in providing hydrogen to decentralised locations. Some respondents noted this would be unlikely due to cost and safety concerns. Maritime transport was also highlighted, with some respondents expecting it to be used to transport hydrogen between countries, potentially using a carrier rather than pure hydrogen.

These insights will continue to play a role in our plans for developing the hydrogen economy in the coming years.

Business model requirement for vehicular transport of hydrogen

Question 20: In your view, is a business model required for vehicular transport and, if so, how might a business model for onshore pipelines transporting hydrogen as a gas be adapted for this? Please explain your answer and set out the specific market barriers that a business model would be required to address as well as providing any relevant evidence.

Consultation position

This chapter set out the initial focus for the hydrogen transport business model will be on onshore pipelines transporting hydrogen as a gas. This is because initial stakeholder feedback has suggested this means of transport is the most suitable for early hydrogen producers and end-users.

However, it is likely that vehicular transport may be needed to support the hydrogen economy, both in the short term and the long term. We asked stakeholders how a business model for onshore pipelines transporting hydrogen as a gas could be adapted for vehicular transport.

Summary of stakeholder responses to consultation

Is a business model required for vehicular transport?	
Response	**Number of responses**
Yes	19
Undecided	10
No	4

Out of the 38 responses received, 33 provided a view on whether business model support would be needed for vehicular transport.

Business model need

Many responses noted that business model support would be required for developing vehicular transport for hydrogen. Reasons included supporting growth in the sector which would help build the hydrogen economy. Some respondents did not state views for or against the need for business models. Others were against business models based on this transport method due to it being costly and inefficient, or on the basis that it faces less risk than pipelines and therefore does not require support.

Adapting a business model

Some respondents signalled support for adapting existing business models to accommodate vehicular transport, including the hydrogen production business model and hydrogen transport business model, with some respondents noting this would be the quickest and simplest way to support vehicular transport development. Two respondents were against adapting existing models, to ensure the complexities of vehicular transport were given due attention and support via its own business model.

Some respondents noted that grant funding would potentially be more suited than a business model to reduce complexity in the support offered. One respondent also noted that a CfD approach may be a better alternative.

Government response

A majority of respondents noted that business model support will be needed to help develop vehicular transport of hydrogen. However, there was less support for providing a business model specifically for this transport method than there was for other onshore and offshore pipelines. Those that did support a business model had a mixture of views on how this could be provided. These included: expanding the hydrogen production business model or the hydrogen transport business model to allow some or all types of vehicular transport to be supported, and offering direct grants to accelerate the access of funds for projects. Some respondents were against adapting existing models.

The responses received have provided a welcome, balanced view of the suitability and appetite for business model support for this sector. Presently, we only have plans to support pipelines transporting hydrogen as a gas via business models but we may review this position in future.

Chapter 3: Hydrogen storage infrastructure (Q21 – 34)

Technical barriers to developing hydrogen storage

Question 21: What do you consider to be the key technical barriers associated with the development of particular approaches to storing hydrogen which should be considered? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we described a variety of hydrogen storage types, along with possible technical constraints on these such as limits to their potential geographical distribution and size. We sought views on the technical barriers facing developers of hydrogen storage.

Summary of stakeholder responses

There were 56 responses to this question.

The majority of respondents noted that technical barriers would vary with the type of store (e.g. salt cavern, depleted oil/gas field etc.) and the state of the hydrogen stored (e.g. liquid, gas, chemical carrier, etc.).

The majority of respondents mentioned geology as a key technical barrier, with four main concerns raised by respondents:

- Salt fields are needed for the development of salt caverns but are not geographically widespread. The geographical imbalance in the location of salt caverns and depleted fields would disadvantage some areas of the country and would require different storage solutions to meet demand.
- The likely locations of geological stores may not be ideal for co-location with electrolysers or other infrastructure with geographical constraints.
- The unique geology and reservoir properties of a store may limit storage capacity.
- The potential for overlapping interest in a store for CCUS or natural gas storage may limit the number of viable hydrogen stores.

Some respondents referenced storage integrity. A key point raised by respondents who mentioned storage integrity is that the smaller size of hydrogen molecules relative to conventional gases risks the seal integrity of stores, particularly in legacy wells, and can lead to hydrogen leakage and embrittlement. Two respondents stated that the lack of subsurface data on such legacy stores creates another barrier to de-risking sites for hydrogen storage.

Some respondents mentioned difficulty achieving the required level of hydrogen purity, given the distinct temperature, salinity and pressure required to store hydrogen. Challenges with preventing contamination from mixing with cushion gas and remnants in repurposed stores or from geochemical and microbial reactions were mentioned. One respondent noted it is crucial for operators to have clarity on the required hydrogen purity specification to ensure adoption of appropriate technology to remove contaminants to the levels required.

Some respondents also noted:

- Long-lead times to develop a store,
- The low levels of maturity of emerging storage technology (e.g. aquifers, hydrogen carriers),
- The impact of porosity of storage media on hydrogen injection and withdrawal rates which could be too low for the intended use case of the stored hydrogen, and
- Health and safety concerns, particularly around brine disposal and mitigating harm to the marine environment.

Government response

We recognise that hydrogen storage facilities may face a number of technical barriers and we intend to support industry to mitigate these where possible. The geographical constraints of geological storage are evident and the development of an integrated hydrogen transport and storage network will be necessary to address this. It is our view that a centralised strategic planner would be best placed to oversee the build-out of hydrogen storage infrastructure and provide mitigations for such issues. Subject to further consultation and ensuring this role is compatible with the overall Future Systems Operator (FSO) framework, we intend for this role to be taken up by the FSO at an appropriate time once established. In the interim however, the UK government will take on this role. We explore this in more detail in the chapter setting out our minded to position on strategic planning.

Some mitigations for issues respondents noted may already exist - for example, literature indicates several methods to reduce the risk of microbial activity and interactions with residual fluids that may occur in depleted gas fields and some salt caverns. We will continue to monitor emerging evidence and engage with relevant government partners.

We are aware of the role innovation could play in providing alternative means of hydrogen storage that do not face the same constraints as more established technologies. We have therefore created measures to support the costs of developing innovative hydrogen storage technologies, for example, through programmes within the Net Zero Innovation Portfolio, including but not limited to:

- The Low Carbon Hydrogen Supply[1] which provided funding to further develop technologies in hydrogen production, transport and storage,
- The Industrial Hydrogen Accelerator[2] which provides grant funding for innovation in end-to-end hydrogen fuel switching projects, including hydrogen transport and storage, and

[1] https://www.gov.uk/government/publications/low-carbon-hydrogen-supply-2-competition
[2] https://www.gov.uk/government/publications/industrial-hydrogen-accelerator-programme

- The Long Duration Energy Storage Demonstration Competition[3] which aims to accelerate the commercialisation of innovative long duration energy storage projects, at different technology readiness levels, including hydrogen, through first of a kind full system prototypes or actual demonstrations.

Identifying the key market barriers

Question 22: In your view, have we correctly identified and characterised the key market barriers facing larger scale hydrogen storage infrastructure, and in particular its deployment by the late 2020s? Please explain your answer and provide any relevant evidence.

Question 23: Do you agree that volume and revenue risk stemming from demand uncertainty represents the main barrier to the deployment of storage infrastructure? Please explain your answer and provide any relevant evidence.

To note, we have combined question 22 and 23 as respondents raised similar points across the two questions.

Consultation position

In the consultation we set out that the main market barriers included demand uncertainty, which creates volume risk, and high costs. High costs alone are not a great barrier but tend to make investment especially risky when they are coupled with lengthy lead times and revenue uncertainty. Other market barriers include policy, regulatory, and commercial uncertainties, for example storage infrastructure ownership, users of facilities, and how access and pricing will work.

We explained that stakeholder feedback had indicated a business model should primarily address volume risk, because demand uncertainty currently means investors are very likely to take final investment decisions on their own.

We said stakeholders were less concerned about regulatory and commercial uncertainty but also noted that we were seeking their views on commercial and regulatory arrangements as part of the consultation. We also noted some of the business model options implied commercial and regulatory arrangements.

[3] https://www.gov.uk/government/collections/longer-duration-energy-storage-demonstration-lodes-competition

Summary of stakeholder responses

In your view, have we correctly identified and characterised key market barriers facing larger scale hydrogen storage infrastructure, and in particular its deployment by the late 2020s?	
Response	**Number of responses**
Yes	44
No	1

Do you agree that volume and revenue risk stemming from demand uncertainty represents the main barrier to the deployment of storage infrastructure?	
Response	**Number of responses**
Strongly agree	5
Agree	31
Neither agree nor disagree	10
Disagree	4
Strongly disagree	0

Many respondents stated that we had identified the main market barriers. A majority also agreed that volume and revenue risk stemming from demand uncertainty represents the main barrier to the deployment of storage infrastructure. Some respondents drew attention to the role long lead times for large-scale storage play in volume risk. One respondent stated that hydrogen networks would help to mitigate volume risk by connecting storage facilities with a larger user base.

Some respondents stated that price risk was another relevant risk stemming from demand uncertainty, and highlighted price-related risks storage facilities might face. Points raised by individual respondents included:

- A risk of "market cannibalism, reducing market price differentials".
- Some users may be able to switch back and forth between using natural gas and using hydrogen as prices of each fluctuate, and this would have implications for storage facility revenues.

- “Underlying market dynamics are very poor at pricing in scarcity and insurance value. Markets tend to undervalue both the seasonal and strategic value of storage and this represents a barrier to deployment”.

Respondents made the following observations on high fixed costs as a barrier to investment.

- The initial user base for geological storage facilities may be relatively low, when compared to the total capacity of those facilities, due to the need to grow the hydrogen economy from scratch, and economies of scale that make investment in geological storage ‘lumpy’. This creates a potential barrier, insofar as user charges may not be able to provide enough revenue to sustain geological storage facilities through an initial period.
- For geological storage facilities, capital costs are more significant than operating costs.

Some respondents said that uncertainty about the roles hydrogen storage would play was also a barrier to investment.

- One respondent stated that uncertainty about “what type of storage we need to build […] [and] the purpose of storage in a future hydrogen system” were barriers to investment.
- A respondent called for a “national strategic plan” for storage which includes a “metric of storage to production”.
- Another respondent called for “a clear vision of where hydrogen will be produced and consumed”.
- A respondent called for “clear, wider roles for the hydrogen system as a precursor to confirming the key risks”.
- Another respondent suggested “some central planning of storage sites” was necessary.

Regarding commercial uncertainty, some respondents echoed our assessment that lack of certainty about the market framework for storage could be a barrier.

- Some respondents stated that a shortage of leadership and ambition, clarity or certainty in government policy could cause, or is causing, barriers to investment.
- A respondent said that barriers to investment are worsened by “the uncertainty on funding envelope/affordability”.
- Some respondents stated that the fact that the government has not yet made a strategic decision on the role of hydrogen in decarbonising heat creates uncertainty of demand for interseasonal storage of hydrogen, as well as the hydrogen economy more widely.
- A respondent stated that barriers could be created through government considering its support mechanisms for transport and storage infrastructure separately, and called for an ‘aligned’ approach, particularly when supporting strategically important projects.

Some respondents stated that geological storage faced a different or more significant set of barriers to investment compared to above-ground storage, due to the high fixed costs and long lead times involved. By contrast, one respondent stated that a ‘lean toward’ geological storage in the consultation proposals risked jeopardising above-ground storage close to production and use sites, despite the potential importance of these to the hydrogen economy.

Government response

We have used the views provided in response to this question to inform our work on the high-level commercial design of the hydrogen storage business model, including pinpointing the key market barriers the business model must address. This is explored in more detail in the storage chapter of the minded to position.

Developing a dedicated business model for hydrogen storage

Question 24: Do you agree that government should develop a dedicated business model for hydrogen storage (subject to value for money and need) and that it should be designed to be technology-neutral? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we outlined the market barriers that may prevent private sector investment in hydrogen storage. We proposed a dedicated storage business model to support project developers and investors to overcome these barriers.

Summary of stakeholder responses

Response	Number of responses
Strongly agree	3
Agree	49
Neither agree nor disagree	6
Disagree	1
Strongly disagree	0

There was strong agreement from respondents that government should develop a dedicated business model for hydrogen storage.

Some respondents who agreed said that a dedicated model is needed to address the risks and market barriers to storage facilities becoming operational, in particular volume risk and revenue uncertainty. Some respondents emphasised that a business model was especially necessary for geological storage. Some respondents agreed that a business model is needed but expressed a preference for storage to operate on a merchant basis eventually.

One respondent expressed a preference for storage to be subsidised as part of the hydrogen transport business model. Other views provided included the risk that government intervention could stifle innovation, that natural gas storage should be prioritised before addressing the need for hydrogen storage, and that hydrogen storage should be a secondary priority after hydrogen production.

Fewer respondents provided direct comment on technology neutrality. Opinion was split amongst the 29 respondents who did provide comments, with 14 respondents agreeing, ten respondents disagreeing, and five respondents providing neutral views.

Of those who agreed, some respondents mentioned they would like liquid organic hydrogen carriers (LOHCs) to be eligible for business model support. Some respondents agreed with the principle of technological neutrality but thought strategic planning and wider system needs should be considered to ensure that ‘low regrets’ or strategically important projects are supported regardless of the technology used.

Of those who disagreed, respondents mentioned the potential for unintended consequences, suggesting that it may not be possible to design a model which adequately serves all storage technologies.

There were also views shared across both groups. For example, some respondents mentioned a need to ensure that storage develops in the right locations, whilst one respondent highlighted the potential for different storage technologies to represent the best value for money in different locations. Some respondents emphasised that there is a particular need to support geological storage, as this is likely to provide the best value for money overall, and some suggested that a route to market should be left open for other technologies.

Government response

Based on these responses, and our ongoing engagement with industry, we plan to design and implement a dedicated hydrogen storage business model. Given the feedback about the importance of support for geological storage, we expect this to be the primary focus of business model support. It should be noted that we plan to retain optionality to support above-ground storage where it faces the same market barriers as geological storage. This is set out in more detail in the storage chapter of the minded to positions.

Scale of storage

Question 25: Do you agree that business model support should focus on larger scale storage, or is there a need to provide further support for small scale storage? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation we outlined existing support for limited hydrogen storage attached to hydrogen production projects through the Hydrogen Production Business Model (HPBM) and Net Zero Hydrogen Fund (NZHF). We set out that investment in large-scale (geological) storage would be unlikely without support to overcome revenue uncertainty for project developers and investors.

Summary of stakeholder responses

Response	Number of responses
Yes, business model support should focus on larger scale storage	28
Neither agree nor disagree	12
No, there is a need to provide further support for small scale storage	10

A majority of respondents agreed the storage business model should focus on large-scale storage, though some respondents disagreed and set out the need for government to provide further support for small-scale storage instead.

Some respondents stated large-scale and small-scale storage serve very different functions across end users and therefore face different market and technical barriers.

When contrasting risk profiles, the majority of respondents felt that large-scale storage faced greater barriers and therefore encountered significantly higher investment risk, compared with small-scale storage. Respondents therefore felt large-scale storage should be the focus of business model support. Barriers included more complex planning considerations, longer lead times, higher development costs, difficult technical feasibility tests and greater demand uncertainty for large-scale storage. Additional reasons mentioned in favour of large-scale included its greater strategic importance in developing long-term market maturation, greater capacity for supporting hydrogen production projects and more favourable economies of scale.

The majority of respondents noted that small-scale storage is anticipated to be already supported by the HPBM or would serve or be owned by defined end-users. It therefore would face less revenue and volume risk and not require support from the storage business model. Some respondents however argued that not all small-scale storage would be subsidised, and therefore would still face high capital costs and require support to de-risk investment.

Some respondents believe that small-scale storage could play a valuable role in providing energy security, particularly in the growth phase of the hydrogen market given the ease with which it could be added or relocated where it is needed.

Some respondents who did not answer or agree with either position to support small or large-scale storage argued a combined approach is needed. They stated both scales of storage would support security of supply, and therefore business model support should focus on individual use cases and not the scale of storage. Some suggested the business model could take a phased approach by providing subsidy for small-scale storage initially and large-scale storage from 2030 onwards, or once a more mature hydrogen market has been established.

It should be noted that some respondents asked for clarity on what we meant by small and large-scale storage. Without a definition, they stated the question was difficult to answer.

Government response

We acknowledge the terminology used in the consultation around large-scale and small-scale storage was difficult to define. On this basis we have categorised storage into three broad types[4] for the purpose of the government response and intend to use the terminology below going forward:

- Geological storage
- Above-ground liquified or gaseous storage
- Chemical storage (ammonia, methanol, metal hydrides)

As noted by respondents, we recognise the diverse roles large-scale (geological) and small-scale (above ground) storage have and agree both will be important to support the growth and maturity of the hydrogen economy. We have used responses to this question to inform our minded to position for the hydrogen storage business model, in which we state that we expect initial allocation of the business model to focus primarily on geological storage. We believe that - given that this type of storage has potentially the lowest cost per unit of capacity - it is essential to support energy security and establish a hydrogen network and hydrogen economy. We also recognise that geological storage is unlikely to materialise without government support. There is existing support for above ground storage facilities attached to production facilities through the HPBM and the NZHF. We believe that chemical storage requires more technological development before it can become eligible for government support.

[4] These have been defined in chapter 3 of the minded to positions.

Likely users and revenue sources of hydrogen storage

Question 26: In your view, who are likely to be users of hydrogen storage infrastructure and which group, or groups, might be best placed to provide revenue to storage owners? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation we set out our view that hydrogen storage may have a variety of users – mainly producers of hydrogen and hydrogen offtakers, including hydrogen to power generation.

Summary of stakeholder responses

Response: Sector	Number of responses
Hydrogen producers	22
Power generation	19
Industry	17
System operator	10
Heat	8
Transport (incl. aviation)	6

We received a range of suggestions on who users of hydrogen storage are likely to be.

- Hydrogen producers of all types were seen as the primary ‘entry user’ of storage. Some respondents highlighted that CCUS-enabled hydrogen production and electrolytic hydrogen production would be in particular need of storage, with their requirements changing over time.
- The power generation sector was recognised as a key user of storage including hydrogen-fuelled peaking plants, combined heat and power units, and storage of surplus renewable energy to avoid curtailment.
- Industry was mentioned as a user of hydrogen storage, particularly in industrial clusters, and energy intensive industries requiring high-grade heat.
- The system operators may require storage for system balancing purposes.

- Heat may be a key hydrogen storage user, depending on the decision due to be taken in 2026.[5]
- Transport was highlighted as a potential offtaker, including one mention of aviation.

On the topic of who should provide revenue to storage providers, we received a smaller sub-set of answers. Suggestions included:

- Hydrogen producers should pay for storage,
- Revenue should come directly from hydrogen offtakers,
- Hydrogen shippers should pay to store volumes,
- The network operator would require storage and therefore should provide a revenue stream to storage facilities.
- The costs of supporting hydrogen storage infrastructure should be socialised across energy users since the benefit of hydrogen storage accrues across the whole energy system.

Government response

Stakeholders have largely confirmed government's view of the likely users of storage and have provided helpful views regarding the timelines in which these users could materialise and the volumes of storage they may require. We have used the information gathered via this question to inform our understanding of the functions or 'use cases' of hydrogen storage – these are set out in the storage chapter of the minded to position. We do not set out a position on whether government will prioritise storage projects based on use case at this stage.

Business model supporting hydrogen storage infrastructure

Question 27: Do you agree with our initial view that a storage infrastructure business model should support providers of hydrogen storage infrastructure (as opposed to users of storage infrastructure)? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we considered how best to provide business model support to overcome the market barrier of demand uncertainty. We identified two main approaches: providing business model support to hydrogen storage owners; and providing business model support to users of hydrogen storage facilities. Our initial view was that providing support to users of storage facilities would be unlikely to achieve the desired outcome since it would not fully address the volume risk faced by storage providers. Consequently, we set out that business model support should be given to owners or prospective owners of storage facilities.

[5] https://www.gov.uk/government/publications/heat-and-buildings-strategy

Summary of stakeholder responses

Response	Number of responses
Strongly agree	6
Agree	36
Neither agree nor disagree	5
Disagree	0
Strongly disagree	0

Many respondents agreed business model support should be given to owners or prospective owners of storage.

Amongst those who agreed, some respondents stated that storage providers are the party taking on the costs, including the cost of cushion gas, as well as volume risk, and are the party who require revenue certainty. One respondent noted that supporting storage providers would be the best way to incentivise the development of geological storage facilities. However, it was noted that a provider-focussed business model risks storage facilities being developed in sub-optimal locations, where sufficient demand might not materialise.

Respondents gave arguments against providing support to users. These included that initially there would not be many users and supporting them via a business model may not provide enough funding to cover the significant up-front costs of new hydrogen stores. One respondent highlighted that users may vary over time and storage projects cannot rely on a transient commitment. Another respondent suggested that supporting users of hydrogen storage would water down the impact of support and would slow the development of the UK's hydrogen economy.

In other views provided in answer to this question, some respondents highlighted that providers of storage and users may not always be mutually exclusive, and that users may also require separate support, for example to help with the cost of switching from natural gas to hydrogen.

One respondent suggested that further consideration should be given to directing business model support to the users of small-scale storage in producer-user networks balancing day-to-day fluctuations in the supply and demand of hydrogen. They argued that since these would be the primary users of hydrogen storage in the early growth of the hydrogen economy, this approach could better leverage the market force of users' demand for storage and incentivise infrastructure to be built where it is most needed. Two respondents questioned the need for a separate hydrogen storage business model altogether, suggesting alternative business models supporting other parts of the hydrogen value chain.

Government response

We acknowledge the agreement amongst respondents on our initial view that supporting storage users via the storage business model is unlikely to result in a liquid market for hydrogen storage.

On the basis of respondents' views in favour of supporting storage providers with revenue certainty, we intend to develop a business model which supports storage providers. This will ensure the business model is investable and provides value for money, keeping in line with our design principles. Our approach is outlined in more detail in the minded to position. We may still consider alternative interventions to support users of storage in future but not as part of the storage business model.

Approaches to subsidy mechanism funding

Question 28: What are your views on possible approaches to funding a potential subsidy mechanism? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we sought views on how best to fund a storage business model. We did not outline an initial view.

Summary of stakeholder responses

Response	Number of responses
Levy	16
General taxation	15
Cost mutualisation	4
Other response	16

There was no majority view from respondents on how subsidy support for the business model should be funded. Many respondents suggested a levy could fund hydrogen storage subsidies. Reasons for this included that a levy could spread the cost over a large group, with only a small cost for each consumer, and that hydrogen infrastructure would benefit the whole energy system and therefore all gas and electricity consumers. Two respondents suggested the hydrogen levy in the Energy Bill should be extended to include hydrogen storage.

Just as many respondents answered that general taxation should be used to fund any subsidies. Reasons for this included that it is a progressive rather than regressive form of funding; that it avoids placing an undue burden on gas or electricity consumers; that it reflects the benefits of hydrogen across society; and that since initial demand is likely to be from industry and transport, domestic households should not pay.

Some respondents answered that cost mutualisation with natural gas should be used to fund the business model. Reasons for this included that applications of hydrogen are likely to displace natural gas and that cost mutualisation places the burden of cost on fossil fuel users.

Some respondents suggested that more than one funding source could be implemented. Most commonly, this was a combination of levy and general taxation. In wider comments, respondents said any subsidy mechanism should be long term and independent of political change. A number of respondents also noted that payments should taper off over time as the hydrogen economy matures.

Government response

No decision has yet been taken on how the hydrogen storage business model will be funded. Options under consideration include a levy and Exchequer funding. The Energy Bill includes powers for the Secretary of State to provide long-term financial assistance to support the establishment of hydrogen storage infrastructure. We have also tabled amendments to the Energy Bill to enable the establishment of a levy to fund the hydrogen storage revenue support contracts if deemed necessary. These amendments are outlined in more detail in the minded to position.

Identifying the main parties and needs for a storage business model

Question 29: In your view, have we correctly identified the main parties whose needs any storage business model will need to account for, and have their needs been correctly outlined? If not, what additional needs should be accounted for? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation we identified that a hydrogen storage business model would need to balance the needs of storage owners and their investors, storage users and government.

Summary of stakeholder responses

Response	Number of responses
Agree	36
Neither agree nor disagree	5
Disagree	7

Many respondents agreed that storage owners and their investors, storage users, and government were the main parties for us to consider when designing a storage business model.

We received several suggestions of additional parties whose needs any storage business model would have to accommodate. Some respondents highlighted the need to consider system operators and transport providers. Two other suggestions were risk-taking intermediaries and parties involved in offshore transport and storage. Respondents also highlighted that some parties would take on several roles in the hydrogen value chain, with the suggestion that these parties would need to be suitably subsidised for each role.

Government response

We believe the main parties have been correctly identified, given the agreement amongst respondents. An updated version of the needs of the main parties, reflecting feedback from respondents, can be found in storage chapter of the minded to position.

We recognise the validity of other suggested parties and their needs in relation to the development of the hydrogen economy. These will be accounted for via our work on strategic planning and through alignment with other government business models. We intend to continue our ongoing engagement with industry across the hydrogen storage value chain.

Business model design options

Question 30: In your view, have we set out the main business model design options, or are there others design options, or variants, that should be considered? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we identified the main business model design options as follows:

- Regulated returns,
- Contractual payments,
- Obligations,
- End user subsidy,
- Co-investment by government, and
- Long-term financing arrangements for cushion gas.

We noted that the options were not mutually exclusive, and some of them could potentially be combined.

Summary of stakeholder responses

Response	Number of responses
Yes	33
No	6

Many respondents agreed we had set out the main business model design options. Some respondents proposed other design options, or variants on the options we identified. Alternative models that were mentioned most frequently were capital support in addition to revenue (such as up-front support, innovation funding or investment incentives such as corporation tax cuts). Some respondents also proposed support payments from networks, wherein networks would support the building out of storage.

Government response

On the basis of feedback, we have assessed the options proposed in the consultation using our key design principles and the views on market barriers from questions 22 and 23. The additional models suggested by respondents were not thought sufficient to meet our strategic objectives.

Appropriate business model designs for different storage infrastructure

Question 31: In your view, are any of the business model design options set out above more suited to supporting particular types of storage infrastructure than others? Please explain your answer and provide any relevant evidence.

Consultation position

We stated that storage infrastructure may be available in a diverse range of sizes and types and could play a variety of roles. Furthermore, developers and their investors are likely to have differing appetites for risk. Consequently, it is possible that one particular model may not be suited to all circumstances.

We indicated the focus of our business model was likely to be on geological storage (see question 25), and we suggested that government co-investment in storage facilities might be limited to those that are of “strategic importance”.

Summary of stakeholder responses

There were 36 responses to this question. The majority suggested that some business model design options may be more suited to particular types of storage than others, depending on their size, use case, network-connected versus single-user status, and strategic importance. On the other hand, some respondents stated that they saw no reason why different models would be better suited to particular storage types.

A common theme was that more government intervention was thought to be necessary for geological storage projects. Several respondents commented that above-ground fast cycling storage might attract merchant investment, or at least be better suited to models with a degree of volume risk sharing, whereas geological storage might require regulated returns or government co-investment to overcome greater barriers.

Respondents also raised the possibility that certain types of storage (but not necessarily all types) could be funded by the HPBM or by networks' allowed revenues.

Government response

These responses have informed our thinking on how to ensure the commercial design of the business model is consistent with the type of storage we expect to support. We explain in the storage chapter of the minded to position that we are designing a single business model and we expect the initial allocation of this to focus on geological storage. We also explain why the commercial design we are minded to adopt is appropriate for geological storage, taking into account the responses we received to this question as well as questions 22, 23 and 32 (below).

Business model design best suited to address market barriers

Question 32: In your view, which business model design options would be most suitable to address the identified market barriers? Please explain your answer and provide any relevant evidence.

Consultation position

We described several high-level options, which were:

- No business model (hydrogen storage operated on a merchant basis),
- Regulated returns models:
    - Regulated Asset Base (RAB) with allowed revenue,
    - Revenue cap and floor,
- Contracts for Difference,
- Government offtake frontstop,
- Capacity availability payments,
- Compulsory stock obligation,
- End user subsidy,
- Co-investment by government,
- Long-term financing arrangements for cushion gas.

We did not identify a preferred model, however, we indicated that some of the models were unlikely to work. These included a merchant model due to demand uncertainty; end user subsidies which would not address volume risk as it would not provide certainty that users would use storage; a compulsory stock obligation, which would not be capable, on its own, of creating enough demand for storage from early users to attract investment in facilities without over-burdening users; and a Contract for Difference (CfD), which in its usual form would not address volume risk.

Summary of stakeholder responses

Model	Respondents expressing a preference for the model
RAB	31
Cap and floor	27
CfD	8
Capacity availability payment	7
Merchant investment	4
Co-investment	5
Frontstop	3
Compulsory stock obligation	3
End user subsidy	1
Long-term financing arrangements for cushion gas	0

There were 42 responses to this question, of which 41 expressed a preference for at least one of the business models we set out in the consultation. Some respondents expressed approval of more than one of the business models. Many preferred a RAB and/or a cap and floor. This was true of prospective storage owners and other respondents too.

According to respondents commenting on the RAB model, its benefits include the revenue certainty it provides, which in turn reduces the cost of financing. It can also spread cost recovery out over a long period of time, removing the risk of very high charges on initial users due to the low user base, and helping to achieve stable charges over time. Respondents said the potential downsides of the RAB include that it may not always incentivise efficient behaviour by facility owners and could over-reward them; it may not be practical to use for all types of storage; and it could make it more difficult to transition to a competitive market.

The cap and floor model was seen by respondents as providing a good level of certainty for investors (albeit less than the RAB) whilst incentivising efficient behaviour by facility owners (to a greater extent than the RAB). Respondents suggested that an additional advantage of the cap and floor is that it may provide a platform for moving to a more competitive market/merchant model over time. Some respondents pointed out that if the floor is not set at high enough level, investment may not be secured.

Government co-investment was seen as insufficient on its own to make facilities investable for the private sector. However, some respondents argued that there may be a need for some form of capital support as well as revenue support. Some storage companies stated that their projects would not be able to move ahead into construction without grant funding or loans.

On the merchant or 'counterfactual' model, some respondents suggested this would not currently secure any investment in storage, while others suggested that it might be viable for particular types of storage, for example, facilities providing fast-cycle balancing services. Some respondents said our ambition should be to move to a merchant model in long term.

Some respondents suggested it would be advantageous to use a model which is familiar to industry and has previously been used to support energy infrastructure successfully. This argument was mainly cited in support of the RAB, cap and floor, and CfD.

We received limited feedback on the ideas of a modified or 'sliding scale' CfD, capacity availability payments, the government offtake frontstop, and long-term financing of cushion gas.

Respondents also proposed or discussed models which we did not discuss in the consultation document.

- Some respondents proposed that strategic investment in storage should be funded by networks, using their allowed revenues,
- A respondent suggested mutualisation, which would involve giving all potential users of storage facilities a financial stake in the storage company, and thereby socialising any gains or losses the storage facility makes,
- Various combinations of our models were also proposed, for example a respondent suggested a compulsory stock obligation to ensure a strategic reserve of gas is kept in store alongside a different business model for attracting investment in the storage facility itself.

Some respondents argued that different types and applications of storage may require different business models, whereas one respondent suggested it would be advantageous if our business model could provide near-universal support for different storage types.

Some respondents also stated that decisions on the business model could not be taken without considering what the broader commercial and regulatory framework for storage will be.

Government response

In selecting a preferred commercial design for our minded to position, we have been guided by respondents' stated reasons for endorsing or rejecting the various options set out in the consultation document, and our own analysis.

Although the majority of respondents stated that they would prefer a regulated returns model – i.e. a regulated asset base or cap and floor model delivered through economic regulation - we are not minded to adopt economic regulation of hydrogen storage at this time. We explain in the storage chapter of the minded to position that we believe economic regulation of hydrogen storage would be unnecessary and disproportionate, given that we expect a competitive market for storage to emerge.

The main reason respondents gave for wanting a regulated returns model was that it would provide revenue certainty. However, revenue certainty can be provided by business models that do not entail economic regulation: for example, private law contracts can provide a very high degree of revenue certainty if they are designed to do so. The business model design we are minded to adopt would provide adequate certainty for facilities and their investors via a private law contract that creates a revenue 'floor' for storage facilities. During our engagement with prospective hydrogen storage facilities since the publication of the consultation document, those facilities indicated that they would be content with this approach and confirmed that they did not necessarily require economic regulation to secure investment.

We are also minded to reject the following commercial designs: CfDs, capacity availability payments, compulsory stock obligations, end user obligations, and end user subsidies. The reasons for this are set out in the commercial design section and Annex A. In summary, capacity availability payments are unlikely to provide optimal value for money, and the other rejected designs are unlikely to provide sufficient revenue certainty for facilities.

The design we are minded to adopt is a private law contract that provides a revenue 'floor'. To an extent this resembles the cap and floor model we described in the consultation document (albeit with the use of a private law contract rather than regulated returns), or the government offtake front stop (which also effectively provides a revenue 'floor'). Additional features of the business model we are minded to adopt are described in the commercial design section the storage chapter of the minded to position.

Organisations best placed to implement the business models

Question 33: In your view, which organisations are best placed to carry out the roles of economic regulator/counterparty/administrator that would be required to implement the business models set out above? Are there any other roles that you consider may be required? Please explain your answer and provide any relevant evidence.

Consultation position

The consultation provided a range of potential business model designs which would require additional participants for implementation. Regulated returns models would require an economic regulator, contractual payment models may require a counterparty, and other models may require an administrator.

Summary of stakeholder responses

Economic regulator:

Response	Number of responses
Total respondents	35[6]
Ofgem	31
The department	4
Other	4

Administrator:

Response	Number of responses
Total respondents	13
Ofgem	11
The department	1
Other	1

Counterparty:

Response	Number of responses
Total respondents	19[7]
LCCC	10
Ofgem	7
The department	3
Other	1

[6] Some respondents mentioned multiple organisations, hence the total number of respondents to this question is lower than the sum of the responses detailed below.
[7] Some respondents mentioned multiple organisations, hence the total number of respondents to this question is lower than the sum of the responses detailed below.

There were 41 responses to this question.[8] A majority of respondents suggested Ofgem would be best placed to carry out the role of economic regulator and best placed to carry out the role of administrator. Reasons for Ofgem being chosen included:

- Experience and track record in similar roles in the energy sector,
- Ability to ensure consistency with other subsidies across the energy sector,
- Expertise in economic regulation,
- Ability to work at pace and scale.

Some respondents suggested the Department for Energy Security and Net Zero (the department) would be best placed to act as economic regulator, particularly in the early stages, and potentially handing the role to Ofgem once the hydrogen economy was in a steady state.

One respondent suggested a new regulatory body should be created, as this would be able to adapt to the specific requirements of the nascent hydrogen economy. Another respondent suggested the North Sea Transition Authority (NSTA) could act as economic regulator, as it regulates the offshore gas storage network. However, they did note this could put the focus on offshore rather than onshore storage.

Twenty-one respondents specified a preferred body to act as counterparty. Of these, the most common response was the Low Carbon Contracts Company (LCCC). Reasons given included:

- Investors recognise and have confidence in LCCC,
- LCCC are established as a counterparty in other government schemes,

Other suggestions included Ofgem, because it is an organisation with knowledge across the energy sector, and the department.

A small number of miscellaneous responses which do not fall into the above results tables suggested that additional roles may be beneficial to implementing the business model. Proposed roles included:

- A government-owned company in hydrogen storage and production, able to purchase companies that become insolvent,
- A role for the NSTA where depleted natural gas fields are repurposed for hydrogen storage,
- A system balancer to determine the storage needs of a network.

Across answers, respondents noted that the bodies chosen for these roles would need to be aware of the specifics of the hydrogen market and be resourced for the additional role.

[8] Some respondents mentioned multiple organisations, hence the total number of respondents to this question is lower than the sum of the responses.

Government response

Respondents noted that the design of the business model would determine the roles needed for implementation. We anticipate the hydrogen storage business model will be delivered by a private law contract. Therefore, we expect this will require a counterparty to manage these contracts. We have tabled amendments in the Energy Bill to provide the Secretary of State with powers to designate a hydrogen storage counterparty and to direct the counterparty to offer to enter into contracts. A decision has not yet been made to confirm whom government will designate for this role. Government will undertake analysis to determine the organisation best suited to the role of counterparty. We are not minded to adopt economic regulation of hydrogen storage at this time (see question 32 of this summary of responses, and the storage chapter of the minded to position, where we set this out in detail).

Early interim measures needed to support the first hydrogen storage projects

Question 34: In your view, are there any early interim measures that we should be exploring to support the development of the first hydrogen storage projects, ahead of a hydrogen storage business model being available? Please explain your answer and provide any relevant evidence.

Consultation position

In the consultation, we sought views on whether government should provide early interim measures to enable investment in storage facilities.

Summary of stakeholder responses

Response	Number of responses
Yes, there are interim measures government should explore	43
Not sure if government should explore interim measures	2
No, the government should not explore interim measures	3

Many respondents expressed a preference for government to explore early interim measures to support the development of the first hydrogen storage projects, ahead of the storage business model being available. Given the long lead times for constructing storage facilities and securing planning and regulatory permissions, respondents felt interim measures would enable final investment decisions and bolster investor confidence. Suggestions broadly fell into two categories - financial and policy.

The majority of respondents favoured capex and/or devex to support the costs of storage infrastructure. Some alternative interim financial measures included:

- A bespoke contract between UK government and storage owners,

- Grants or loans,
- An offtake agreement to enable storage providers meet initial offtaker requirements,
- An interim short-term business model if the storage business model cannot be brought forward.

Some respondents proposed interim financial measures be provided for initial large-scale storage projects, given their likely strategic importance within the hydrogen economy, whilst others felt small-scale projects were better placed to receive support for quicker deployment. Some stated a need for interim measures for storage, particularly the financial ones, to align with those for transport to ensure holistic development of the hydrogen network.

Respondents suggested a focus for early financial interim measures. Individual responses included:

- Liquid organic hydrogen carriers given their low investment costs and shorter development timelines,
- Research and development studies for early demonstration projects for more established storage technologies as well as emerging, innovative technologies to support them becoming commercially viable,
- Encouraging other energy sectors to support the growth of the hydrogen economy. One respondent recommended oil and gas companies reinvest upstream windfall profit into hydrogen storage, whilst another suggested using excess renewable energy, that would otherwise be curtailed, for hydrogen production,
- Reducing UK Emissions Trading Scheme free allowances be reduced to drive demand for hydrogen.

A minority of respondents suggested policy interventions, which included:

- A UK government strategy for developing large-scale storage assets to encourage investor confidence,
- Defining the use cases for hydrogen (e.g. blending, hydrogen for heat), given the uncertainty around demand, the type, scale and location of storage required to support this, and the potential for this uncertainty to be a limiting factor for investment in storage infrastructure, and
- A regulatory framework with clear legal guidance be set out for innovative storage technologies, to enable issues to be identified and mitigated early in the development process,
- Clarifying that grey hydrogen use will be phased out.

Government response

By committing to designing the hydrogen storage business model by 2025, we recognise sufficient storage infrastructure is needed to support our hydrogen production and wider decarbonisation ambitions. We do however acknowledge the scope for interim government measures to support the development of necessary storage infrastructure. Ahead of the business model being available, we have created measures to support the construction of storage assets. For example, the NZHF and HPBM is anticipated to provide limited funding for T&S infrastructure associated with hydrogen production projects. We are also planning to provide funding to support the development of innovative storage technologies through the Net Zero Innovation Portfolio.

As well as these forms of support, we are developing our approach to strategic planning for hydrogen storage infrastructure at pace to help identify and prioritise early strategically significant projects. This strategic planning will form the basis of the storage business model allocation process and its interaction with the nature and timing of support for early hydrogen storage projects. As set out in chapter 4, we will publish a ‘hydrogen networks pathway’ that will set out a strategic framework for hydrogen network planning and a vision for the build-out of hydrogen T&S infrastructure ahead of the business models being available.

Chapter 4: Strategic planning (Q35 – 44)

The need for strategic planning

Question 35: In your view, should the build out of hydrogen transport infrastructure evolve through either a) a solely market-led approach, b) a form of strategic planning, or c) neither?

Question 36: In your view, should the build out of hydrogen storage infrastructure evolve through either a) a solely market-led approach, b) a form of strategic planning, or c) neither?

Consultation position

The consultation set out three lenses through which the potential value of a specific transport or storage project could be assessed: whether it meets an immediate need, builds enabling capacity for the growth of the hydrogen economy, or brings wider system benefits. While assessing the first of these would be a reasonably typical function of asset owners, a business model delivery/allocation body or regulator and therefore help drive optimal outcomes in a market-led approach, assessing the other two may require reference to wider strategic priorities and plans. Where the market and regulatory framework involves cost-reflective prices this can help produce efficient whole system outcomes but may be difficult to plan for longer-term infrastructure demand and wider systemic benefits in practice.

The consultation asked whether a strategically planned approach is needed where infrastructure is purposely planned and delivered against strategic objectives, to achieve the efficient roll out of hydrogen transport and storage infrastructure maximising likely long-term benefit to the whole energy system. The analytical annex to the consultation set out that strategic planning could be needed to ensure the coordinated rollout of infrastructure, enabling ongoing matching of supply and demand as the hydrogen economy grows.

Summary of stakeholder responses

Transport

Response	Number of responses
A solely market-led approach	2
A form of strategic planning	53
Neither	0
A mixture of strategic planning and market-led development	5

Not answered or unclear	30

60 respondents commented on transport infrastructure. The majority indicated their preference for a form of strategic planning or a mixture of strategically planned and market-led development. In their explanation respondents described varying roles and timescales for more market-led development, as well as different degrees and forms of strategic planning. Two respondents expressed a preference for solely market-led development but did not give specific reasons.

The majority gave their main reason for favouring some form of strategic planning as it would lead to more efficient build out, at the right pace, location and scale, resulting in greater investor confidence, ensuring that decarbonisation goals are met. Some also included that strategic planning would allow better integration with other systems, including managing environmental impacts, use of marine space for multiple infrastructure requirements and identifying efficiencies through coordination with other infrastructure projects.

Other reasons given in favour of strategic planning were the possibilities of cost savings, faster development, clarity on infrastructure requirements and identifying no regrets projects for early support.

Those who favoured a mix of strategic planning with some market-led elements pointed to strategic planning providing some level of framework, such as total capacity, or critical features of larger scale nationally significant infrastructure, leaving the market to drive provision of specific infrastructure solutions within that framework.

While overall there was considerable support for some form of strategic planning, respondents added caveats and risks to be taken into consideration. These included some respondents who noted that strategic planning should not become too prescriptive, allowing a role for market-led competition in bringing forward early projects, and some who considered that centralised strategic planning should probably evolve over time towards a more market-led approach – although most respondents felt that some level of strategic planning would need to be enduring. Other risks of strategic planning raised were inhibiting viable projects from coming forwards and dampening competition in providing value for money in infrastructure build-out.

Storage

Response	Number of responses
A solely market-led approach	5
A form of strategic planning	38
Neither	1
Not answered or unclear	45

A majority of respondents also favoured a strategic planning approach to the build out of hydrogen storage infrastructure. Respondents who took this view were well represented across the different stakeholder types that engaged with this consultation, though the majority of responses were received from stakeholders in hydrogen production, storage companies and trade associations.

A key reason for favouring strategic planning was belief it would enable an integrated and holistic approach to developing storage infrastructure. Some stated that, given the nascency of the hydrogen economy and uncertainty around factors that will influence hydrogen production, (e.g. hydrogen for heating decision, supply and demand for hydrogen, electricity usage etc.) the future state of the hydrogen economy (i.e. high, medium, low hydrogen usage) is undetermined, as is how this will impact storage requirements. Strategic planning, therefore, was seen as necessary to maximise the benefits of hydrogen storage in balancing hydrogen supply and demand and supporting security of supply and energy resilience.

Respondents stated this approach supports an efficient and widespread build out of storage infrastructure, minimising potential for stranded assets and enabling a coordinated approach to developing other hydrogen infrastructure. Respondents argued a strategic planner would be best placed to determine the location, capacity and time at which storage is required and, depending on the use case, which type of storage technology would best serve these needs. Respondents suggested this would foster greater investor confidence in the long-term growth of the hydrogen economy.

Respondents considered the role of strategic planning in addressing the needs of the wider energy system, stating this approach would promote coordination between hydrogen and other sectors aiming to address cross-cutting issues within our energy system. Concerns were expressed around the potential for competing interest in storage assets between hydrogen, carbon capture usage and storage (CCUS) and natural gas. Respondents suggested strategic planning could play a role in mitigating potential conflict.

Some respondents also stated this approach could evolve to being market-led once the hydrogen economy becomes steady-state, mature and liquid.

Some respondents favoured a market-led approach to developing storage infrastructure – those taking this view were evenly represented across the different stakeholder types engaging with this consultation. Respondents suggested a market-led approach would encourage a competitive market, providing the most value for money. Another respondent suggested a significant strategic plan may not be necessary and the market should be left to emerge on its own, especially if, for example, the hydrogen economy were comprised of multiple, small-scale hydrogen production facilities interconnected by transport infrastructure. Alternatively, some respondents suggested merit in limited strategic planning complementing a market-led approach – for example, strategic planning limited to defining required storage capacity, providing incentive through a business model and/or retaining some storage assets as national reserves for use in industries such as transport or power, where quick withdrawal of hydrogen may be required.

Some respondents believed a blended strategic planning and market-led approach from the outset was most favourable. These respondents were either from research institutions or trade associations. Respondents suggested a strategic planning approach for “nationally strategic assets” (e.g. large-scale geological storage or storage that would enable quick withdrawal of hydrogen) for industry or domestic use would be favourable, whereas a market-led approach could be taken for less strategically important assets (e.g. above-ground storage).

It is worth noting the majority of respondents supported the need for a coordinated approach between the build out of hydrogen transport and storage infrastructure, as the value of each of these assets is dependent on the other.

Government response

We recognise the central importance of hydrogen transport and storage infrastructure within the hydrogen economy and therefore consider that some form of central strategic system planning, possibly combined with elements of market-led development, is necessary for the efficient, coordinated build-out of transport and storage infrastructure. An entirely market-led build-out carries a high risk of failing to efficiently deliver the level of market-enabling infrastructure required to grow the hydrogen economy at pace and realise potential whole system energy benefits. Strategic planning can help identify and mitigate the risk of undersizing or other market-constraining infrastructure gaps as well as identifying opportunities for a more efficient, cost-effective build out of major infrastructure.

The form of strategic planning

Question 37: In your view, if strategic planning was to be implemented for hydrogen transport infrastructure what form should it take?

Question 38: In your view, if strategic planning was to be implemented for hydrogen storage infrastructure, what form should it take?

Consultation position

As noted in the consultation, and in line with the Net Zero Strategy, as the energy system goes through significant change and integration, our approach to system governance needs to evolve to help the whole energy system achieve our net zero ambitions. Government is legislating for an independent Future System Operator in response to this need for a ‘whole system’ approach coordinating the ever more integrated electricity and gas systems, both onshore and offshore, while looking ahead to emerging markets like hydrogen.

Stakeholders were asked if some form of strategic planning was to be implemented for hydrogen transport (Q37) and storage (Q38) infrastructure whether it should take a centralised network planning approach, a coordinated approach, an evolved approach, a blended approach of strategic planning and market-led approaches or none of these forms.

Summary of stakeholder responses

Transport

Response	Number of responses
Coordinated approach	13
Central Network Planner	11
Blended approach	8
Evolved approach	4
Combination of approaches	7
None of the above	2
Not answered or unclear	44

Some respondents favoured a coordinated approach. Some saw this as a combination of some level of central strategic planning, either supported by, or evolving out of, a more coordinated approach.

Some respondents saw the value of a coordinated approach as helping balance elements of strategic planning with market forces in an increasingly interconnected energy system. Coordinated strategic planning could help market participants understand respective roles and intentions, making it possible to plan their own projects more efficiently. Some suggested making strategically significant decisions was a specific role for government.

Other reasons given for preferring a coordinated approach included ensuring alignment across transport, storage and production, promoting value for money, ensuring project delivery, and identifying priority projects for early support. Beyond those, one respondent felt that the FSO would not be an ideal focus for central hydrogen network planning, as infrastructure build-out is likely to be regional, but that there could be links across for higher level energy system planning.

Some respondents expressed a preference for the central network planner approach. Four respondents who preferred the central network planner approach suggested that it would evolve towards a more market-led approach over time.

Respondents said a central network planner could play a coordinating and informing role among market participants, help identify strategically important projects and identify synergies between infrastructure development and whole system interaction. Two respondents, for example, cited the likely cost-effectiveness of producing and transporting hydrogen rather than investing in electricity grid reinforcements to convey energy from places where electricity generation is curtailed.

Respondents noted the challenges facing a whole system approach, including the complex interaction between transmission and distribution level grids and between local, regional and national level planning across the UK, and how electricity, natural gas and hydrogen systems will operate together.

Three respondents favouring a central network planner stated that if this were to be the FSO in the future, an interim solution allowing early strategic planning to occur would be needed.

Some respondents preferred either a blended approach or a combination of approaches including a role for central strategic planning, coordination and evolution over time.

The most common reason given in favour of a blended approach was that it represents the best way to balance strategic planning for efficiency and supporting early FOAK projects with the value-for-money benefits of market-led development. The blended approach was described as a “central planner making capacity and location decisions and enabling a framework to drive competition in production and storage and build confidence for the demand side to convert.”

Another respondent recommended a similar approach to the electricity grid’s holistic network design emphasising the role of the strategic planner should be primarily to bring together industry voices to highlight system needs.

Some respondents said where market forces are sufficient to bring projects online, administration associated with conforming to a network plan should be avoided to prevent slowing down construction, especially for smaller scale transport infrastructure.

Some favoured an evolving approach, but respondents who preferred other approaches also referenced the need for any approach to evolve over time. Of those that explained their preference, half recommended an early market-led approach to bring smaller scale projects online rapidly, evolving into a more strategically planned system, and half recommended centralised strategic planning to support necessary and future-proofed early network development that could then evolve into a more market led approach.

Storage

Response	Number of responses
Coordinated approach	12
Central Network Planner	11
Blended approach	8
Evolved approach	11
None of the above	2
Not answered or unclear	47

44 responded to this question. There were no distinct preferences to the form strategic planning should take, with support split between the central strategic planner, coordinated and evolved approaches. It is worth noting that the majority of respondents stated that a consistent form of strategic planning should be taken for hydrogen transport and storage to promote an aligned, efficient approach given the requirement of both assets to connect producers and offtakers. Respondents represented all stakeholder types that engaged with our consultation, but the majority of responses were from storage companies, hydrogen producers and trade associations.

Some respondents favoured a coordinated approach to strategic planning suggesting a coordinated approach to strategic planning would enable sufficient storage capacity, optimally located to support supply and demand at the required time, with consideration of the characteristics of the storage required (e.g. fast withdrawal of hydrogen). Respondents believed a coordinated approach would ensure alignment between other hydrogen infrastructure projects and help secure the best value for money and support project delivery. One respondent suggested Project Union could serve as a central point for a hydrogen network that could be extended to connect hydrogen production projects funded through the Net-Zero Hydrogen Fund (NZHF).

Some respondents favoured the evolved approach to strategic planning. Respondents favoured a central strategic planning approach that evolves to being market-led. Respondents recognised the value of a central strategic planner, particularly in the early growth phase of the hydrogen economy to mitigate the risk of market failure. Respondents believed a central strategic planner would take an integrated approach to developing storage assets by considering interactions with other infrastructure projects and how this may contribute to UK government’s net-zero targets and support the needs of hydrogen offtakers. The Future System Operator (FSO) was suggested as best placed to take on this role, but in the interim UK government should do so, informed by views of key industry stakeholders. Respondents suggested markers of a mature hydrogen market that could be market-led would include increased numbers of market participants, better understanding of the significance of the role of hydrogen in the energy system and a decision on market maturity from the central strategic planner and government. Five respondents suggested once a market-led approach is taken, some storage assets may warrant continued central strategic planning and be considered as national strategic assets - for example, larger storage assets that can provide fast hydrogen withdrawal to supply certain industries or domestic use. Alternatively, three respondents suggested the evolved approach should take a central strategic planner form for large, underground storage only and eventually evolve to being market-led and small-scale, above-ground storage should be able to evolve by an unregulated, market-led approach from the outset.

Some respondents favoured the centralised strategic planner approach. The rationale for favouring this was similar to those favouring a central strategic planner for the evolved approach. Respondents believed there was strong justification for a central strategic planner given the critical role hydrogen storage could play in the hydrogen economy and wider energy system. Respondents suggested a central strategic planner would be able to consider the location (and co-location with electrolysers and other hydrogen infrastructure), capacity, technology type, time at which storage assets are required and issues affecting the sector and provide steers to industry to enable these requirements to be met and support in problem-solving. Some respondents acknowledged that given the likely need for a business model for many storage projects, a central strategic planner – again, suggested as UK government prior to the FSO being established - would be necessary to oversee this to support investor confidence and encourage the switch to hydrogen.

Three respondents expressed concern over the activities within scope for a central network planner, stating they could stifle competition as projects could be selected even though they may not offer the best value for money. One respondent suggested a centralised strategic planner may not be necessary for all types of storage (e.g. small or large scale, above-ground or underground) which may serve different purposes (e.g. fast-cycle, interseasonal, seasonal).

Some respondents favoured the blended approach to strategic planning, comprised of a central network planner and a market-led approach. Noting uncertainty around the future state of the hydrogen economy, respondents favoured a blended form of strategic planning as they believed it would provide flexibility. These respondents also acknowledged the value of a central network planner – the FSO once established but UK government in the interim - taking an integrated approach to developing storage infrastructure by considering the needs of the wider energy system and aligning the approach with other hydrogen infrastructure. Respondents suggested the role of the central strategic planner be limited to subsidy allocation based on value for money, or determining where storage infrastructure can be developed to promote optimal distribution of assets. One suggested larger storage facilities would benefit from strategic planning, but decentralised storage would not and should be market-led. Alternatively, another respondent suggested, given the geological requirements for large-scale storage, the location of these assets is effectively pre-determined and therefore should be able to emerge through a market-led approach that could be supported by strategic planning to guide phased development of these stores. Some respondents suggested this approach could evolve to being solely market-led as the hydrogen economy matures and becomes more liquid.

Only a few respondents did not agree with any of our suggested forms of strategic planning. One respondent stated the hydrogen market was too nascent to decide the form strategic planning should take and efforts should be focused on strategic planning for natural gas. Another respondent suggested a solely market-led approach would be preferable, supported by strategic planning only to define the required storage capacity to support the emergence of a competitive market.

Government response

While there was more support among respondents for a coordinated approach to strategic planning for both transport and storage infrastructure, the advantages of a significant role for a central strategic network planner advanced by respondents were compelling. Moreover, many of the advantages of a more coordinated response can be designed into the details of how a central strategic planner should operate alongside other institutions. This may be especially relevant when considering the interactions between local, regional and national level infrastructure planning.

Given this, we intend for the FSO, in due course, to take on a role as a central strategic network planner for hydrogen network infrastructure. While this does not preclude an evolution towards more market-led development over time, some element of whole system strategic planning covering hydrogen infrastructure is likely to be enduring. The FSO, through its independence and expertise, will be ideally placed to provide many of the roles suggested by respondents as useful from a strategic planner, including coordination and knowledge sharing across regulatory, governmental and industry ambitions, and taking a whole system view. The form, detail and scope of the FSO's strategic planning role will require further development however, and these details will be subject to further consultation in due course.

Alignment between transport and storage

Question 39: Further to your answers to questions 35 – 38 above, in your view, is it important for there to be alignment between the ways in which hydrogen transport infrastructure and hydrogen storage infrastructure are built out and, if relevant, the form of strategic planning involved?

Consultation position

In the consultation, we suggested that the location and sequencing of the roll of out of both hydrogen transport and storage infrastructure will have important implications not just for the growth and development of the hydrogen economy, but also for maximising the benefits to the wider energy system.

For example, storage will be needed to provide security of supply for end users including in power generation but is likely to rely on hydrogen transport infrastructure to connect to both producers and these end users. Realisation of whole energy system benefits, for instance through the roll out of hydrogen to power, is therefore likely to rely on a strategic and aligned deployment of both hydrogen transport and storage infrastructure.

Summary of stakeholder responses

Response	Number of responses
Agree is it important for there to be alignment between the ways in which hydrogen transport infrastructure and hydrogen storage infrastructure are built out and the form of strategic planning involved	40
Disagree that is it important for there to be alignment between the ways in which hydrogen transport infrastructure and hydrogen storage infrastructure are built out and the form of strategic planning involved	2
Partially agree	6

Not answered or unclear	41

The majority of those who gave a view agreed that it was critically important for there to be alignment between the ways in which hydrogen transport infrastructure and hydrogen storage infrastructure are built out and, where relevant, the form of strategic planning involved. Key reasons given included their inherent interdependency, the need to ensure effective and efficient infrastructure build-out and that alignment would offer the most value for money. Alignment minimises the risk of asset stranding and provides opportunities to minimise environmental impacts and coordinate investment timings.

For example, one respondent commented that “the viability of transport and especially large-scale storage is dependent on both elements being developed in tandem.”

Of those that agreed that alignment was important, some noted that this need not always be entirely full alignment, and as long as there was partial alignment there was room for different approaches to transport and storage infrastructure build-out where useful. Some respondents highlighting the need to avoid efforts at greater alignment delaying investment, suggested one mitigation would be to focus initially on aligning network development within regional demand centres.

Two respondents disagreed, suggesting that the approaches could be decoupled. One suggested early focus on storage, while the other suggested that strategic planning was likely to be needed for transport infrastructure before storage.

Government response

We agree that the approaches taken to strategic planning for storage and transport infrastructure should be closely aligned due to the interconnectedness and interdependencies between them. While the approach to strategic planning and the resultant build-out need to be closely aligned, there may be some variation in the detailed role strategic planning plays in shaping project delivery, depending on the distinct requirements of each asset within the hydrogen economy and the exact role strategic planning will play in the allocation of the respective business models, which remains to be determined. We envisage a coordinated allocation process, and our current thinking on the business models themselves is set out in chapters 2 and 3 of the hydrogen transport and storage infrastructure: minded to positions.

Impact of different infrastructure types

Question 40: Considering onshore and offshore hydrogen transport and storage infrastructure, do they have specific characteristics, or wider interactions with other infrastructure, which may mean the different infrastructure types favour a market-led approach or a form of strategic planning?

Consultation position

In the consultation, we set out the implications the location and sequencing of hydrogen transport and storage infrastructure would have for decarbonisation, the natural gas grid, the electricity system and CCUS. Both onshore and offshore infrastructure build-out was implicated in the interactions between hydrogen network infrastructure and these areas.

We suggested that the increased complexity and interlinkages within the wider decarbonised energy system will mean the development of hydrogen infrastructure cannot be considered in isolation, and that some form of strategic planning might be required for most types of hydrogen infrastructure. We proposed that both the location of assets and their capacity would be key considerations for planning and constructing hydrogen transport and storage infrastructure to meet the increasing demand for hydrogen across the energy system.

Summary of stakeholder responses

Response	Number of responses
No, most types of infrastructure require some level of strategic planning	22
Yes, differences between infrastructure favour either a market-led approach or a form of strategic planning	11
Not answered or unclear	54

The majority of those that provided a view stated that most types of infrastructure onshore and offshore merited some level of strategic planning. Reasons given included the importance of maximising whole system benefits and overall energy network performance and resilience, the increasing interconnectedness of both energy and non-energy systems (such as water) and the ability of a strategic planner to consider less-quantifiable considerations, such as offshore spatial planning and public acceptability.

Scale and limited availability of optimal locations for hydrogen storage were given as critical infrastructure features necessitating strategic planning, as was potential competition between use cases for storage locations, and the potential benefits of coordinating onshore and offshore pipeline construction. Some suggested that smaller scale infrastructure would be in less need of strategic planning considerations, which they believed are more relevant to larger scale assets.

Some respondents said there were key differences meriting different approaches, such as asset scale and off-taker numbers. Some suggested that smaller assets, such as offshore pipelines with a small user base or above ground storage should not require strategic planning and their development could be market-led. One respondent argued that transport via shipping did not require strategic planning.

Government response

Strategic planning is necessary for both onshore and offshore infrastructure, but the degree and specificity of planning required may vary based on features of infrastructure type such as scale or level of networking. Early strategic planning will focus on onshore gaseous pipelines and the storage sites connected to them. We agree there may be less need for some above-ground or point-to-point infrastructure to be strategically planned, but only in so far as that the construction of such infrastructure does not result in future market constraints. Whether whole transport or storage vectors, such as all above-ground storage or shipping, can be entirely exempt from strategic planning is not a position we are minded to take at this stage, given both the current uncertainty of overall network design and requirements and the increasing interconnectedness across the whole energy system.

Factors in strategic planning

Question 41: In your view, are there any factors, other than those listed above, that should be considered if a strategic planning approach was to be adopted?

Consultation position

In the consultation, we set out some of the factors the strategic planning process would need to consider and potentially balance against one another when planning hydrogen transport and storage infrastructure. These included location of assets, required capacity, lead times for construction, impacts on and interaction with the natural gas system and coordination among owners and operators.

We asked whether there were any additional factors other than those listed above that should be considered if a strategic planning approach was to be adopted.

Summary of stakeholder responses

Response	Number of responses
Yes, additional factors should be considered	35
No, all necessary factors have been considered	5
Not answered	50

Of the 35 respondents suggesting additional factors, six suggested the addition of factors related to investment costs, including providing justification and support to invest in initially over-sized assets. Respondents also highlighted the importance of understanding the likely future market and economic framework of the hydrogen economy. Two respondents raised driving decarbonisation as a key consideration, where the costs of decarbonisation by alternative means could be used as a counter-factual to assess the value of hydrogen assets.

Seven respondents emphasised that strategic planning should take a whole system approach. Included within this was not only existing and future energy-specific infrastructure, but related infrastructure and systems – particularly carbon capture and storage and water availability for electrolysis. Five respondents focused on the importance of including security of supply and resilience considerations.

Four respondents raised coordination with system planning for natural gas infrastructure, especially with regards to sequencing of repurposing and decommissioning, the value of using existing skills within the natural gas industry and the need to coordinate support for both natural gas and hydrogen as the market transitions towards net zero.

Six respondents raised locational factors they felt had been overlooked. They wanted to see the location of production included, as well as greater consideration of local needs and equitable regional distribution of infrastructure investment. Greater consideration of enabling import and export of hydrogen was raised by 4 respondents along with any implications of changes in the EU energy system.

Four respondents referenced differing storage discharge rates as a critical factor to be included in strategic planning. Individual respondents suggested that environmental impacts had been overlooked as a critical factor, as had grid connections and approvals and the role of production technologies that are less dependent on larger scale transport solutions as a means of streamlining transport build-out.

Government response

The importance of locational factors and interactions with the gas grid were key factors set out in the consultation, along with the potential need to over-size assets in the near-term to build future markets. The additional detail provided by respondents will help further develop how considerations are made, especially with regards to regional and national planning interactions. Investment costs may be an important factor for a strategic planner to consider, particularly when assessed against demand-side counterfactual costs of decarbonisation, as this will drive the assessment of demand areas most likely to benefit from having access to hydrogen networks. Similarly, investment costs may also be important when considering whether repurposed or new assets are preferable in given areas. Impacts of network design on decarbonisation and system resilience are useful additional key considerations, as are detailed aspects of infrastructure characteristics, such as storage flow rates.

The role of the FSO

Question 42: If the UK were to create a central network planner role for hydrogen, would the FSO (if it is established by the Energy Bill) be best placed to take this role on? If not or if the FSO is not established, is another organisation more suited to the role or would a new body need to be created? If yes, in your view what temporary solution could be implemented prior to the FSO taking on the role?

Consultation position

In the consultation, we suggested that should a central network planner be the preferred approach, the FSO's role could be expanded to take on responsibility for central strategic planning of the hydrogen network, alongside its electricity and gas network planning responsibilities. The FSO's statutory duties, including its duty to consider whole system impacts, will require it to take a broad view of the energy sector as it carries out its functions. From day one, it will need to take account of the impacts of what it does, such as network planning and forecasting, on the production, storage and transportation of hydrogen and their impacts on the electricity and natural gas sectors. This would leave the FSO well placed, in due to course, to oversee the investment and build out of hydrogen transport and storage infrastructure, ensuring optimisation within the hydrogen economy and with other energy vectors. If it did become the strategic planner for the hydrogen network, the FSO might recommend and advise on the location, sizing and timing of new and repurposed hydrogen assets, with separate body/bodies (for example central government, a regulator or business model delivery body) making the final decisions on whether and how support will be allocated.

We asked for views (Q42) on whether the FSO will be best placed to take this role of central network planner, or whether another organisation is more suited or should be created. We also asked what temporary solution could be implemented prior to the FSO taking on the role.

Summary of stakeholder responses

Response	Number of responses
Yes, the FSO would be best placed	37
No, another or new organisation would be preferable	4
Partial agreement/agnostic	7
Not answered	42

The majority of respondents agreed that the FSO, if created, would be best placed to take on the role of strategic planner for hydrogen. Some respondents said they were either currently agnostic to the identity of the strategic planning body, or that the FSO was probably best placed but that its suitability will depend on how the FSO is set up and what strategic planning for hydrogen will actually entail.

The most cited reason for supporting the role of the FSO was that it would be uniquely placed to take a whole energy system approach, as it is already due to look across system planning for electricity and gas, both of which are highly relevant and interrelated with hydrogen system planning. Some respondents also flagged the independence of the proposed FSO as an advantage, and some highlighted that the role of strategic planner for hydrogen fit within its proposed remit.

Four respondents did not think the FSO should take on a role as system planner for hydrogen. One cited a potential conflict of interest with the FSO's system operator role. Three suggested a new independent body should be set up, either as a collaboration between market participants, technical advisors and government, or like the Climate Change Committee (CCC). One suggested system planning should be a coordinated private sector activity.

Many respondents agreed that interim arrangements would be required to conduct strategic planning activities prior to the FSO being able to take on the role, and many of these made specific suggestions – including the Department for Energy Security and Net Zero, Ofgem or National Gas taking on the role, or a collaborative approach between all three plus distribution network operators and other organisations such as the CCC and NIC.

Some respondents stated that the immediate needs of the hydrogen economy meant that an interim solution would be required before the FSO was ready to take on the role, with some adding that time would be needed for the FSO to develop the requisite skills and experience in hydrogen to perform the strategic planning role. Some respondents suggested that the FSO could take on a shadowing role to the organisation or organisations that take on interim strategic planning work.

Some cited the importance of considering how a national strategic planner would work with and interact with local and regional planning requirements. Some suggested that regional system operators, being suggested under the Local Energy Governance review, could play a role.

Government response

We agree with the majority of respondents that the FSO, once established, would be the right body to take on a central role in strategic hydrogen network planning after an appropriate time to enable upskilling and competence building in hydrogen infrastructure. While concerns about the FSO's capability to take on this role are noted, its whole system remit and role in electricity and gas makes designation of a new alternative body for hydrogen that would by necessity work very closely with the FSO, a less favoured option. As noted above, the form, detail and scope of the FSO's strategic planning role will require further development which will be subject to consultation.

Role of strategic planning in business model support

Question 43: In your view, what role could the strategic planner have in the provision of business model support? How would this role change under different strategic planning approaches?

Consultation position

In the consultation, we suggested that a strategic planner is likely to play an important role in either informing or making decisions on provision of business model support to projects. This would ensure that the build out of transport and storage infrastructure is consistent with the strategic plan.

How decisions are taken may vary based on the form of strategic planning approach taken. We proposed that decisions on provision of business model support would likely be influenced by either a proactive or reactive approach:

- Proactive: The strategic planner proactively identifies the need for hydrogen transport and/or storage infrastructure of strategic importance,
- Reactive: Project developers make business cases to the strategic planner for assessment through the strategic planning process.

Summary of stakeholder responses

Please note, some respondents provided multiple views on the role of the strategic planner in the provision of business model support, therefore the following table does not tally numerically with the number of respondents, but reflects their references to specific themes (i.e. one respondent had two views, both of which are represented in the totals below).

Response	Number of responses
Proactive approach	7
Reactive approach	4
Advice body	7
Consider strategic/regional/locational allocations	7
Transition to market/merchant model	3
Others	9
FSO/Planner to have no role in business model	4
Not answered or unclear	54

36 respondents directly addressed this question. Respondents were broadly split between the strategic planner taking a proactive role in business model allocation through planning or acting as an advice body on allocation with some support for a more reactive approach through assessing value and business cases.

Of those favouring the proactive approach, seven respondents suggested it would provide stakeholders with a strategic oversight of the hydrogen economy for existing and future infrastructure and demand allowing greater confidence in investment. They referenced the value of the in-depth knowledge and ‘whole systems view’ of a strategic planner. One commented that being reactive risks the UK ‘falling behind the curve, constraining private investment’ and losing its ‘ability to compete globally.’

A smaller number of respondents favoured the more reactive approach, stating that the strategic planner's role should be in assessing value and business cases for support from the business model. This approach would allow quicker responses to changes in the hydrogen economy such as major and innovative developments and potential market failures.

Seven respondents suggested that the strategic planner take on an independent advisory role to government and regulators. Most of these respondents stated that this advice should be centred around business model support allocations and cost benefits analysis of proposals and strategic and technical advice on priority proposals.

Seven respondents suggested the key role of the strategic planner in business model allocation was in giving due consideration to the future needs of the hydrogen economy, including transport and storage networks being developed in regional clusters or locations of strategic importance.

Some stated that the strategic planner should have a role in planning the transition towards a market or merchant approach as the hydrogen economy develops.

Four felt the strategic planner should have no role in the provision of business model support.

Government response

Not all roles that a strategic planner could play in business model allocation suggested by respondents are mutually exclusive. The degree to which the strategic planner plays either a proactive or reactive role in business model allocation will be a critical element of business model design and stakeholder responses to this consultation will be taken into consideration in that design process. The role of the strategic planner will continue to be developed alongside and in collaboration with business model design.

Identifying priority projects

Question 44: In your view, should government seek to identify "low or no-regrets" and/or systemically important projects to prioritise their development if possible? If so, how might such projects be identified and how might they best be prioritised?

Consultation position

In the consultation, we suggested it may be possible to identify early "low or no-regrets" and systemically important projects which could be key enablers for the future growth of the hydrogen economy. "Low or no-regrets" projects are those which have little to no risk of becoming stranded assets and which are highly likely to provide value to the hydrogen economy in the long-term. Systemically important projects are those which are likely to provide significant capacity allowing for future growth in the hydrogen economy, for example, through the provision of greater resilience and competition driving down system costs.

Were a strategic planning approach to be taken within the UK, the body responsible for strategic planning could develop processes for identifying and selecting specific projects of systemic importance and/or “low or no-regrets” with a view to potentially fast-tracking their development through early bespoke support, be that through regulatory, financial or other means.

We noted further considerations will need to be made regarding how this support interacts in the longer term with any support provided through business models.

Summary of stakeholder responses

Response	Number of responses
Strongly agree	14
Agree	28
Uncertain	3
Disagree	1
Strongly Disagree	1
Not answered	43

Of the 46 respondents who provided an answer to this question, the majority agreed, and some of those strongly agreed, that government should seek to identify low or no regrets and or systemically important projects to prioritise their development. Two respondents disagreed with the need to identify low or no regrets or systemically important projects, one on the basis that project development should be market-led, the other on the basis that government is not best placed to identify the correct projects.

Three respondents were more ambivalent, citing that while some support might be justified reaching an effective market framework to bring forward investment is preferable, and in the current state of uncertainty on future uses of hydrogen identifying the right projects will be too difficult to do with certainty.

Suggestions were made as to how best to identify projects for early support. Eight respondents focused on known early development sites for hydrogen production. They recommended using Net Zero Hydrogen Fund projects and/or hydrogen cluster development and interconnection between them as key factors to identify infrastructure that would provide ‘quick wins’ to stimulate wider development.

Four respondents focused on using demand as a key factor to identify critical infrastructure, for example industry with limited options to decarbonise outside of hydrogen would pose a relatively secure offtaker base that would benefit from a connection to hydrogen. Likewise, projects that could provide relevant network infrastructure for the aviation sector and electricity generation could be viewed as especially important. One respondent recommended using decarbonisation benefits to identify projects, and a number also included decarbonisation benefits as a means of prioritising projects.

Four respondents recommended using a project's ability to scale up demand or otherwise play a market growth enabling role as a means to identify priority projects. A further six respondents referenced key locational/geographical factors including market stimulation and specific regional needs, among benefits to the wider energy system, such as system resilience. One pointed out the strategic importance of salt cavern location for hydrogen storage development, suggesting selection criteria based on capacity, scalability, proximity to renewable wind generation, cost competitiveness, local support and located to avoid environmental or other landscape disturbance.

Four respondents focused on value for money alongside considerations of asset scale, construction impact, project credibility, and deliverability, e.g. as determined by project operator experience, and/or the readiness of a project to progress.

Four respondents suggested it was the role of government to identify the most appropriate projects to prioritise, and that government should be actively seeking out projects if the market has not already brought them forward. This was described as critical to supporting the 2030 hydrogen production ambition.

Having identified potential projects, support could be prioritised according to decarbonisation benefit, as recommended by three respondents, and/or market enabling role, whole system benefit including resilience and use of repurposed infrastructure, capacity unit cost, or rapid deliverability.

Respondents also referenced projects enabling blending as possible 'low or no' regrets projects and the need for any identification and prioritisation process to enable timely project progression.

One respondent suggested there may be particular stages or parts of project development more in need of additional support than others, and another suggested prioritisation of support was more relevant for supporting construction, whereas most DEVEX for credible infrastructure could be considered low regrets. An expression of confidence via DEVEX funding could be sufficient to send clear signals to developers that network infrastructure would definitely materialise.

Government response

We agree with respondents that focusing on known early development sites is a critical factor in identifying priority projects. We also agree that focusing on the most certain areas of demand, such as hard to decarbonise industrial sectors or electricity generation, could provide a way to identify no, low or 'acceptable' regrets projects that can play a critical role in decarbonisation. Likewise, the scalability and market-enabling role of projects, tied closely to related locational factors, should be factored in.

We agree that prioritising these projects for early support needs to consider physical system considerations and project value and deliverability. We recognise points raised by respondents on the role of government in early identification of projects and the enabling role early prioritisation will play. Nevertheless, while the hydrogen economy is in its early growth phase, identification of future critical infrastructure will need to be aligned with the wider direction of hydrogen development, especially on production. Some decisions may be best left until infrastructure needs are clearer. Identifying the evidence necessary to reach these decisions will be a critical interim role for strategic planning and part of the work we intend to take forward.

Chapter 5: Regulatory framework (Q45 - 56)

Part 1 - Market framework: adequacy of existing market framework and industry commercial arrangements for hydrogen

Suitability of existing market framework

Question 45: In your view, are the existing market framework and industry commercial arrangements for hydrogen optimal for supporting the development of hydrogen transportation and/or storage infrastructure? Please note we are seeking your views on the whole existing market framework and industry commercial arrangements, including any possible gaps, and not just matters relating to the Gas Act. Please explain your answer and provide any relevant evidence.

Addressing shortcomings in the existing arrangements

Question 46: If you answered 'No' to the previous question, how do you think this should be addressed:

a) Through amendments to the existing market framework / industry commercial arrangements?

b) Through the replacement of aspects of the existing market framework / industry commercial arrangements (for example, with new arrangements that are specifically designed for hydrogen)?

c) Through a different approach?

Please explain your answer and provide any relevant evidence.

Consultation position

In our consultation we noted that since hydrogen is a "gas" for the purposes of the Gas Act 1986, regulatory requirements and prohibitions that apply to the transportation, shipping, supply and storage of natural gas may also apply to hydrogen. We recognised that these existing arrangements, together with those provided by industry commercial arrangements, may not be conducive to the emergence of hydrogen transport and/or storage infrastructure. Consequently, we sought the views of stakeholders on these existing arrangements, and the extent to which they are optimal for supporting the development of hydrogen transportation and/or storage infrastructure. We asked stakeholders for their views on how any perceived shortcomings might be addressed.

Overview of responses

Of the 40 responses that we received to question 45, 3 thought that the existing market framework and industry commercial arrangements for hydrogen were optimal whilst 33 thought they were not. The remainder were unsure.

Of those respondents that thought the existing market framework and industry commercial arrangements were not optimal, 8 thought that any shortcomings should be addressed through amendments to existing arrangements whilst 9 thought they should be addressed through the replacement of aspects of the existing arrangements. 15 thought that any shortcomings should be addressed through a different approach, although a third of these said that any shortcomings should be addressed through a combination of amendments and replacements to the existing market framework and industry commercial arrangements. One respondent did not provide a view on how shortcomings should be addressed.

In aggregate, these responses suggest that there is little consensus amongst respondents as to which approach should be adopted for addressing any shortcomings.

Summary of responses to Question 45

Response	Number of responses
Yes - the existing market framework and industry commercial arrangements for hydrogen are optimal for supporting the development of hydrogen transportation and/or storage infrastructure.	3
No - the existing market framework and industry commercial arrangements for hydrogen are not optimal for supporting the development of hydrogen transportation and/or storage infrastructure.	33
Not sure.	4

Summary of responses to Question 46

Response	Number of responses (who answered "No" to Question 45)
Shortcomings in the existing market framework and industry commercial arrangements should be addressed through amendments to these arrangements.	8
Shortcomings in the existing market framework and industry commercial arrangements should be addressed through the replacement of aspects of these arrangements,	9

for example, with new arrangements that are specifically designed for hydrogen.	
Shortcomings in the existing market framework and industry commercial arrangements should be addressed through a different approach to the two mentioned above.	15

Stakeholder views on the market framework and industry commercial arrangements

Thirty-three respondents to questions 45 and 46 provided views on more than 30 issues, reflecting the breadth and complexity of the subject matter, as well as the diversity of those individuals and organisations who responded. The issues which attracted the greatest amount of attention from respondents are summarised below.

Hydrogen should have its own industry commercial arrangements separate to the existing Uniform Network Code (UNC) (16 out of 33 respondents).

The UNC is the legal document that forms the basis of arrangements between licensed gas transporters and the shippers whose gas they transport. It is concerned with the conveyance of gas through pipeline, and broadly defines “gas” (for the purposes of the UNC) as any hydrocarbons or mixture of hydrocarbons and other gases consisting primarily of methane[9]. This is a much narrower definition of “gas” than that provided by the Gas Act, which, for example, includes a substance in a gaseous state which consists wholly or mainly of hydrogen. Accordingly, nearly half of respondents said that hydrogen should have its own arrangements (i.e. something equivalent to the UNC but specifically for hydrogen) distinct from those for natural gas. In contrast, 6 respondents (about 18%) thought that the UNC could be adapted to accommodate the conveyance of hydrogen.

5 respondents (15%) said that for hydrogen, signatories to a network code (whether it is a new network code or an adapted UNC) should be extended to include other connected parties, for example hydrogen producers and storage facilities. One of these respondents noted that such an arrangement might require the activities undertaken by these parties to be licensable – it should be noted that hydrogen production and hydrogen storage are currently not specifically subject to a licensing regime.

Hydrogen should have its own legislation/market framework (10 out of 33 respondents)

As noted above, hydrogen is a “gas” for the purposes of the Gas Act, but about a third of respondents were of the view that hydrogen specific arrangements should be developed to operate outside of the Gas Act. Some of these respondents qualified their responses by stating that such arrangements might only be needed once the hydrogen economy has reached a certain size, whilst others thought a new regulatory framework should be streamlined

[9] Uniform Network Code – General Terms Section C paragraph 3.1.1.

(compared to existing arrangements) or designed in such a way that it could accommodate identifiable phases of growth in the hydrogen economy.

A review of the market framework/industry commercial arrangements if is required (9 out of 33 respondents)

A little over a quarter of respondents were of the view that the adequacy of existing arrangements for supporting/regulating hydrogen should be reviewed. In one instance, it was stated that this review should extend to arrangements that apply in Northern Ireland (where the Gas Act and UNC do not apply).

The role of the shipper/balancing arrangement should be reviewed (8 out of 33 respondents)

About a quarter of respondents drew attention to the role of shippers in the hydrogen economy, mainly in relation to concerns about balancing frequency, i.e. the number of occasions within a given period that a shipper's entry and exit flows must be balanced. Line-pack 'flex' (i.e. increasing and decreasing pipe-line pressures) plays an important role in the natural gas system, buffering within-day imbalances in entry and exit flows and helping to ensure that pipe-line pressures remain within a tolerable range. The opportunity for line-pack flex will be much lower on hydrogen networks, mainly due to the much lower energy density of hydrogen compared with natural gas. Consequently, some respondents were of the view that hydrogen networks will need to be much more actively managed than is the case for natural gas systems where shippers are the primary balancers (the shipper licence gives licensees a daily balancing obligation). Some respondents questioned the role that shippers might play within the hydrogen economy, with some questioning whether there would even be a need for shippers if their role in balancing were to be moved elsewhere, e.g. to a central balancer who would have the ability to undertake a range of balancing activities.

There is a need for a hydrogen pipe-line safety specification (8 out of 33 respondents)

About a quarter of respondents noted that there is a need for a safety/quality specification for hydrogen conveyed through pipe-lines. Some of these respondents thought that this could be achieved through amendments to the Gas Safety (Management) Regulations 1996 which apply to the conveyance of gas through pipes to domestic and other consumers, and which currently only permit up to 0.1% hydrogen in gas. A few said that any new specification should align with EU specifications in order to better facilitate future cross-border trade in hydrogen.

A market framework for hydrogen should be introduced in a phased manner (7 out of 33 respondents)

About a fifth of respondents were of the view that specific arrangements for hydrogen should be introduced in a phased manner to align with the growth of hydrogen transport and storage infrastructure. Some mentioned that the market framework should support the development of the hydrogen economy.

Other issues

The views of respondents on issues where 4 (12%) respondents or fewer expressed a view are set out in the table below.

	Issue
1	The hydrogen production business model policy position on risk taking intermediaries (RTIs) is not compatible with the existing market framework due to the role played by shippers.
2	There is merit in retaining the existing market framework because participants are familiar with it.
3	Cross-vector regulation should be considered (i.e. hydrogen and electricity).
4	The “end goal” of the hydrogen economy should inform the nature of the market framework.
5	Legislation is needed to support transport and storage infrastructure business models.
6	Lessons could be learned/adopted from the approach government is taking towards heat networks regulation.
7	The transport and storage ownership unbundling and independence requirements of the Gas Act are not suited (or may not be suited) to infrastructure within the emerging hydrogen economy.
8	Transport and storage ownership unbundling/independence requirements should be a component of the hydrogen market framework (i.e. the opposite of the view set out above).
9	Third party access requirements for transport and storage infrastructure should be disapplied whilst the hydrogen economy is in its infancy.
10	Third party access requirements for transport and storage infrastructure should be a component of the hydrogen market framework (i.e. the opposite of the view set out above).
11	Ofgem is best placed to regulate hydrogen transport and storage infrastructure.
12	The energy regulator should have a net-zero mandate.
13	The scope of industry codes which aim to deliver consumer protections (e.g. the Retail Energy Code and the Smart Energy Code) may need extending to include hydrogen.
14	Hydrogen transport infrastructure will need its own price control or should be included in the existing price controls.

15	A market framework is needed for offshore hydrogen infrastructure.
16	The existing market framework was developed to support a mature natural gas market – it might act as a barrier to investment in hydrogen T&S investment and stifle innovation.
17	Moving away from the existing market framework could create instability.
18	The hydrogen market framework should include a greater focus on decarbonisation.
19	Hydrogen production should be a licensable activity.
20	Hydrogen production should not be a licensable activity (i.e. the opposite of the view set out above).
21	Hydrogen storage should not be a licensable activity.
22	The market tests for minor facility exemption ("MFE") from the Gas Act requirement for third party access to storage facilities are not fit for purpose for hydrogen.
23	Storage connection agreements which set the parameters for storage (hydrogen quality, injection rates etc) are needed.
24	The market framework for Northern Ireland should align with the GB framework.
25	The market framework for hydrogen should be sufficiently flexible to accommodate the repurposing of infrastructure currently subjected to the RIIO price controls.
26	The "duty to connect" requirements of sections 9 and 10 of the Gas Act may need to be amended to provide gas transporter optionality of hydrogen and natural gas.

Government response

In light of the above, and in keeping with government's ambitions to deliver a thriving low carbon hydrogen sector in the UK, it is government's intention to keep the market framework and industry commercial arrangements under review with a view to introducing timely amendments where they are warranted. This review will include ongoing work taking place through the Hydrogen Advisory Council's Transport and Storage working group in the first instance but is likely to encompass further engagement with stakeholders via a call for evidence and/or consultation on more specific proposals at a later date. In line with comments made by stakeholders, we will remain mindful of our long-term vision for hydrogen transport and storage infrastructure when thinking about which arrangements will best serve participants in the emerging hydrogen economy.

Part 2 – Non-economic regulatory framework: adequacy of existing non-economic regulatory framework for hydrogen

Overall onshore regulatory framework

Question 47: Further to the regulatory assessment set out above, in your view, is the existing onshore non-economic regulatory framework optimal for supporting the development of a rapidly expanding UK hydrogen economy?

Question 48: If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)?

Consultation position

In this consultation, we acknowledged that the current existing onshore non-economic regulatory framework for hydrogen is designed to accommodate the limited use of hydrogen that exists today, primarily within industrial settings. We anticipate that future increases in hydrogen production, transport, storage and end use may require updating the existing framework. We considered that the future hydrogen economy requires a careful consideration of existing non-economic regulatory frameworks in the areas of planning, health and safety, licensing, permitting, technical standards and wider environmental regulations. This consultation proposed that the department, in areas of non-economic regulation, work closely with relevant governmental and regulatory bodies to ensure the development of a robust and conducive non-economic regulatory framework.

Summary of stakeholder responses

Response	Number of responses
Agreed that the existing onshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy	4
Disagreed that the existing onshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy	25
Not answered or unclear	61

Out of the 29 applicable answers that we received to questions 47 and 48, 4 respondents agreed, whereas 25 respondents disagreed that the existing onshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy.

Amongst those who disagreed, 18 respondents highlighted the length of time required to obtain planning consent, with delays in obtaining a Development Consent Order (DCO) as a particular issue noted by some respondents. One respondent also noted similar issues in Scotland.

There were also suggestions from 16 respondents for clearer regulatory guidance for industry and regulators to help progress hydrogen projects, with some respondents calling for more clarity on hydrogen development in the National Planning Policy Framework (NPPF), and other respondents suggesting revisions or changes to the National Policy Statements (NPS) to include hydrogen.

Eleven respondents noted the limited regulatory resources available to support hydrogen projects and recommended greater resourcing for relevant UK regulators. Seven respondents suggested a review of existing and required health and safety standards. This included creating a potential hydrogen quality standard to provide greater confidence for operators across the hydrogen supply chain – similar to the Gas Safety (Management) Regulations (GS(M)R), ensuring hydrogen quality standards align closely to EU standards, and a review of the Control of Major Accident Hazards (COMAH) tier pressures. There were 2 respondents suggesting the need for greater policy consistency across the UK at national and local levels, with 1 respondent stressing the need for local authorities to prioritise and give greater weight to decarbonisation projects.

Government response

We have considered the issues raised by respondents regarding the existing onshore hydrogen regulatory framework. We note that many comments provided by respondents to this question overlap with answers provided to other questions below. These are responded to in the relevant sections in greater detail.

GS(M)R is led by the Health and Safety Executive (HSE), who are the regulatory authority responsible for hydrogen safety standards in Great Britain. We will continue to consider the need for standards, such as a GS(M)R equivalent, through work done in the Regulators Forum, where a working group led by the British Standards Institution (BSI) is coordinating hydrogen standards more generally.

On respondents' suggestions for greater regulatory resources to support hydrogen projects, we are aware of this concern, and we will continue to work with regulators through the Regulators Forum to assess their likely needs as the hydrogen economy continues to develop and scale up.

To facilitate greater policy consistency across the UK, the Regulators Forum includes representatives from the devolved administrations, as well as local representation from the Local Governments Association.

The department will work closely with relevant industry and regulatory bodies to examine and develop the onshore regulatory framework suitable for hydrogen projects to help address issues raised in this consultation, including discussions within the Regulators Forum.

Onshore (non-pipeline transportation) health and safety

Question 49: In your view, is the existing regulatory framework for the non-pipeline transportation of hydrogen optimal for supporting the development of a rapidly expanding UK hydrogen economy?

Question 50: If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)?

Consultation position

For the hydrogen economy to develop, existing health and safety regulations need reviewing to assess their suitability and applicability to enable the future hydrogen economy. The department recognises it is imperative that essential health and safety measures are in place to protect people and the environment, and we are engaging closely with the HSE regarding the interactions our work will have with health and safety legislation, as well as broader engagement through the Regulators Forum. In addition, several safety and innovation trials are generating evidence to help understand the suitability of the existing gas networks for hydrogen transportation. Transporting hydrogen through non-pipeline vehicular means (e.g., by road, rail, sea, or air) currently occurs only in low volumes in the UK. Regulations currently exist to facilitate the safe transportation of hydrogen. This consultation set out that if non-pipeline vehicular capacities were to increase, existing standards may need to be reviewed. The consultation welcomed stakeholder views on the suitability of existing regulations to enable and support the development of the future hydrogen economy.

Summary of stakeholder responses

Response	Number of responses
Agreed that the existing regulatory framework for the non-pipeline transportation of hydrogen is optimal for supporting the development of a rapidly expanding UK hydrogen economy.	10
Disagreed that the existing regulatory framework for the non-pipeline transportation of hydrogen is optimal for supporting the development of a rapidly expanding UK hydrogen economy.	15
Not answered or unclear.	65

Out of the 25 applicable responses that we received from questions 49 and 50, 10 respondents agreed, whereas 15 respondents disagreed that the existing regulatory framework for the non-pipeline transportation of hydrogen is optimal for supporting the development of a rapidly expanding UK hydrogen economy.

Most respondents who thought that the existing regulatory framework for non-pipeline transportation of hydrogen is optimal, provided a general rationale. Some respondents specifically highlighted that the Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) appears suitable. ADR is an international agreement with 54 contracting parties; UK has committed to implementing this agreement to ensure that dangerous goods can be safely transported both domestically and internationally. As revisions to the ADR Agreement are agreed by the United Nations Economic Commission for Europe (UNECE) every 2 years to take account of technological advances, the UK amends the implementation of ADR, as appropriate to reflect any changes to the agreement.

Implementation is achieved through the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG) which is made under powers in the Health and Safety at Work etc. Act 1974. The ADR is intended to ensure the safety of international transport of dangerous goods by road.

Amongst the respondents who thought that the existing regulatory framework for non-pipeline transportation of hydrogen is not optimal, 2 key themes were identified on how issues should be addressed. One popular suggestion from 7 respondents was to allow larger volumes/pressures of hydrogen to be transported through non-pipeline vehicular means to support the development of the future hydrogen economy. In other suggestions, 3 respondents were of the view that the adequacy of the existing ADR should be reviewed to see if it is fit for purpose. In 2 instances, it was noted that that hydrogen transported via vehicle is prohibited through 10 road tunnels in the UK – based on its classification under the ADR.

There were also some general views on clearer regulatory guidance for the non-pipeline transportation regulatory framework from 4 respondents.

Government response

Overall, we note there is reasonable support for the existing regulatory framework for the non-pipeline transportation of hydrogen, for supporting the development of a rapidly expanding UK hydrogen economy.

We recognise the views raised by respondents on amending and reviewing the ADR, increasing carriage volumes and pressures, and tunnel restrictions.

ADR is amended and negotiated at the UNECE with separate committees each meeting biannually. This means that ADR is subject to constant review. Alongside this, UK Government officials regularly hold meetings with stakeholders to canvas industry concerns and issues with ADR. We invite and encourage any respondents of this consultation to contact the Dangerous Goods Unit at the Department for Transport (DfT) (DangerousGoods@dft.gov.uk) with evidence-based proposals of any changes they would like to make to amend the regulations, these can then be reviewed and potentially brought forward by the UK to be negotiated internationally. New participants interested in attending stakeholder meetings are always welcome to join - as this ensures that DfT negotiators have diverse and representative views from a multitude of UK industry sectors to inform them of their objectives at the UNECE. ADR provides an essential regulatory framework that allows industry to safely operate their businesses whilst minimising the risks and hazards to public health and the environment. Since its introduction in 1957, ADR has ensured high standards, mutual recognition, and safe movement across the countries that are signatories to the agreement.

ADR contains no regulatory restrictions on maximum carriage pressures for hydrogen and any limitations to industry practice are technical in nature. Any vessel – whether tank, tube, pressure drum or cylinder – that is designed to carry hydrogen, must comply with specific design and safety requirements, which are regulated to ensure suitable performance, but there is no upper limit on their maximum pressure set by the regulation.

There are also no maximum limits to the volumes of hydrogen carried as a compressed gas or cryogenic liquid in ADR, instead being capped by rules concerning the maximum authorised weights for vehicles/combinations and the technical pressure specifications of the vessel. Dangerous Goods Safety Advisors (DGSAs) have the responsibility to advise those moving Dangerous Goods on the best way to comply with ADR obligations and may be able to assist or advise on specific individual hydrogen movements.

In the UK, each tunnel has a tunnel restriction code which is assigned by the Tunnel Operator informed by the results of a risk assessment. The tunnel operators notify DfT of the assigned code so that DfT in turn can notify the UNECE and other parties to the agreement. Similarly, every substance regulated in ADR is assigned a tunnel restriction code by the UNECE which stipulates the types of tunnels they can be carried through. These tunnel codes have been designed to minimise 3 major dangers that may cause numerous victims or serious damage to the tunnel structure. These are: explosions, release of toxic gas or volatile toxic liquid, and fires (ADR 1.9.5.2.1). Hydrogen, whether carried as a refrigerated liquid or compressed gas (UN numbers UN 1966 and UN 1049 respectively) can result in all three of these hazards which is why they are assigned tunnel code “B/D” and restricted from being carried through 8 of the 9 tunnels with dangerous goods restrictions in the UK. We are sympathetic to the added journey length that these restrictions cause for transport operations. However, given that there are sufficient alternative routes, we judge that tunnel codes for hydrogen are necessary to save lives and protect important road network infrastructure. These codes are assigned under ADR on an empirical basis, relating to the risk from the substance in question. A fire or release of substance in the confined space of a tunnel can have disastrous consequences including loss of life, so the UNECE always takes a cautious, evidence-based approach in determining the tunnel codes applicable.

The department will continue to consider the issues raised and the suggestions put forward by respondents and work closely with DfT and HSE to review existing standards and regulations.

Onshore planning

Question 51: In your view, are the current NSIP and TCPA regimes optimal for supporting the development of a rapidly expanding UK hydrogen economy?

Question 52: If you answered 'Yes' to the previous question, please explain which elements you think are conducive to the development of the hydrogen economy. If 'No', please explain how you think they might be improved (e.g., a dedicated hydrogen NPS). Please explain your answer and provide any relevant evidence.

Consultation position

In this consultation, we asked respondents how suitable Nationally Significant Infrastructure Project (NSIP), and Town and Country Planning Act (TCPA) regimes were for supporting the developing of the UK hydrogen economy. We acknowledged that infrastructure projects acquiring a DCO through the NSIP regime or working with TCPA regimes can involve consultation and assessments with regulators, developers, environmental experts, and interested local communities to ensure issues are identified and considered properly. The consultation proposed that the process of securing planning consent is factored into overall project timelines in a realistic way, and to take opportunities to understand how best government(s), regulators, and local authorities can work together to ensure prospective projects are informed on what regulatory processes they must consider and follow.

Summary of stakeholder responses

Response	Number of responses
Agreed that the current NSIP and TCPA regimes are optimal for supporting the development of a rapidly expanding UK hydrogen economy.	2
Disagreed that the current NSIP and TCPA regimes are optimal for supporting the development of a rapidly expanding UK hydrogen economy.	28
Not answered or unclear.	60

Out of the 30 respondents who responded to questions 51 and 52, 2 respondents agreed, whereas 28 respondents disagreed that the current NSIP and TCPA regimes are optimal for supporting the development of a rapidly expanding UK hydrogen economy.

Amongst those who disagreed, 23 respondents argued for an improved NPS to support hydrogen transmission and storage projects, and also for Carbon Capture and Storage (CCUS) related infrastructure, with a few respondents suggesting a dedicated NPS for hydrogen should be considered, or that the existing NPS should be adapted for hydrogen. Thirteen respondents argued for clearer/additional guidance on the planning process, with some respondents suggesting that the existing NPPF currently does not outline a framework for hydrogen development, as the lack of explicit mention of hydrogen may cause doubt in the determination of a planning project relating to hydrogen development at the local planning authority level.

Other respondents also stated that consenting authorities should be given clearer advice for determining planning applications relating to hydrogen projects/infrastructure. Another issue highlighted by 12 respondents was that a consistent policy approach should be taken across national and local levels, and also across devolved administrations, with 1 respondent stating that viewed in isolation, the NSIP and TCPA regimes applying only to England and Wales made it sub-optimal to support a coordinated hydrogen economy across the UK. Ten respondents raised the issue of planning timing impacts on infrastructure project timelines, with suggestions of planning exemptions for some hydrogen projects, or a more streamlined process to ensure DCO reviews are more consistently conducted. There were also suggestions from ten respondents for greater resourcing for local planning authorities and planning regulators, which could provide both bodies with improved means to deliver guidance and support, as well as provide consent under faster timeframes.

Government response

We have considered the issues raised and the suggestions put forward by respondents. The government will work with industry and regulators to consider reviewing existing guidance, including how suitable it is for industry in terms of signposting relevant parts of the planning process, including relevant licensing requirements.

New drafts of the Energy NPS documents were published for consultation on 30 March 2023. References to hydrogen are now included in the relevant NPS documents to provide additional guidance on hydrogen planning and development. The government invited responses to revisions to the NPS from 30 March 2023 to 25 May 2023 (extended to 23 June 2023) and is examining the reviews provided by relevant stakeholders on these latest changes. The department will continue to monitor and assess whether a bespoke NPS for hydrogen is needed. The department will also continue to work with relevant regulators, stakeholders and local authorities to understand their views on planning and hydrogen projects, including discussions within the Hydrogen Regulators Forum.

On 28 February 2023, Department for Levelling Up, Housing and Communities (DLUHC) published the technical consultation ‘stronger performance of local planning authorities supported through an increase in planning fees’. The consultation asked for views on proposals to increase planning fees by 35% for major applications and 25% for all other applications to increase resourcing and improve the performance of local planning authorities. DLUHC published the government response[10] to this consultation on 25 July 2023, indicating draft regulations were laid on 20 July 2023 to implement these proposals.

The government has also committed to improving the NSIP process and making it better, faster, and greener. The NSIP Action Plan sets out 18 actions to achieve this, working to make

[10] https://www.gov.uk/government/consultations/increasing-planning-fees-and-performance-technical-consultation/outcome/technical-consultation-stronger-performance-of-local-planning-authorities-supported-through-an-increase-in-planning-fees-government-response

the system more optimal, as raised here as an issue, while keeping communities and the environment at the heart of decision-making. One of the reform areas in the NSIP Action Plan is to improve system-wide capacity and capability, which includes developing skills and training, and extending proportionate cost recovery by the Planning Inspectorate and key statutory consultees to support effective preparation and examination of NSIPs and build resilience into the system.

We will consider responses from this consultation that suggest potential changes to national planning policy on energy. Wider planning reforms are currently underway, being led by DLUHC. Planning reforms are being partly delivered through the Levelling Up and Regeneration Bill and partly through reviews of national planning policy. This consultation does not pre-empt the outcomes of wider planning reforms, nor the outcome of any supporting government consultations.

Onshore environment

Question 53: In your view, is the existing environmental regulatory framework optimal for the future hydrogen economy?

Question 54: If you answered ‘No’ to the previous question, how do you think this might be addressed?

Consultation position

Regulations are essential to ensure that the natural environment is protected from adverse impacts. As hydrogen projects are being designed environmental impacts of such projects must be considered for assessment by the appropriate authority. Given the nascent nature of low carbon hydrogen technologies, further work is required to determine the environmental impact of the future hydrogen economy and whether new, hydrogen-specific environmental regulation may be required. Government announced £3.85 million funding to explore the environmental response to hydrogen emissions, successful projects starting from October 2022. Government set out that research aims to address uncertainties and gaps in knowledge regarding hydrogen’s environmental behaviour. Noting the status of low carbon hydrogen technologies this consultation proposed that further work may be required to determine environmental impacts of the future hydrogen economy, querying whether new, hydrogen-specific environmental regulation is required.

Summary of stakeholder responses

Response	Number of responses
Agreed that the existing environmental regulatory framework is optimal for the future hydrogen economy.	8
Disagreed that the existing environmental regulatory framework is optimal for the future hydrogen economy.	25

Not answered or unclear.	57

Out of the 33 applicable responses received for questions 53 and 54, 8 respondents agreed, whereas 25 respondents disagreed that the existing environmental regulatory framework is optimal for the future hydrogen economy.

We received various suggestions from respondents, from which 7 key themes were identified on how the existing environmental regulatory framework could be improved or explored in more detail.

Of those respondents who stated the existing environmental regulatory framework is not optimal, environmental licensing, consent and permitting delays were the most cited rationale, with 15 respondents nothing this. Ten of these respondents suggested that greater resourcing of regulators is needed to address delays. In a few instances, it was noted that amendments to various legislation, including the Energy Act (1976) should be made to include hydrogen.

Seven respondents noted the lack of policy consistency and emphasised the need for an international and collaborative regulatory approach, including the implementation of hydrogen standards across relevant regulations, such as Environmental Impact Assessment requirements and emissions standards. Three of these respondents also noted that regulatory barriers need to be considered against a global need for hydrogen. For example, one respondent stated that the overuse of the precautionary principle leads to project delays or cancellation.

There were also views on the lack of clarity regarding existing regulation from 8 respondents. Some respondents put forward suggestions for developing existing guidance, including enhancing guidance on best available techniques (BAT) for hydrogen production technologies.

Four respondents also noted that a review of current environmental regulations is needed, as regulation may be over burdensome for hydrogen projects. This included suggestions from one respondent to address fugitive emissions in a review of the environmental impact assessment process, whereas another respondent thought that lower impact assessment thresholds are needed to increase development of hydrogen projects.

Six respondents also highlighted the necessity for further research on the atmospheric/climate impact(s) of hydrogen, including hydrogen leakage. One respondent also emphasised that current environmental regulations do not extend across transport and storage infrastructure, which needs to be reviewed to avoid potential negative climate impacts.

Another suggestion to improve the existing environmental regulatory framework from 6 respondents was the consideration and prioritisation of decarbonation in the wider framework (which lacked specific detail), with some noting that the current Storage of Carbon Dioxide Regulation (2010) restrict the use of carbon dioxide as a cushion gas.

Additionally, 2 respondents recommended improvements to the planning regime process, which included proposals for more legislation and guidance for sustainable water resources as a part of project planning.

Government response

We note some support from respondents for the UK's approach to environmental regulations. We also acknowledge the views raised and the suggestions put forward by respondents on how these issues could be addressed to ensure the environmental regulatory framework is optimal for the future hydrogen economy.

UK environmental regulators have worked together, with industry and other stakeholders to produce guidance on emerging techniques for hydrogen production with carbon capture - GOV.UK (www.gov.uk). Further guidance is planned on emerging techniques of hydrogen production via electrolysis. For smaller electrolysis plants, low impact installation standard rules permits and simplified permitting processes are available where applicable. Operators may contact the relevant environmental regulator for more details.

In April 2023, the department published the offshore hydrogen regulation consultation, which closed on 22nd May. The proposals in the consultation for the regulation of offshore hydrogen pipeline and storage infrastructure projects intend to ensure that environmental impacts of such projects are duly considered and that activities are conducted with proper regulatory oversight. This includes a functioning pipeline decommissioning regime when activities are completed.

Government considers the issue of fugitive hydrogen to be important now that a Global Warming Potential for hydrogen has been identified and will consider how fugitive hydrogen should be included in standards. The department, in collaboration with other government departments, is continuing the work with UK specialists and the National Physical Laboratory (NPL) to develop more reliable estimates of GB fugitive emissions, identify their impacts and increase our capability to find, measure and quantify hydrogen emissions in a more systematic way.

The department will continue to work with relevant regulators to prioritise considering and assessing the environmental regulatory regime for hydrogen, and will take views, raised in this consultation, into account when future policy/regulation is being designed.

Offshore

Question 55: Further to the regulatory assessment set out above, in your view, is the existing offshore non-economic regulatory framework optimal for supporting the development of a rapidly expanding UK hydrogen economy?

Question 56: If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)?

Consultation position

In this consultation, we anticipated that the future hydrogen economy may include the storage of hydrogen in suitable offshore reservoirs such as salt caverns and/or depleted oil and gas fields, with pipelines connecting offshore storage facilities to an onshore hydrogen network. We considered that current regulatory responsibilities across the future offshore hydrogen economy are currently not clearly defined in some areas of the existing framework. For example, storage of hydrogen is not currently a licensable activity under the Energy Act 2008. These considerations are important for first-of-a-kind (FOAK) offshore hydrogen production demonstration trials to proceed. FOAK hydrogen projects are world-first demonstrations of producing hydrogen offshore using offshore wind and then piping (sub-sea) hydrogen onshore, which have been awarded partial innovation funding from the department through the Net Zero Innovation Portfolio (NZIP). The consultation proposed that the department should, for non-economic regulatory work, prioritise considering the future offshore regulatory regime for hydrogen.

Summary of stakeholder responses

Response	Number of responses
Agreed that the existing offshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy.	3
Disagreed that the existing offshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy.	23
Not answered or unclear.	64

Out of the 26 responses received for questions 55 and 56, 3 respondents agreed, whereas 23 respondents disagreed that the existing offshore non-economic regulatory framework is optimal for supporting the development of a rapidly expanding UK hydrogen economy.

Amongst those who disagreed, 3 key themes were identified on how any shortcoming to the existing offshore regulatory framework should be addressed. Out of the 23 respondents who disagreed, 12 respondents argued for a licencing regulatory regime for offshore hydrogen pipeline and/or storage, with 3 respondents suggesting the role of Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) and the North Sea Transition Authority (NSTA) in facilitating the regulation of offshore hydrogen pipeline and storage activities, and one of these respondents also suggesting the role of HSE. In one instance, it was stated that the creation of a NPS for hydrogen is required to better explain the interface between terrestrial and offshore consenting regimes. In other views provided, one respondent highlighted that multiple offshore consenting regimes may cause inefficiencies and suggested that the NPS could provide clarity on consenting regimes.

Six respondents drew attention to the need for general regulation and guidance. There were nuances to how this should be addressed, with two respondents stressing clearer regulations for offshore carbon capture usage and storage, whereas one respondent’s views focused on market involvement and consent and marine planning. In other comments, one respondent raised concerns regarding the differences in and complexities of regulation across the devolved administration and advocated closer working with the Welsh Government.

In another instance, the coordination of hydrogen with the wider offshore energy sector was highlighted as important.

Government response

We note the views raised by respondents regarding the existing offshore non-economic regulatory framework not being optimal in supporting the development of a rapidly expanding UK hydrogen economy. We have considered the issues raised and the suggestions put forward by respondents. In April 2023, the department published the Offshore Hydrogen Regulation Consultation, which closed on 22nd May 2023. The consultation sets out initial proposals for secondary legislation to extend offshore oil and gas pipeline construction & use consenting responsibility of the North Sea Transition Authority (NSTA), in Part 3 of the Petroleum Act 1998 to apply to hydrogen pipelines. This would enable the NSTA, who is the UK regulator responsible for authorising the construction and use of offshore oil and gas pipelines in the UK Continental Shelf, to grant Pipeline Works Authorisations for offshore hydrogen pipelines and would also enable the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), which is part of the department, to operate an applicable decommissioning regime. The consultation also proposes and seeks views on plans to amend the definition of ‘gas’ in Chapter 2 of Part 1 of the Energy Act 2008 so that it includes hydrogen, which would among other things enable the NSTA to issue offshore hydrogen storage licences. As a consequence of these proposals, OPRED would be responsible for relevant offshore environmental impact assessments and habitats assessments prior to NSTA granting relevant approval(s).

We regard this as an initial approach to regulatory design which is operable for early offshore hydrogen projects and may be subject to further evolution. The department will continue to review the future offshore regulatory regime for hydrogen and will work with relevant regulators and industry to identify what further changes to the regime may be necessary, including through discussions within the Hydrogen Regulators Forum.

Chapter 6: Hydrogen blending (Q57 – 63)

Hydrogen transport and storage infrastructure lead times

Question 57: To what extent might lead times for hydrogen transport and storage infrastructure limit the scale of hydrogen production capacity in the early years of the hydrogen economy? If applicable, can this be quantified for your project (e.g. in terms of production volumes, load factors, etc.)?

Consultation position

The government has committed to design new business models for hydrogen transport and storage infrastructure by 2025. However, there would then be further lead times for infrastructure development. We identified that an initial lack of larger-scale hydrogen transport and storage infrastructure may create volume risk in the early years of the hydrogen economy, by potentially limiting the ability for producers to grow new offtake markets beyond a localised area. We asked to what extent lead times for hydrogen transport and storage infrastructure might limit the scale of hydrogen production capacity in the early years, to assess the significance of this volume risk.

Summary of stakeholder responses

Response	Number of responses
Agree that hydrogen transport and storage infrastructure lead times may limit the scale of production capacity in the early years	38
Disagree that hydrogen transport and storage infrastructure lead times may limit the scale of production capacity in the early years	1
Not sure	0

Most respondents agreed that lead times for development of hydrogen transport and storage infrastructure could limit the scale of hydrogen production capacity in the early years of the hydrogen economy. Respondents cited that a potential inability to link supply with demand could increase risk for hydrogen production projects, due to uncertainty in securing sufficient offtakers to cover their costs. As the lead times for the development of hydrogen transport and storage infrastructure are likely to exceed the lead times for some hydrogen production projects, respondents noted that early production may therefore be sized to meet local points of demand which could limit the growth of the overall hydrogen market. This could potentially reduce early investment into UK hydrogen production. One respondent added that these lead times could also deter end-users and reduce confidence in the availability of hydrogen.

One respondent did not agree that these lead times could limit the scale of hydrogen production capacity in the early years, citing that excess hydrogen could be converted back into electricity if needed.

Two respondents quantified the scale of impact for their projects; both cited that a significant scale of production capacity in their projects may require larger-scale hydrogen transport and storage infrastructure.

Arguments in agreement that hydrogen transport and storage lead times could limit early growth

Most respondents agreed that hydrogen transport and storage infrastructure development lead times could limit the scale of hydrogen production capacity in the early years of the hydrogen economy, with key reasons below:

- **Disconnect between supply and potential demand** was cited by 22 respondents as a risk caused by transport and storage infrastructure development lead times. 18 of these respondents noted that an inability to move hydrogen across UK regions could restrict hydrogen economy growth beyond industrial clusters, despite significant potential for early demand outside the clusters. Eight of these respondents specifically referred to a risk that electrolytic production may be limited without suitable infrastructure, due to difficulties in connecting with an offtake market.
- **Increased production risk and reduced investment** was cited by seven respondents, as production investments are largely reliant on finding accessible, stable sources of demand. One respondent noted that production costs would be lowered when operating continuously at a near full rate, which may be challenging to achieve if producers are constrained to only deliver to a local offtake market where there could be inconsistent demand profiles.
- **Reduced economies of scale** was cited by four respondents, who noted that if production plants are sized smaller to match local demand, this could increase levelised hydrogen costs compared to larger capacity plants or plants running at higher load factors.

Arguments in disagreement that hydrogen transport and storage lead times could limit early growth

One respondent disagreed that hydrogen transport and storage infrastructure lead times could limit the scale of hydrogen production capacity in the early years of the hydrogen economy, citing the reason below:

- **Conversion of hydrogen into electricity** was cited by one respondent as a potential solution, as electricity may be more easily traded.

Government response

We note the agreement that hydrogen transport and infrastructure development lead times could limit the scale of production capacity in the early years of the hydrogen economy. We will continue to consider the impact such lead times may have on the development of the hydrogen market and explore options to mitigate any resulting volume risk. This includes strategic planning for the deployment of such infrastructure and further progressing with our proposed position for blending to act as a reserve offtaker, if bending is enabled by government, to potentially help manage this volume risk for producers.

Blending as a reserve offtaker

Question 58: Do you see a potential for blending in helping to address this challenge by providing a route to market as a reserve offtaker? For how long do you expect this role of blending may be required? Please explain your answer and provide any relevant evidence.

Consultation position

As lead times for larger-scale hydrogen transport and storage infrastructure may limit the scale of hydrogen production capacity in the early years of the hydrogen economy, blending may be able to help 'bridge' the gap by providing a route to market for hydrogen volumes whilst both infrastructure and end user markets develop. In this question, we asked about the potential for blending to address volume risk caused by transport and storage infrastructure lead times by acting as a reserve offtaker, and for views on how long this role of blending may be required.

Summary of stakeholder responses

Response	Number of responses
Agree	46
Of whom agree that blending could help address volume risk caused by transport and storage infrastructure lead times	*43*
Of whom agree with blending's potential to help address this risk, but disagree with the reserve offtaker role	*3*
Disagree	8
Of whom disagree that blending could help address this risk	*5*
Of whom disagree with use of hydrogen for blending more generally (without citing volume risk)	*3*
Not sure	0

Most respondents agreed that blending could help address the risk that transport and storage infrastructure lead times may limit the scale of hydrogen production capacity in the early years, by providing a route to market as a reserve offtaker. The main reason cited was that blending could help to de-risk investment by providing more demand security for hydrogen producers, with some respondents noting that this could "kick-start" production projects to prepare for large-scale transport infrastructure and alternative sources of demand. Providing system flexibility was also cited as a key reason to agree with the statement, with some respondents noting that blending may help align production and demand profiles. Supporting the decarbonisation of the gas networks and potentially helping to enable a transition to 100% hydrogen for heat were also cited by a few respondents as reasons in favour of blending more generally.

Three respondents did agree that blending could help address volume risk caused by transport and storage infrastructure lead times but thought blending should play an alternative role to that of a reserve offtaker. Two of these respondents thought blending should play a more prominent role in the hydrogen economy than that of a reserve offtaker and one thought blending should act as a 'flexible offtaker', where the role of blending varies according to locational needs.

Some respondents disagreed that blending could help address this risk by acting as a reserve offtaker. Two respondents cited that alternative measures would be preferential for addressing this risk, such as co-locating production with demand. One respondent cited that blending's technical complexity and variations in gas network demand could limit blending's ability to absorb excess hydrogen volumes and address the risk in practice. Two respondents, without citing volume risk, thought that hydrogen should only be used as a last resort for sectors that have no alternatives to decarbonise.

Of the 18 respondents who considered how long the role of blending as a reserve offtaker may be required, most thought that this would be primarily determined by developments in other areas of the hydrogen economy, such as the roll out pace of transport and storage infrastructure and the outcome of the 2026 government decision on whether to transition to 100% hydrogen for heat.

Arguments in support of blending having value to address volume risk caused by transport and storage lead times

Most respondents agreed that blending could help address volume risk caused by transport and infrastructure lead times by acting as a reserve offtaker, with key reasons below:

- **Providing demand security** was cited by 36 respondents, who thought that blending could de-risk production investment by providing an early route to market for excess hydrogen volumes and by providing system flexibility in case of variable demand. Five of these respondents noted that blending could act as a 'bridge' to absorb excess hydrogen volumes before larger-scale transport and storage infrastructure is in place to better connect supply with demand.

- **Providing geographically extensive demand** was cited by 13 respondents, who noted blending may support development of hydrogen production in geographically disperse locations, including areas that do not have early pathways to large-scale industrial demand. Seven of these respondents noted that this could benefit electrolytic hydrogen producers.
- **Lowering costs and increasing confidence in supply** was cited by six respondents. These respondents cited that by helping to de-risk production, blending may be able to lower costs of hydrogen and increase certainty of supply. In turn, this could encourage other potential offtakers to adopt hydrogen, providing greater demand security.

Arguments against blending having value to address volume risk caused by transport and storage lead times

- Some respondents disagreed that blending could help address this volume risk by acting as a reserve offtaker, with key reasons below: as being preferential to blending in addressing this risk. Ideas included co-locating production with demand and using hydrogen for power as an alternative reserve offtaker.
- **Alternative measures** were cited by two respondents as being preferential to blending in addressing this risk. Ideas included co-locating production with demand and using hydrogen for power as an alternative reserve offtaker.
- **Technical complexities and/or variations in gas network demand** was cited by one respondent, who thought that this could be a barrier to blending absorbing excess hydrogen volumes and de-risking production investment in practice.

Government response

We note the agreement that blending could help to address volume risk caused by transport and storage infrastructure lead times by acting as a reserve offtaker. We will continue to develop and reflect upon this approach as we progress towards a blending policy decision. We note that a few respondents did not agree with this approach and we will take these views into account during policy development.

Blending transport and infrastructure requirements

Question 59: Do you think that new transport infrastructure for 100% hydrogen may be required solely for the purposes of blending? If applicable, what scale of 100% hydrogen transport infrastructure would your project require to reach the GB gas networks (at distribution or transmission level)?

Consultation position

If producers intend to blend and are not located close to the existing gas network and/or a suitable blending injection point, they may require new 100% hydrogen transport infrastructure to transport their hydrogen to a suitable injection point on the gas network. We asked whether new 100% transport infrastructure may be required solely for blending and sought to understand the potential scale of infrastructure required for respondent’s projects, if applicable.

Summary of stakeholder responses

Response	Number of responses
Agree that new 100% hydrogen transport infrastructure may be required solely for blending	21
Disagree that new 100% hydrogen transport infrastructure may be required solely for blending	17
Not sure	2

Respondents’ views were mixed on whether new 100% hydrogen transport infrastructure may be required solely for the purposes of blending. Of the 40 total respondents, seven cited that if transport infrastructure was required, it would likely be at a small-scale given the likely proximity between hydrogen producers and the gas networks. Two respondents noted that the scale of transport infrastructure required would depend on the roll-out model for blending, as producers may require additional transport if available blending injection points were strategically limited. One respondent noted that electrolytic producers may be more likely to rely on non-pipeline transport in the early years due to their geographical dispersal and potentially irregular production patterns.

Seven respondents mentioned the risk of stranded assets. Of these, four thought this risk could be minimised with planning, as transport infrastructure could potentially be repurposed or continue to be used if a decision was made to transition to 100% hydrogen for heat. Two thought that such assets would likely become stranded in practice and one thought that such infrastructure should only be developed where the risk of stranded assets is minimal.

Seven respondents mentioned costs and potential commercial support mechanisms for such transport infrastructure. Two thought that commercial support should be provided by the Hydrogen Production Business Model, and four thought that commercial support for such infrastructure may be difficult to justify, citing potentially high costs and alternative, more strategically important uses of that support. One respondent thought that, given the broad coverage of the gas network and likely limited scale of transport infrastructure required, costs are unlikely to be a commercial constraint.

Two respondents were unsure whether 100% hydrogen transport infrastructure may be required solely for the purposes of blending.

On the scale of 100% hydrogen transport infrastructure that may be required for respondents’ projects, three out of the four relevant responses cited that their projects would be located near the gas networks and/or alternative suitable offtakers, with two of these citing that they would require small-scale pipelines to connect to a gas network injection point. One respondent cited that their project may require 5 - 10km of 100% hydrogen transport infrastructure to reach suitable points on the gas network to blend.

Arguments around developing 100% hydrogen transport infrastructure for blending

Respondents had differing views on the potential requirement for 100% hydrogen transport infrastructure developed solely for blending, with key considerations below:

- **Scale of transport infrastructure** was cited by nine respondents. Seven of these respondents cited that the extensive coverage of the gas network and the likely proximity of hydrogen producers may minimise the size of any required transport infrastructure. Two of these respondents noted that the scale would depend on the roll-out model for blending, as any potential restrictions on available blending locations could increase the scale of transport required to reach those locations.
- **Stranded assets** were cited by seven respondents. Four respondents stated that 100% hydrogen transport infrastructure for blending could be reused for other purposes, especially with careful system planning, which could mitigate the risk of stranded assets. Conversely, two respondents expressed concerns about assets becoming stranded, recommending caution in this area. One respondent stated that such infrastructure should only be developed where the risk of stranded assets is minimal.
- **Costs and commercial support mechanisms** were cited by seven respondents. Four of these respondents stated that it would be difficult to justify investment into such infrastructure, given potentially high costs and alternative, more strategic uses for that funding. However, one respondent thought that, given the broad coverage of the gas network and likely limited scale of transport required, costs are unlikely to be a commercial constraint. Two respondents thought costs for such infrastructure should be supported by the Hydrogen Production Business Model.

Government response

We thank respondents for their views and note the varied responses to this question. We will continue to consider the potential need for 100% hydrogen transport infrastructure solely for the purposes of blending as we progress towards a policy decision. This includes consideration of the value for money for such infrastructure and whether and/or how such infrastructure should be supported, if required.

Stimulating growth in hydrogen demand

Question 60: Do you think that a reserve offtaker (e.g. blending) could help stimulate growth in hydrogen demand, by providing potential offtakers with more confidence to switch to hydrogen? If so, for how long might this be beneficial? What alternative measures could be enacted to help stimulate growth in hydrogen demand? Please explain your answer and provide any relevant evidence.

Consultation position

There is a risk that delays to at scale hydrogen adoption by end use sectors could create a mismatch where the potential for hydrogen production capacity outstrips available demand. A reserve offtaker may help mitigate this volume risk by providing a route to market for volumes of hydrogen without an alternative offtaker available. This may incentivise additional production capacity by reducing investment risk which, in turn, could promote security of hydrogen supply and provide more confidence for end users to switch to hydrogen, thus also increasing demand. In the consultation, we asked whether a reserve offtaker, such as blending, could help stimulate growth in hydrogen demand by providing potential offtakers with more confidence to switch to hydrogen. We also sought views on how long this may be beneficial for, and for views on alternative measures to help stimulate growth in hydrogen demand.

Summary of stakeholder responses

Response	Number of responses
Agree that a reserve offtaker could help stimulate growth in hydrogen demand	40
Disagree	7
Of whom disagree that a reserve offtaker could help stimulate growth in hydrogen demand	*4*
Of whom disagree with use of hydrogen for blending more generally (without citing stimulation of growth in demand)	*3*
Not sure	2

Most respondents agreed that a reserve offtaker, such as blending, could help stimulate growth in hydrogen demand. A key reason cited was that a reserve offtaker could de-risk and therefore stimulate investment into production capacity, providing more certainty of supply which could encourage other potential offtakers to switch to hydrogen. Some respondents noted that a reserve offtaker may also help reduce overall hydrogen costs, by helping develop a more competitive economy of scale and helping to avoid the need for costs to ramp production up and down in response to variable demand. A few respondents cited a reserve offtaker as being able to overcome a 'chicken and egg' problem for the hydrogen economy, by incentivising early production to help increase consumer confidence and unlock potential sources of demand.

Some respondents did not agree that a reserve offtaker could help stimulate growth in hydrogen demand. Three of these respondents stated that a strategic approach for developing the demand-side of hydrogen could be more effective in aligning production with demand. Two respondents, without citing stimulation of growth in demand, thought that hydrogen should only be used as a last resort for sectors that have no alternatives to decarbonise.

Two respondents were unsure whether a reserve offtaker could help stimulate growth in hydrogen demand.

Of the eight respondents that considered how long this reserve offtaker role may be required for, seven cited that the role would be required during the early years of the hydrogen economy ahead of a mature market with large-scale hydrogen transport and storage infrastructure. Two of these respondents cited the late 2030s as the end of a reserve offtaker's usefulness for the hydrogen economy.

Arguments in support of a reserve offtaker being able to stimulate growth in hydrogen demand

Most respondents agreed that a reserve offtaker, such as blending, could help stimulate growth in hydrogen demand, with key reasons below:

- **De-risk and stimulate investment into production** was cited by nine respondents, who noted that this could increase certainty of hydrogen supply.
- **Lowering costs** was cited by seven respondents, who thought that blending could help create economies of scale and avoid operational costs being incurred in ramping production up and down, which could in turn lower the levelised cost of hydrogen.
- **Increase confidence for other potential offtakes** was cited by 13 respondents, who noted that a greater security of supply could build confidence in low-carbon hydrogen and encourage other potential offtakes to fuel-switch. Four of these respondents noted that this may help overcome a potential 'chicken and egg' challenge for the hydrogen economy, where production investment may be limited by available demand and vice versa.

Arguments against a reserve offtaker being able to help stimulate growth in hydrogen demand

Some respondents did not agree that a reserve offtaker, such as blending, could help stimulate growth in hydrogen demand, with the key reason below:

- **A strategic approach to developing hydrogen demand** was cited by three respondents as being a more effective means to grow the hydrogen economy than using a reserve offtaker, such as blending.

Alternative measures to help stimulate growth in hydrogen demand

Twelve respondents cited alternative measures that may help stimulate growth in hydrogen demand. These include:

- **Commercial measures to spread risk and/or support fuel-switching** were cited by eight respondents. Ideas to incentivise demand included guarantees of origin, obligations for low-carbon fuel use and providing financial support to convert equipment and processes to hydrogen. Commercial measures are further explored in Question 61, below.

- **Supporting development of demand from end-use sectors** was cited by three respondents, who thought supporting development of large-scale industrial applications of hydrogen, such as through technology development, could help stimulate growth in demand.
- **Hydrogen storage and exports** were cited by three respondents, two of whom noted the requirement for infrastructure development in these areas.

Government response

We note the agreement that a reserve offtaker, such as blending, could help to stimulate growth in hydrogen demand. We will continue to consider the value of blending in this role as we progress towards a policy decision and as part of our wider low-carbon hydrogen demand strategy to understand the potential market-building benefits it may have. We note that a few respondents did not agree with this assessment and we will take these views into account during policy development.

Blending and demand volatility

Question 61: Do you agree with our assessment of the range of options to address demand volatility? In addition to these measures, do you think a reserve offtaker (e.g. blending) could have value in managing producer volume risk caused by volatile demand? Please explain your answer and provide any relevant evidence.

Consultation position

Even where producers have secured offtaker(s) of hydrogen, they may face volume risk caused by volatile demand, such as if an offtaker goes into insolvency. The consultation reviewed a series of technical and commercial risk mitigation strategies to help mitigate demand volatility and/or manage any impacts it may cause. We asked whether respondents agreed with our assessment of the range of options to address demand volatility, and whether a reserve offtaker, such as blending, could have value in addition to these measures.

Summary of stakeholder responses

Do you agree with our assessment of the range of options to address demand volatility?

Response	Number of respondents
Agree with our assessment	34
Disagree	6
Not sure	1

In addition, do you think a reserve offtaker (e.g. blending) could have value in managing producer volume risk caused by volatile demand?

Response	Number of responses
Agree that a reserve offtaker has value in managing demand volatility in addition to these measures	28
Disagree that a reserve offtaker has value in managing demand volatility in addition to these measures	5
Not sure	2

Most respondents agreed with our assessment of the range of options to address demand volatility, with two respondents noting that they are currently looking into these measures for their own projects.

Some respondents disagreed with our assessment of the range of options. Three of these respondents cited concerns about the suitability of some of the options, which are noted in the bullet points below. One respondent cited additional potential measures, such as converting excess hydrogen into electricity, and one respondent thought that the assessment did not put sufficient weight on the role blending could play in managing volume risk.

Arguments around the range of options to address demand volatility

Of both the 34 respondents who agreed and the six respondents who disagreed with our assessment of the range of options to address demand volatility, nine cited the following concerns with the range of options presented:

- **Adjusting production could be suboptimal** was cited by eight respondents. These respondents cited that, although producers may technically be able to ramp production up and down to meet demand, this could cause inefficiencies, increase levelised costs of hydrogen and/or decrease potential decarbonisation and should therefore be avoided where possible.
- **Commercial measures that transfer risk to consumers could be unattractive** was cited by three respondents, who thought that offtakers may be unwilling to enter contracts with producers where some of the commercial risk is transferred to them.

Most respondents agreed that a reserve offtaker, such as blending, could have value in managing volume risk caused by volatile demand in addition to the other assessed measures. A key reason was that blending could help producers avoid the need to ramp production down in response to variable demand, which in turn could lower costs and maximise carbon abatement. Another key reason was that a reserve offtaker could provide producers with another option to choose from when considering their risk management strategies, helping provide flexibility in their approach.

Some respondents did not agree that a reserve offtaker could have additional value in managing demand volatility. Two of these respondents cited that producers should take responsibility for managing their own risks, without need for a reserve offtaker. Two respondents thought a reserve offtaker would not be necessary with sufficient strategic planning to match supply with demand. One respondent cited that blending may offer limited demand flexibility as a reserve offtaker.

Arguments in favour of a reserve offtaker having additional value in managing demand volatility

28 respondents agreed that a reserve offtaker, such as blending, could have value in managing demand volatility in addition to the other assessed measures, with key reasons below:

- **Avoiding the need to ramp production up and down** was cited by nine respondents. Six of these respondents noted that a reserve offtaker could help maximise the carbon abatement from low-carbon hydrogen production by avoiding the need to ramp production down in response to drops in demand. One respondent noted that ramping production up and down could increase project costs and therefore potential government support required. One respondent cited that if demand fell to zero, a production project would no longer receive revenue protection from the Hydrogen Production Business Model, whereas a reserve offtake may enable continued operation until other offtakers become available.
- **Providing more choice to producers** was cited by seven respondents. These respondents saw value in deploying a diverse range of solutions to manage demand volatility, including a reserve offtaker, to help enable producers to select the optimal solution(s) according to their project requirements.
- **Providing baseline demand** was cited by three respondents, who thought a reserve offtaker could help to kickstart hydrogen production ahead of significant alternative demand sources.

Arguments against a reserve offtaker having additional value in managing demand volatility

Five respondents did not agree that a reserve offtaker, such as blending, could have value in managing demand volatility in addition to the other assessed measures, with key reasons below:

- **Producers should be responsible for the risk** was cited by two respondents, who thought that businesses should be able to manage demand volatility without requiring a reserve offtaker.

- **Supporting development of demand from end-use sectors** was cited by two respondents as a preferable alternative approach for managing demand volatility.
- **Limited blending flexibility and/or gas network demand** was cited by one respondent, who thought that this could be a barrier to blending managing demand volatility in practice.

Government response

We note the agreement with our assessment of the range of options available to address demand volatility. We also thank respondents for providing views on alternatives and will continue to explore any such options that may be available to producers. We recognise that some respondents had concerns about the potential downsides or limitations of some options, such as in decreasing some decarbonisation benefits. These will be further considered as we continue to develop our strategic approach for blending to act as a reserve offtaker, if blending is enabled by government.

We also note the agreement that a reserve offtaker, such as blending, could have value in addition to those other measures. We will continue to explore this as we develop the case for hydrogen blending, with consideration of the duration for which a reserve offtaker may be beneficial in helping to address demand volatility. We recognise that some respondents did not agree with this assessment and we will take these views into account during policy development.

Alternative reserve offtakers

Question 62: If you believe a reserve offtaker would be beneficial for the hydrogen economy, are there any alternative reserve offtakers that could fulfil this role instead of, or in combination with, blending? Please explain your answer and preferred reserve offtaker(s) with supporting evidence.

Consultation position

Having reviewed different forms of volume risk and explored blending's potential value in helping to address them as a reserve offtaker, we asked whether alternative reserve offtakers could fulfil the same role instead of, or in combination with, blending.

Summary of stakeholder responses

Response	Number of responses
Identified alternative reserve offtakers	25
Did not identify alternative reserve offtakers	8
Not sure	0

Most respondents who answered this question identified alternative reserve offtakers that could be used instead of or in combination with blending. Key alternatives cited include:

- **Storage** was cited by nine respondents as a potential alternative reserve offtaker that could be used instead of or in addition to blending. Three of these respondents noted that hydrogen could potentially be used to meet cushion gas requirements (gas volumes that are permanently required in storage sites to retain sufficient pressure for use) in natural gas storage. Two noted that lead times for 100% hydrogen storage infrastructure development could make it less suitable as a reserve offtaker than blending during the early years of the hydrogen economy.
- **Ammonia production** was cited by six respondents. Four of these respondents noted that ammonia could serve both UK and international consumers, such as for use in maritime and rail. Two respondents noted that this may lead to further ammonia storage requirements with associated lead times.
- **Power** was cited by four respondents, where either hydrogen blends or 100% hydrogen may be served to power generators directly rather than via gas networks. One respondent noted that this may enable power generators to better manage the rates of blends they receive.
- **Exports** were cited by four respondents, with one of these respondents citing a prior need for hydrogen transport infrastructure development to enable exports.
- **Line pack** was cited by two respondents, where producers may be able to utilise the capacity of available 100% hydrogen pipelines for the purposes of storage.

Eight respondents stated that there were no or limited alternative reserve offtakers that could provide support to manage volume risk, especially in the early years of the hydrogen economy.

Of the 11 respondents who stated their preferred reserve offtaker(s), nine preferred blending, with key reasons cited being blending's potential for early deployment, flexibility and low cost compared to some alternatives. Conversely, one respondent preferred ammonia production and one respondent preferred hydrogen storage as a reserve offtaker.

Government response

We thank respondents for their views on the potential alternative reserve offtakers. This will be useful as we continue to develop our understanding of the demand-side of the hydrogen economy. Whilst we will continue to explore the viability of these alternatives, we will also continue to develop our strategic rationale for blending to act as a reserve offtaker, if blending is enabled by government.

It is worth noting that we believe blending can only be a transitional option, as it relies on an extensive natural gas network being available to blend into, which will reduce as we progress to net zero. Some of the alternative offtakers identified by respondents may have longer lead times for development than blending, but they may also have longer-term roles to play in supporting development of the hydrogen economy.

Benefits and risks of blending

Question 63: In addition to those mentioned in this chapter, do you see any benefits and/or risks associated with blending? Please explain your answer and provide any relevant evidence.

Consultation position

Throughout this consultation chapter, we noted various potential benefits and risks associated with blending. These include blending's potential benefits in helping to manage volume risk and the potential risk that new 100% hydrogen transport infrastructure developed for blending may become stranded assets. In this final question, we sought views on whether there are benefits and/or risks associated with hydrogen blending in addition to those mentioned in this chapter

Summary of stakeholder responses

Response	Number of responses
Identified benefits and/or risks associated with blending	43
Of whom identified benefits	*29*
Of whom identified risks	*29*
Not sure	0

An equal number of respondents identified benefits and risks associated with blending. Some of these comments restated the importance of benefits and risks already mentioned within this chapter, and some identified additional benefits and risks.

Identified potential benefits associated with blending

- **Hydrogen market development** was cited by 22 respondents as a key benefit of blending. Most of these respondents thought that blending could help 'kickstart' growth across the hydrogen economy by supporting production and thereby incentivising demand. One respondent noted that this could be a key enabler for growth in regions without large-scale sources of potential industrial demand. Another noted that, by ensuring the UK is an early mover in the global hydrogen transition, blending may help provide significant opportunities for developing domestic low-carbon hydrogen supply chains.
- **Promoting investment and lowering costs** was cited by 16 respondents. Most of these respondents thought that blending could be a low cost means to de-risk investment and encourage economies of scale. In turn, this could potentially help to

lower levelised costs of low-carbon hydrogen and the government support required to enable hydrogen to compete with natural gas.

- **Reducing carbon emissions** was cited by 11 respondents. Six of these respondents thought that blending could be a significant short-term step towards decarbonising domestic heat and other sectors connected to the gas grid. Three noted that this could help to achieve government net zero objectives.
- **Increasing energy system resilience** was cited by four respondents, such as by diversifying the input of energy supplies. Three of these respondents noted that blending could enable hydrogen from electrolysis to contribute to energy system resilience and flexibility.
- **Helping to enable a potential transition to 100% hydrogen for heat** was cited by four respondents, who saw value in lessons learned from blending to better inform any potential transition. One respondent noted that the physical network, commercial and regulatory framework changes required for blending may help ease this potential transition.
- **Increasing social acceptance of hydrogen** was cited by three respondents, who noted the value blending may have in improving consumer 'buy-in' for low-carbon hydrogen.

Identified potential risks associated with blending

- **Safety and usability of blends for gas networks and connected end users** was cited by 18 respondents as a key blending risk. 15 of these respondents noted a risk that end users that are more sensitive to variations in gas composition could find it challenging to accept hydrogen blends and/or variable blend rates. Seven cited a potential need for installation of deblending infrastructure to help mitigate any such risks, with three noting the need for further thinking on the cost allocation for such infrastructure. Five respondents specifically referred to end users connected at transmission level as being potentially more at risk to variations in gas composition. One respondent noted a potential risk of hydrogen leaks and/or damage to the existing gas network and one stated that any accidents resulting from blending could be damaging to the wider low-carbon hydrogen sector.
- **Limited reduction of carbon emissions** was cited by five respondents. Three of these respondents noted the lower volumetric energy density of hydrogen compared to natural gas, meaning if hydrogen was blended up to a maximum of 20% by volume this would provide carbon savings of up to 6-7%. One respondent had concerns that the decarbonisation benefits of blending might be oversold by a presentational focus on volumes of hydrogen that are blended, rather than energy content delivered.
- **International gas trading impacts** were cited by five respondents, who noted that if the UK and the EU adopt different levels of hydrogen blends into transmission networks this could impact cross-border gas trading via interconnectors.
- **Costs** were cited by five respondents, who noted the potential need for blending infrastructure development costs and the impact blending may have on consumer bills.

- **Stranded assets** were cited by four respondents, as there is a risk that infrastructure developed for blending could become obsolete if a transition to 100% hydrogen for heat was not made and/or if relevant parts of the gas network could not be repurposed for other uses.
- **Slowing developments in other areas of the hydrogen economy** was cited by four respondents. Two of these respondents cited that hydrogen transport or storage assets may lose investment value if blending offers a more convenient route to market.
- **Other risks** were cited by nine respondents. Three were concerned that a reserve offtaker role for blending may not be realised in practice, either due to blending outcompeting other uses of hydrogen or due to blending being technically constrained. Two noted a need for government clarity on blending and/or wider regulatory frameworks to assist in the roll out of low-carbon hydrogen projects. Two cited a need to better inform the public on hydrogen to increase consumer acceptance of blends. One respondent cited that blending could open the door for continued fossil fuel gas usage and delay the conversion of some energy users to emissions-free solutions. One respondent noted that blending could not benefit locations without gas network access, which may require further strategic planning to account for.

Government response

We thank respondents for their assessment of the benefits and risks that may be associated with hydrogen blending. As well as the benefits, we are aware of the risks cited by respondents and will continue to consider and account for them as we develop the case for hydrogen blending. We note that some of these risks, such as impacts on international gas trading, may be more applicable when making a decision on whether and/or how to enable blending into the gas transmission networks. Transmission-level blending may be enabled via a separate policy decision at a later date. However, we will also aim to account for any such risks when making a decision on whether and/or how to enable blending into the GB gas distribution networks. We intend to provide further details on our assessment of the benefits and risks associated with blending via an upcoming hydrogen blending consultation, which we aim to publish and consider ahead of our policy decision intended in 2023.

Acronyms

Acronym	Definition
CAPEX	Capital expenditure
CCC	Climate Change Committee
CCUS	Carbon capture, usage and storage
CfD	Contract for difference
COMAH	Control of Major Accident Hazards
DEVEX	Development expenditure
EU	European Union
FID	Final Investment Decisions
FOAK	First of a kind
FSO	Future Systems Operator
GB	Great Britain
HSE	Health and Safety Executive
HMG	His Majesty's Government
HPBM	Hydrogen Production Business Model
LCCC	Low Carbon Contracts Company
LOHC	Liquid Organic Hydrogen Carriers
NPL	National Physical Laboratory
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NZIP	Net Zero Innovation Portfolio
NOAK	Nth of a kind

NSTA	North Sea Transition Authority
NZHF	Net Zero Hydrogen Fund
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
Ofgem	Office of Gas and Electricity Markets
OFTO	Offshore Transmission Owner
OPEX	Operating expenditure
RAB	Regulated Asset Base
SDAP	Hydrogen Sector Development Action Plan
SoS	Secretary of State
T&S	Transport and storage
TCPA	Town and Country Planning Act
UNC	Uniform Network Code
UK	United Kingdom
UK ETS	UK Emissions Trading Scheme

Glossary

Term	Definition
Allocation	The process of allocating revenue support through the hydrogen business model
Balance sheet	The national balance sheet shows the market value of the financial and non-financial assets for the UK
Carbon Budget 6	Limits the volume of greenhouse gases emitted over a 5-year period from 2033 to 2037, taking the UK more than three-quarters of the way to reaching net zero by 2050
Carbon Capture Utilisation and Storage	The process of capturing carbon dioxide from industrial processes, power generation, certain hydrogen production methods. The captured carbon dioxide is then either used or stored permanently
Carbon price	A cost applied to carbon emissions to encourage emitters to reduce the amount of greenhouse gases they emit into the atmosphere
CCUS cluster sequencing process	The process by which CCUS industrial clusters are chosen, with two anticipated by the mid-2020s, and a further two clusters by 2030 as outlined in the 10 Point Plan
CCUS-enabled hydrogen production	A process for producing low carbon hydrogen, and capturing, monitoring, metering and exporting CO2 generated in the production process
Contract for difference	A Contract for Difference, as set out in the Energy Act 2013, is a contract between a generator and a counterparty to encourage the generation of low carbon electricity whereby the counterparty will pay an electricity generator the difference between the CfD reference price and the CfD strike price
Electrolysis	A hydrogen production process which involves using electricity to generate hydrogen from water. Low carbon hydrogen is created when low carbon electricity is used as the input fuel.

Electrolytic hydrogen production	Hydrogen produced from electrolysis
Energy Bill	A Bill to make provision about energy production and security and the regulation of the energy market.
First of a kind	The first low carbon hydrogen projects accessing revenue support through the business model, who take on first mover risk by entering an undeveloped low carbon hydrogen market
Hydrogen production business model	The objective of the hydrogen business model is to incentivise the production and use of low carbon hydrogen, and help us achieve our ambition of up to 10 GW by 2030, subject to affordability and value for money. It is designed to provide hydrogen producers with revenue support to overcome the operating cost gap between low carbon hydrogen and fossil fuels in order to unlock private investment in hydrogen projects.
Low carbon hydrogen	Hydrogen that is produced with significantly lower greenhouse gas emissions compared to current methods of production – methods include methane reformation with CCUS and electrolysis using renewable electricity. The hydrogen produced will be subject to meeting the 20gCO2e/MJ LHV of hydrogen threshold set out in the proposed UK LCHS to be considered low carbon for the purpose of this scheme.
Net zero	Legislation passed by the government to reduce greenhouse gas emissions to net zero by 2050
Net Zero Hydrogen Fund	A £240m fund to support low carbon hydrogen production
Nth of a kind	Low carbon hydrogen projects entering into a more developed hydrogen market using mature technologies and processes with less risk
Ofgem RIIO mechanism	RIIO is a mechanism established by Ofgem that involves setting Revenue using Incentives to deliver Innovation and Outputs designed to encourage energy network companies to: play a full role in delivery of a sustainable energy sector and deliver value for money network services for existing and future consumers.
Reference price	Reflects the price that the producer would receive for hydrogen in the market under a variable premium model
Renewable Transport Fuel Certificates	Suppliers of fuels, both renewable and non-renewable, totalling 450,000 litres or more in an obligation period have a responsibility under the RTFO. They can meet their obligation by claiming their RTFCs for the supply of renewable fuels. For every litre of renewable fuel, one certificate can be claimed.

	However, some fuels are incentivised and awarded double the RTFCs per litre (or kilogram) supplied, depending on specific wastes and residues.
Renewable Transport Fuel Obligation	Mechanism to support the production and use of renewable fuels based on obligation on suppliers of transport and non-road mobile machinery fuel in the UK to show that a percentage of the fuel they supply comes from renewable and sustainable sources
Revenue support	The funding provided on an ongoing basis, for an agreed term, which would cover a proportion of operating costs and an appropriate rate of return on private sector capital invested
UK Emissions Trading Scheme	Replacing the UK's participation in the EU ETS, the UK Emissions Trading Scheme applies to energy intensive industries, the power generation sector and aviation
Volume risk	The risk that a hydrogen production facility is unable to sell enough volumes of hydrogen to cover costs with reasonable confidence

This publication is available from: www.gov.uk/government/consultations/proposals-for-hydrogen-transport-and-storage-business-models