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Response to: Hydrogen transport and storage infrastructure – A consultation on business model designs, regulatory arrangements, strategic planning and the role of blending

22 November, 2022

Uniper is a leading international energy company, has around 11,500 employees, and operates in more than 40 countries. The company plans for its power generation business in Europe to be carbon-neutral by 2035. Uniper's roughly 33GW of installed generation capacity make it one of the world's largest electricity producers. The company's core activities include power generation in Europe and Russia as well as global energy trading and a broad gas portfolio, which makes Uniper one of Europe's leading gas companies. In addition, Uniper is a reliable partner for communities, municipal utilities, and industrial enterprises for planning and implementing innovative, lower-carbon solutions on their decarbonization journey. Uniper is a hydrogen pioneer, is active worldwide along the entire hydrogen value chain, and is conducting projects to make hydrogen a mainstay of the energy supply. The company is based in Düsseldorf and is one of Germany's largest energy supply companies.

In the UK, Uniper operates a flexible generation portfolio of seven power stations capable of powering around six million homes, and a fast-cycle gas storage facility.

Consultation Response

We have set out below our answers to the consultation questions. Our views in summary:

- Government support and strategic planning will be needed to develop the hydrogen system including storage as the reserve offtaker; taking pragmatic steps now and transitioning to a competitive market-led approach with regulation of natural monopoly infrastructure (i.e. pipeline transportation) as the market matures.
- Hydrogen blending could play an important role; however, it comes with its own risks and costs, and its value is ultimately determined by the decision on hydrogen for heat, which has significant implications for infrastructure development, e.g., the extent of pipelines and the need for seasonal hydrogen storage.
- The timely development of hydrogen specific standards and regulation will be needed to underpin the hydrogen economy.

General Considerations

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.

The consultation says that "From the mid-2030s onwards, we envisage regional and/or national scale networks to be developing". Depending what is meant by "developing", this may be too late. If hydrogen is going to be a key vector for decarbonising industry and providing low-carbon dispatchable power generation, at least some regional and national infrastructure will need to be available by the late-2020s. This means the development of regional and national infrastructure – FEED and planning – needs to begin no later than the mid-2020s. New infrastructure, such as salt cavern storage, may take 6-8 years to get through planning alone.

We agree with your assertion that the need for large, integrated and resilient infrastructure is not dependent on the decision about hydrogen for heating, but the shape and design of the network is highly dependent on it: the scale and location of pipelines and storage will be significantly different if hydrogen is to be used domestically as well as by industry. There may be a need for more or different government intervention if hydrogen is to serve a significant proportion of domestic heat as well as industrial demand: the current system suggests there are a lack of market signals to bring forward interseasonal storage. The decision on hydrogen for heat cannot be delayed.

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.

We don't agree the need for the initial business model to serve both FOAK and NOAK projects: we will see an evolution of support as FOAK projects deliver learning and, through operation, develop an investible market. Support will also need to evolve through the transition from natural gas to hydrogen: without government support it may not be possible to maintain a legacy gas market until the transition to hydrogen is complete. NOAK hydrogen projects might not need support, if market returns are predictably adequate.

Hydrogen Transport Infrastructure

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? Please explain your answer and provide any relevant evidence.

Yes. It should be noted that supply and demand uncertainly is very significantly exacerbated by uncertainty over the role of hydrogen for domestic heating. A decision on this needs to be made as soon as possible, ideally before – and certainly not later than – the 2026 date that government has set out.

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

Yes. A merchant model is unlikely to be suitable for pipelines, but is likely to be the best model for non-pipeline transport.

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.

Uncertainties over the scale and timing of supply and demand for hydrogen and a limited user/customer base are likely to be the biggest barriers to investment in, and future-proofing (i.e. right-sizing) hydrogen pipeline infrastructure.

Where hydrogen production projects require support from the construction of new local and regional hydrogen pipelines, rather than on-site use or the repurposing of existing infrastructure, investment will probably only be made where there is reasonable certainty that off-takers will be there long enough to make the investment risk acceptable.

Uncertainties with the planning processes and the timescales for getting consents could also be barriers to the construction of new hydrogen networks. Planning and environmental consents may be the biggest barrier to actually getting infrastructure built, once investment decisions have been made.

6. In your view, which business model design options do you consider may be suited to address the barriers in a growth phase? Please explain your answer and provide any relevant evidence.

Government as a long-term capacity booker or government as co-investor is likely to be needed to support decisions to scale pipeline infrastructure for future, rather than current, supply and demand.

There may be a need for support for Local Authority planning departments and supporting regulatory consultees for non-economic regulation. Our experience is that some non-economic regulators and consultees, and particularly the Environment Agency, are already struggling to deal with their existing application workload.

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.

Yes. Whilst onshore pipelines are quicker to build than network-scale storage, securing planning consent for new infrastructure is a very lengthy process (upwards of 6 years). Implementing measures to streamline this process will be critical, such as publishing clear statements in the NPSs and providing significant support to planning authorities and regulators for resourcing and upskilling to develop rules for hydrogen infrastructure and efficiently process applications.

Early projects, including non-pipeline transport projects, will also need support ahead of 2025 for DEVEX and CAPEX costs. For very early hydrogen pipelines, support through either the existing gas network RAB or funds like Ofgem's Strategic Innovation Fund may enable early deployment. In the longer term, for fairness reasons, it is important that hydrogen transport customers pay for the costs that arise from the construction and/or operation of a hydrogen transport network and that costs are not passed on to the natural gas network customers (no cross-subsidisation).

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? Please explain your answer and provide any relevant evidence.

Yes.

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? Please explain your answer and provide any relevant evidence.

Yes, there is a need for compatibility so we can transition from one to the other without market distortions. However, they don't need to be the same. As the market moves toward maturity and the scale of future use becomes clearer, FID for futureproofed infrastructure will not depend on government support, which can be reduced or phased out.

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? Please explain your answer and provide any relevant evidence.

Yes. Operators of natural gas T&S infrastructure are likely to be the same as operators of hydrogen T&S infrastructure, and every organisation has finite investment resources. Government support will be needed to manage the transitional period when natural gas infrastructure is still needed but hydrogen infrastructure is the growth opportunity for investors. Additional support for remaining gas infrastructure may be required to bridge the transition. It is likely that the same RAB model will work to support hydrogen pipelines as has supported gas pipelines. However, in the early days of the hydrogen market, and in the late days of the legacy gas market, there won't be enough consumers to fund the RAB and additional government support will be needed.

Government should ensure separation of regulated asset bases, with requirements for legal distinction of hydrogen and gas network operators.

11.In your view, are there any other considerations we should take into account? Please explain your answer and provide any relevant evidence.

Government will need to ensure that hydrogen transport infrastructure is developed in tandem with CCUS transport infrastructure. There may need to be some centralised strategic assessment of future needs to support effective coordination.

There may be a need for support for Local Authority planning departments and supporting regulatory consultees for non-economic regulation to ensure that determinations of planning applications can be processed in a timely manner.

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? Please explain your answer and provide any relevant evidence.

Private ownership is the most suitable model for hydrogen networks, though co-ownership may be suitable for strategically important early projects.

The effective separation of network operators from activities of production, supply and storage, i.e. vertical unbundling, is important to avoid conflicts of interest and ensure fair competitive access to networks:

- The same company should not be allowed to control both the hydrogen network and hydrogen production, storage or supply interests.
- The construction, ownership and operation of power-to-gas and hydrogen storage installations should always be provided for by the market to ensure efficiency.

This may not always be practical in the very early days of network development. In advance of market maturity, it would be reasonable to make exceptions for geographically confined industrial or commercial areas, such as intra-cluster pipelines,

or for existing hydrogen networks. Government should look to time-limit any such exceptions, with a view to requiring complete vertical unbundling by the mid-2030s, or before.

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.

Yes. An external funding mechanism will cease to be needed when transport / network operators are able to make investible judgements about the scale of future supply and demand. If external funding is discontinued significantly in advance of this, it is likely that pipes will be scaled to existing supply and demand, which could inhibit future growth and require expensive upgrades.

14.In your view, if needed, what are your views on possible approaches to funding a potential external subsidy mechanism? Please explain your answer and provide any relevant evidence.

However an external subsidy mechanism is funded, it is critical that the funding is supported in law and is not subject to sudden changes, which would significantly increase the cost of investment. Grandfathering provisions in early project contracts ensure that the investment case remains stable for the contractual period.

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

We do not have a view on this.

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? 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.

It is not clear that a separate business model would be needed, but clearly additional enabling regulation would be – a further burden for planning departments and regulators.

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

We do not have a view on this.

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.

Business model support will be needed for elements of the hydrogen network located offshore. Offshore assets may be more capital intensive, and support for such assets will need to weigh up their relative cost as well as their strategic value. It is not clear that a different business model would be needed for offshore assets: it will be important that onshore and offshore assets face a level playing field in terms of support and regulatory burden, to ensure that assets are optimally located, rather than located according to short term convenience.

19.In your view, how may 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.

Non-pipeline transport will be a flexible option for the movement of small volumes of hydrogen, or the movement of hydrogen between locations that are not served by pipeline infrastructure. It is likely to be widely used by electrolysers and industrial facilities outside of clusters and there will be a long-term role for it, as there is for natural gas today. The scale of that long term role will depend on the extent of the hydrogen networks (transmission and distribution) of the future.

The existing regulatory framework for the movement of hydrogen by road, rail or sea may not be adequate to support a significantly larger hydrogen non-pipeline transport sector.

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.

There may be a need for external funding for the early development of non-pipeline transport, which will provide critical flexibility for hydrogen producers and users that are not connected to hydrogen networks. It may be possible to include this in other business models, particularly the HBM.

Hydrogen Storage Infrastructure

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.

The key technical barriers are dependent on the type of storage technology used, and on whether the stored hydrogen is pure, blended, or in a carrier.

Uniper has experience of storing pure hydrogen in salt caverns. The technical challenges we have encountered will be familiar to you – in particular, hydrogen embrittlement, microbial activity, formation of corrosive substances on the wet-side of the storage process, and potential issues around pressure stability as there is less flex available than there is in natural gas storage.

There are significant technical barriers associated with storing hydrogen in a natural gas blend: depending on the proportion of hydrogen in the blend, we would need to make very extensive changes to processing equipment in our existing natural gas storage facilities – well below blends of 10%. We would consider this to impact across existing T&S infrastructure and is unlikely to be restricted to Uniper and/or storage sites. This has implications for blending hydrogen into the existing gas network.

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.

You have correctly identified the key market barriers, though you have underplayed the range and scale of policy and regulatory uncertainty hydrogen storage operators face.

In terms of policy uncertainty, storage operators need to know what the system needs. Building interseasonal storage is very different from building storage that can facilitate very rapid injection and withdrawal. This means questions about the scale of the future

network and, particularly, the role hydrogen will play in domestic heating and balancing the electricity network need to be answered in order for operators to design storage facilities.

In terms of regulatory uncertainty, the regulatory regime for hydrogen will have major impacts on the costs and speed of new projects. Under the current planning system approval for large infrastructure projects is very lengthy (6+ years). Will hydrogen storage be fast-tracked through the planning process? Without this it is not realistic to believe that new projects will be coming online by the late 2020s – although it might be possible to repurpose existing / previous storage, which already has planning permission, in that time.

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.

Yes – but it's not just about volume risk but also uncertainty about future market shape: we don't know what type of storage we need to build because we don't know who the customers are (producers vs users vs operators, etc.). We need to understand the purpose of storage in a future hydrogen system: will it be just a network sink in the early days, or will storage need to play more of a network balancing role (as it does today)? When and how much interseasonal storage will the UK need?

Government needs to offer greater clarity about the future role of hydrogen so developers and operators can make assessments about the type of storage that will be needed.

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.

Yes. Given the very significant uncertainty and lack of market signals for early operators, and the high capital costs of building storage, hydrogen storage will need business model support in the near term. This should be technology neutral, so that the emerging market can efficiently pick technologies. For the first storage projects, the business model will need to take the form of individualised contracts, like the first CCUS power projects.

As the market matures and competition develops, hydrogen storage will become competitive and self-supporting. This means a RAB model would not be appropriate for storage: government should consider time-limited cap and floor support for storage in the growth phase of the hydrogen market.

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.

It depends on what you mean by 'small scale' and 'large scale' here. Project-specific, enabling storage is already provided for in the NZHF and HBM, so no additional support is needed for this. But there is a need for support for storage that will serve multiple customers and/or be network connected, to some extent regardless of its scale. There is certainly a need for support for system-balancing storage, as well as very large scale interseasonal storage.

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.

Likely users include Regional Gas Distribution network companies and National Grid, which is developing plans for national infrastructure, CCUS Clusters – or individual members thereof, electrolytic hydrogen producers, shippers, transport fuel aggregators, importers and traders, and potentially some large end users. This range of potential users indicates the potential range of scale and type of hydrogen storage facilities.

Storage may play a critical role in the future power system, enabling dispatchable hydrogen power when renewables aren't generating. One revenue model for some hydrogen storage would be an obligation on network operators to oversize their networks and ensure they have a buffer, which would mean they'd have to invest to grow storage. This would help manage availability and flexibility in supply and demand and therefore reduce CAPEX and risks elsewhere in the supply chain. This model is currently in place for natural gas transporters with their 1 in 20 obligation: they have to have to size their networks for a 1 in 20 year demand. This would not be adequate to drive investment in developing new hydrogen storage, but could help maintain existing storage once it becomes operational.

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.

Yes. In the early days of storage there will be very few users, and supporting only users may not provide enough funding to cover the significant up-front costs of new hydrogen stores: not just the capital costs but also the significant costs associated with the huge amounts of cushion gas that will be needed before stores can become operational.

Once there is a functioning market, government could consider transferring this support to users – potentially through an obligation on network operators, as set out above.

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

The most critical consideration is that any future subsidy mechanism is supported in law and is not subject to sudden changes, which would significantly increase the cost of investment.

As set out in our answer to question 14, external subsidy funding should come from general taxation, rather than other energy users, until funding can come from hydrogen users.

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.

Yes.

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.

Yes.

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.

A revenue cap and floor model would be most appropriate for the majority of networked hydrogen storage ahead of market maturity, with government co-investment being a potential solution for key, strategic infrastructure that would not otherwise be supported by the market.

A RAB model is neither suitable nor necessary for the majority of networked hydrogen storage, which will become self-supporting in a competitive market over time. RAB may be required for strategic large-scale interseasonal facilities, if they require ongoing subsidy.

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.

A revenue cap and floor model will provide storage developers and operators with certainty of returns and enable investment – much as the CfD has done in the renewable generation sector.

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.

At present, Ofgem appears to be best placed to carry out the roles of economic regulator and cap and floor administrator, as it already does for interconnectors and Offshore Electricity Transmission Owners.

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.

Yes. Early interim measures you should explore include:

- pre-FEED, FEED, and CAPEX support for early projects,
- policy decisions to provide greater certainty about the role of hydrogen and the scale of the future system – including decisions about hydrogen for heat and continuing to drive demand by reducing free UK ETS allowances,
- streamlining the planning and consenting system and developing the regulatory framework, and
- properly resourcing planning authorities and regulators.

Strategic Planning

35.In your view, should the build out of hydrogen transport infrastructure evolve through either a) a solely a market-led approach, b) a form of strategic planning, or c) neither? Please explain your answer and provide any relevant evidence.

Because the hydrogen system needs to develop more quickly than it naturally might, an element of strategic planning will be needed. Government should focus on strategic planning to address early market failures and ensure the delivery of key infrastructure ahead of the signals that the mature market will send. With strong policy signals for

supply and demand and a pipeline network business model that is similar to the existing gas model, there is more scope for organic development of networks – as long as sufficient oversizing of assets is permitted to meet future forecasted requirements.

36.In your view, should the build out of hydrogen storage infrastructure evolve through either a) a solely a market-led approach, b) a form of strategic planning, or c) neither? Please explain your answer and provide any relevant evidence.

As above; strategic planning will be required in advance of market maturity.

Strategic planning needs to be holistic, covering the whole value chain from producer to transport to end users and driving both supply and demand. It will need to consider regulatory and policy as well as physical considerations, ensuring that enabling and support frameworks are complementary.

Storage and networks are dependent on supply and demand and if the latter is unclear the needs for the former are unclear. Government needs to make the critical decision on hydrogen for heat, as soon as possible. Further to this, we need more information to set the parameters for storage – hydrogen quality, injection rates, etc. This should be coordinated and developed on a consistent national basis, rather than being allowed to evolve differently in different networks, to enable efficient connection of separate regional networks as the national infrastructure evolves.

37.In your view, if strategic planning was to be implemented for hydrogen transport infrastructure what form should it take? a) central network planner, b) coordinated approach, c) evolved approach, d) a blend of strategic planning and market-led approaches, or e) none of the above? Please explain your answer and what this approach might look like in a UK context.

Strategic planning for hydrogen transport should take a coordinated and evolved approach, combining strategic planning and market-led approaches and transitioning to a market-led approach as the market matures. Whilst early projects will need some strategic planning to ensure they are in the right place, at the right time and at the right scale to enable early market development and support future use, projects entering a mature market will be able to respond to market signals. As part of an evolved approach, government should provide a concrete roadmap from early support to a functioning market.

Early regional pipelines, rather than intra-cluster pipelines, are likely to be developed and operated by the regional Gas Distribution Network companies. Inter-cluster and pan-regional national pipelines will depend in part on the policy decision on hydrogen for heat and build out at the regional distribution level, although National Grid plc is already developing proposals for key pan-regional infrastructure in its Project Union.

38.In your view, if strategic planning was to be implemented for hydrogen storage infrastructure, what form should it take? a) central network planner, b) coordinated approach, c) evolved approach, d) a blend of strategic planning and market-led approaches, or e) none of the above? Please explain your answer and what this approach might look like in a UK context.

As above, strategic planning for hydrogen storage should take a coordinated and evolved approach, lessening as we move towards market maturity. The key coordinating need for storage, over and above planning the network, is policy and regulatory clarity.

It is worth noting that as well as a larger role in security of supply, storage could play more of a system balancing role than it does now. This is especially true in a system with hydrogen blending and deblending.

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? Please explain your answer and provide any relevant evidence.

Yes. Future-proofing – i.e. right-sizing – early infrastructure will require strategic oversight and probably government support. Small-scale above-ground storage is likely to develop naturally, but we will need larger storage for national network infrastructure.

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? Please explain your answer and provide any relevant evidence.

Onshore above-ground storage is likely to be small-scale and serve individual project needs, so won't need strategic oversight. But we will need clarity about the regulatory framework and there may need to be upskilling. A lot of small-scale onshore storage is likely to be at facilities that have not previously been COMAH sites, and which do not have the necessary expertise. Early development of networked storage and transport facilities will reduce regulatory burden and be more cost effective and safer overall.

Networked transport and storage is likely to need central planning in the early days to ensure that infrastructure is in the right locations at the right time, and that it is future-proofed in scale.

There is potential for onshore underground networked hydrogen storage, but this will depend on public acceptance and planning permission.

Some conflicts have already appeared between the development of carbon dioxide storage infrastructure and windfarms in similar locations offshore. Strategic planning is going to be necessary to ensure that the development of hydrogen transport and storage infrastructure can complement the other infrastructure that will be needed to achieve net zero by 2050.

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? Please explain your answer and provide any relevant evidence.

In addition to coordination of owners and operators of hydrogen infrastructure assets, wider stakeholder engagement will be required, and there may be some benefits to some elements of this being centrally managed – e.g. national public engagement on the safety and value of hydrogen infrastructure, to ensure smooth passage through planning processes.

Any strategic planning approach will also need to take into account current and future commercial drivers: early plans will need to consider the economic framework within which future projects will operate. For example, if the future framework for storage is intended to be wholly merchant-based, as it is now, government will need to exercise caution against supporting projects that will never become commercially viable.

Another factor that will become increasingly important is the link between investing in and growing the hydrogen network whilst continuing to operate the natural gas network. There will come a point where there isn't sufficient value in natural gas in the UK to support O&M costs for storage and pipelines, but there is a continued need for it. The support for hydrogen and natural gas will need to be complementary as we transition from one gas to the other.

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? Please explain your answer.

It would not be appropriate for the FSO to take on responsibility for planning, as that would conflict with its impartial system operator role and create conflicts of interest. A new body may be needed, but it is unlikely to be adequately resourced or experienced to deliver the broad, multi-market view that will be needed from the mid-2020s. Before any other body is able to take on this role, it would be most appropriate for government or Ofgem to take it on, working with industry. Some market participants are already starting to think about strategic infrastructure, for example National Grid is consulting widely with potential users about the location and staging of various elements of its proposed hydrogen 'backbone', Project Union. The Gas Distribution Network companies are also developing plans for hydrogen networks through a range of initiatives; including the East Coast Hydrogen, HyNet and Capital Hydrogen projects.

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? Please explain your answer and provide any relevant evidence.

The strategic planner should have a proactive role whilst the hydrogen market is in its infancy, setting targets for industry and asking operators to come forward to meet them. We would suggest a focus on salt caverns for the first networked storage sites, as sites of reasonable scale that can be brought online quickly. Many salt caverns can be brought online in a modular fashion too, with additional chambers connected to the first operational chamber as and when the market conditions are right.

A strategic planner could define the storage product that is needed, helping early operators design storage by defining injection/withdrawal rates, energy efficiency, gas quality, etc.

A strategic planner role could be purely advisory / target setting, or more directive – e.g. playing an active role in funding decisions by prioritising amongst projects that have qualified for government support.

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 the best be prioritised? Please explain your answer and provide any relevant evidence.

Yes. In order for the hydrogen market to develop at speed, transport and storage infrastructure that enables major emitters to make decisions about switching to hydrogen should be prioritised. And if the decision is made to decarbonise domestic heating with hydrogen, the supporting infrastructure, which is likely to include significant interseasonal storage, will need to be put in place.

Decisions about "low or no regrets" and systemically important infrastructure need to be made in discussion with network and storage operators and CCUS clusters, and with a view to locations in the UK that would significantly benefit from hydrogen (such as industrial clusters outside the CCS clusters). It may not be a question of which project to support so much as what stage of project to support: it will be strategically important but economically challenging to fill new stores with cushion gas, for instance; this could be a key focus of government support.

Regulatory Framework

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.

No. There is no comprehensive regulatory framework for the production, transportation and storage of hydrogen.

It is not clear whether the Gas Act covers all types of hydrogen transportation by pipeline and/or storage, or just where it involves injection of hydrogen into the existing natural gas network. If it does cover all instances of hydrogen transport by pipeline, then it requires “shippers”, and thus is not compatible with the HBM. We noted government’s proposal for an exemption from the requirement for shippers to register as hydrogen producers. This could work in the short term but in the longer term is likely to bring compatibility issues – shippers play a key role in a liquid and competitive market but it may be difficult to move away from blanket exemptions.

We are going to need a network code for hydrogen. The obvious starting point would be the Uniform Network Code (UNC), but this may be too complex for the very early hydrogen market (also, the UNC is enforced via shipper licences, so shippers need to exist). If we are not going to apply the UNC to hydrogen, work needs to begin as soon as possible to develop a new code.

We also need storage connection agreements: these set the parameters for storage – hydrogen quality, injection rates, etc. – and storage is designed on that basis. Blended gas storage could be designed under existing agreements, but we’ll need new agreement for pure hydrogen storage. Where UK legislation or standards for the quality of hydrogen are developed, they should be consistent with comparable European and international standards so there are no barriers to onward hydrogen supply.

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?

We are going to need a mix of (a), (b), and (c):

(a) A lot can be done through amending existing arrangements: clarifying whether hydrogen is entirely under the Gas Act, and reviewing the UNC and the terms of the HBM.

(b) We’ll need to develop new terms for some elements of the hydrogen regulatory framework, e.g., new hydrogen connection agreements, to enable storage design.

(c) We may need some additional preparatory / coordination work, such as central planning to ensure the first cluster networks have common technical standards to enable them to be joined in future without having to be completely redesigned, and/or support for right sizing early assets

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

Again, no. There are many gaps in the existing framework. For example, we'll need standards, as we have for natural gas – for hydrogen itself and for the equipment needed to process and store/transport the hydrogen. There is a risk that production standards will be different from storage standards: we will need whole-system view to ensure that costs are minimised across the whole system (it will be much more expensive to make all system users comply with a very wide hydrogen standard or very low quality hydrogen). In addition to new standards, new criteria will need to be developed for regulators to assess equipment and systems to. The capacity within regulators to develop and apply new criteria may be a barrier to the development of the non-economic framework for hydrogen.

Distributed onshore, small scale storage – i.e. in tanks – is going to significantly increase the non-economic regulatory burden if a lot more sites are storing hydrogen. It is likely that a lot of sites that are not currently COMAH sites will have to become so. COMAH knowledge and skills could be a barrier to a lot of small scale hydrogen storage.

48.If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)? Please explain your answer and provide any relevant evidence.

The timely development of hydrogen-specific standards and regulation will be needed to support the development of the UK hydrogen economy. In our view, a number of codes and Statutory Instruments – including the UNC, the Supply Point Administration Agreement, the Smart Energy Code, the Gas (Calculation of Thermal Energy) Regulations 1996, the Gas Safety (Management) Regulations 1996 - will need revision. In addition, the details on pipeline design and integrity, maximum operating pressures, building proximity distances and population density limits that are set out for natural gas in the Pipeline Safety Regulations 1996 and its associated standards may need to be revalidated for natural gas/hydrogen blends, or indeed just hydrogen.

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?

A mature regulatory regime for the transport of hydrogen by road appears to exist via the European Agreement on the International Carriage of Dangerous Goods by Road (ADR) regime and related safety regulations. However, this will need to be tested for its suitability and operability as the UK hydrogen economy expands.

50.If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)? Please explain your answer and provide any relevant evidence.

N/A

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

In principle, yes. The two regimes are mature and should be sufficient to support development of a UK hydrogen transport and storage infrastructure. However, obtaining planning consent for hydrogen transport and storage projects has not been common and further guidance on planning for developing hydrogen transport and storage infrastructure in the energy National Policy Statements would be beneficial,

particularly where clarity could be provided on details that are specific to hydrogen, rather than natural gas, infrastructure.

The timely determination of applications under either regime could prove to be a barrier, putting a significant risk on hydrogen infrastructure project development, financing and deployment. Although it is yet to be tested, there could be an issue with adequate resources being available to deal with the volume of planning applications coming from the UK industrial clusters that are likely to form the backbone of the hydrogen economy. Under the TCPA regime, in particular, adequate resources need to be available to determine applications not just within Local Authority planning departments, but within supporting regulatory consultees. Our experience is that some non-economic regulators and consultees, and particularly the Environment Agency, are already struggling to deal with their existing application workload.

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.

As set out above, clear statements on hydrogen infrastructure in a published NPS – either in the revision to the NPS for gas supply infrastructure and gas and oil pipelines (EN-4) or through a dedicated hydrogen NPS - would help with making planning applications and decisions via either the NSIP or TCPA regime. This could prove particularly useful for TCPA applications by providing guidance to Local Authorities and, hopefully, ensuring a consistent approach to decision-making.

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

Like the planning regime, the existing environmental regulatory framework should be adequate to cover the elements of the future hydrogen economy, including production, transport and storage. What will have to be seen is whether it has the flexibility to include new techniques and whether the system is efficient enough to allow the potentially large volume of new permits and consents to be delivered to the timescales that development of the hydrogen economy will require.

It is also possible that development of the hydrogen economy could test conflicts between local and national environmental objectives (i.e. local air quality versus national emissions targets) and the environmental regulatory framework needs to be robust enough to deal with such issues when they arise.

54.If you answered 'No' to the previous question, how do you think this might be addressed? Please explain your answer and provide any relevant evidence.

Ensuring the environmental regulatory framework can support the future hydrogen economy will require increased support for all the agencies involved in providing approvals for new infrastructure – including financing for staffing, training, and the development of guidance. Delivered properly, a hydrogen economy is a nationwide opportunity for levelling up.

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?

We don't know much about the offshore framework, but it needs to be consistent in terms of regulatory burden – it is important that offshore infrastructure does not become the 'wild west'.

There is likely to be a need to balance demand for offshore storage for CO_2 and hydrogen. Government should consider whether there is a need for a comprehensive

assessment of potential demand for offshore CO_2 and hydrogen storage, and the available UK offshore storage potential.

This will not be an issue for all types of storage – for example, salt cavern storage doesn't use facilities that could otherwise be used for CO_2.

56.If you answered 'No' to the previous question, how do you think this might be addressed (regulation/standards/guidance, etc.)? Please explain your answer and provide any relevant evidence.

N/A

Hydrogen Blending

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.)?

This will in part depend on the demand profile of a hydrogen production project's offtakers. Predictable offtake combined with turn down capability of the production plant may overcome initial limitations on the availability of hydrogen transport and storage infrastructure. The availability of hydrogen transport infrastructure in particular will help reduce the turn down requirement, to the extent that linepack provides some element of storage in absence of dedicated large volume storage connected to a pipeline network. We have quantified this for some of our projects, the information for which has been made available as part of the Cluster Sequencing Process.

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 for blending may be required? Please explain your answer and provide any relevant evidence.

Yes. Blending is not an entirely straightforward proposition (see our answer to Q63) but in the absence of other reserve offtakers it could help de-risk early hydrogen production projects by ensuring that they can sell all of their volumes of low carbon hydrogen. This will be valuable until there is enough pure hydrogen network capacity and the necessary HBM support to enable injection of excess volumes into that. We would therefore expect the volume of blending to decrease over time. Our preference would be for hydrogen storage to be the reserve offtaker from as early as possible: this would be a more strategic use of 'excess' hydrogen volumes.

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)?

Yes. The rate of change for any gas blending parameters is a significant risk for end users; where we have been considering blending, our assumption has been that this would happen at site, not in the network, with parallel hydrogen and natural gas transport infrastructure. In the case of production we anticipate a short length of privately owned hydrogen pipeline would be required to connect to the largest gas distribution network node close to our production location.

Electrolysers are likely to rely on non-pipeline transport in the early days, if they are going to sell to blending, because of small and irregular quantities and geographic dispersal (many electrolysers will be sited with renewable generation infrastructure, rather than within industrial clusters), so this will be 100% hydrogen.

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.

Yes, the availability of large volumes of low carbon hydrogen will give confidence to existing operations considering fuel switching or attracting new development to a region. Having said that, pure hydrogen reserve offtakers (e.g., hydrogen storage and network operators and hydrogen aggregators) are likely to be better for promoting confidence in switching to 100% hydrogen. In addition, developing hydrogen storage and networks will have greater long-term strategic benefit than developing extensive blending infrastructure.

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.

We agree with your assessment of the options to address demand volatility where that demand does not drop to zero. Where a producer only has one or two offtakers and they all cease to operate, resulting in sales falling to zero, the HBM does not provide any revenue protection. In these circumstances blending, in the absence of aggregation and storage, would enable a producer to continue to operate until their offtakers come back online or they find new ones.

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.

Our preferred reserve offtaker would be hydrogen storage. As storage sites begin to come online, they will need to be filled with hydrogen cushion gas. It would make much more sense to support the filling of storage sites than to blend hydrogen into natural gas, where the emissions savings become very small: functional storage is going to be critical in any functional hydrogen market.

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.

In advance of hydrogen storage and network infrastructure, blending could play an important transitional role in ensuring hydrogen market growth, so government will need to work with industry to ensure that access is broad and fair.

There are, however, a number of risks associated with blending, which mean that alternatives should be brought forward as soon as possible:

- Blending may not work well as the offtaker of last resort as it is not a wholly flexible tool, given network constraints and gas standards;
- Blending requires its own transport route from the production facility;
- The impacts of blending on existing infrastructure is likely to be significant and costs for operators associated with ensuring continued safe and secure operation across the whole gas supply value chain should a) not be underestimated and b) be thoroughly assessed and understood ahead of making such a strategically significant decision as pursuing blending as a

reserve offtaker. Blending doesn't mitigate a risk – it transfers it to other places in the chain;

- Blending could be a significant problem for storage – blending of more than 2% hydrogen to the natural gas system leads to high costs for the technical upgrading of the storage facilities (up to several millions € per site). In addition to the physical considerations there are economic concerns: storing a blended gas would materially change the commercial outlook for Holford, as we would be storing less energy for same volume. Additional costs for retrofitting of systems and commercial losses would need to be government subsidised;
- If it is needed, a deblending service could be expensive: in a system where only a small number of users have to pay high costs for a service that merely restores the status quo, who should pay?