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* This document will be continually updated, therefore please note some information may not be available at the present time

1. Future of Gas – to be updated

2. Innovation broadening the horizon

If there are innovative ideas we have in the supply chain for development can we tap into the innovation funds NGG have? For example there may be new auto welding/NDT/coating ideas for linear pipelining projects which have been sparse for last 10 years - who can we contact?

Innovation projects that are funded by Ofgem (NIA/SIF) will need to have an end consumer benefit, the examples would appear to be possible, each individual project will need to be reviewed in light of the project criteria.

Other funding opportunities such as UKRI and EU funds can be more flexible and we could work alongside the supply chain to develop project applications for these calls.

Contact the innovation .box (box.GT.innovation@nationalgrid.com)

3. GMAP – Gas Markets Plan

What do you mean by risk of investment sterilisation due to blending?

We wanted to highlight the importance of getting the physical roll-out model correct to enable network blending. It is important that the consequences of the different potential physical roll-out models are fully considered.

What is been done to address the EU not recognising UK GoOs, and any potential impacts on the development of H2 GoOs in the UK?

The UK Government has indicated they intend to review the existing Guarantees of Origin (GoO) arrangement with the EU so that in the longer term, 'domestic recognition of GoO issued in EU countries will take place only on a reciprocal basis.' The final report from the Hydrogen GoO project includes recommendations for how UK market participants can take steps to keep up to date on EU hydrogen GoO developments, to benefit future cross border trade. For example, UK market participants could request to become working group members of the dedicated EU hydrogen GoO project CertifHy.

The supply-side GHG emissions of gas delivered to the NTS vary widely - compare NCS gas v. some LNG sources. Why not adopt GoOs for natural gas as well as H2?

Guarantees of Origin for natural gas products is a topic that certainly could be pursued in the future to account for the different emissions of natural gas supply sources. However, upfront work would be required to gather accurate data on emissions from the range of natural gas supply sources delivered to the NTS.

Will the current commodity of UK Natural Gas continue in parallel with a Hydrogen price? or will the blended UK product be on a DA and Futures market?	National Grid cannot strongly comment on the commodity markets and how they will evolve. It's clear from the government's H2 strategy that the short term focus is the link to Natural Gas as a way of managing the affordability to end users. How this will evolve over time as carbon prices increase and the cost of H2 production falls is uncertain.
What risks is posed to the future development of the UK gas markets by NGG's decision to divest your gas transmission business?	There are no additional risks to the market developments from divestment. The subject of market development and governance for both gas and electricity is currently subject to government and regulatory review through the Future System Operator (FSO) and Energy Codes Review. These initiatives will set direction for the industry and potentially lead to changes to meet the challenges to come.
Will the market changes be regional if the rollout is regional?	In short, the future direction is not set. It will depend on many factors, for example how geographically specific will the solutions be in the first instance, what benefits will industry rules give? It is possible that private contracts with bespoke rules are used as the basis to start the H2 clusters and govern the rules within them. Should Project Union connect the clusters, then there will very likely be a need for open, consistent and competitive market rules to ensure strong markets that produce the best outcomes for end consumers

4. Transitioning to a hydrogen backbone

What is the likely split between UK hydrogen generation and hydrogen import. Russia is re-purposing to export hydrogen (via reforming)?	It is difficult to say at this stage but the UK has great potential for hydrogen production, so import may not be a large portion of our supply. There may be potential for the UK to be exporting hydrogen.
Is there an argument that those connecting the South and West (i.e.: Bacton, Milford Haven and Southampton) should be prioritised due to lack of CO2 stores?	In planning the conversion of gas networks to hydrogen, a range of criteria will be considered that will inform the phasing/timing of conversion, including decarbonisation, technical feasibility, resilience, economic, deliverability, societal and consumer benefits.
Do you see the backbone coming ahead of gas blending given the UK's priority is to decarbonise industrial clusters?	The first feeder conversion for the backbone will begin in 2026. The government will make a decision on blending in 2023 and FutureGrid will have blending test evidence from 2023, so we may see blending before the backbone. The two may then develop in parallel but this depends on a variety of factors. Some of the backbone feeders may go through a blend to reach 100% too, this is yet to be fully defined but will be through Project Union.

<p>Is the 'highest value' aspect of blue hydrogen the fact it offers flexibility without the need for storage?</p>	<p>One of the benefits of blue hydrogen is its reliable production profile but some storage would still likely be needed. There are also other benefits such as its scalability and current lower cost in comparison to green hydrogen, which will enable hydrogen market growth.</p>
<p>Doesn't the introduction of H2 mean GSMR will have to be replaced eventually with a series of local/regional gas specs?</p>	<p>That is certainly one possibility, there could also be a scenario where we continue to have a national GSMR and local differences are managed through commercial agreements. It is very difficult to say what the end outcome is. Currently IGEM, in collaboration with industry stakeholders are running a project looking to update GSMR and transpose the composition aspects of GSMR into an IGEM standard.</p>
<p>Can you clarify what is meant by 'converting the network' vs flowing hydrogen and the points in time these happen?</p>	<p>'Conversion' is a fairly general term but I would say primarily refers to repurposing existing assets e.g. pipelines to flow hydrogen rather than natural gas. The counter case would be to build new assets.</p>
<p>Has NG's plans now gone away from blending Hydrogen into the natural gas network?</p>	<p>No, this is still being considered as a solution, primarily as a transitional tool to get us to 100% hydrogen.</p>
<p>Could the timeline be accelerated if it looks like we will miss the 1.5 degree target?</p>	<p>To meet the targets agreed as part of the Paris Agreement, urgent action is required and tracking performance against carbon budgets is critical. The clean energy transition will need to be sustainable, considering how to maximise environmental impact while ensuring energy security and affordability in the context of that urgency. Planning and appropriate timing of decision-making will be key to success.</p>
<p>Are local generation hubs needed as H2 can't be transported long distances?</p>	<p>Hydrogen can be transported long distances but local production may also be needed to support the system</p>
<p>What's projects unions vision for the midlands region giving it seems to fall between sections of the backbone and is in-land in respect of the coastal clusters</p>	<p>The exact routing of the backbone is to be determined and connecting up the midlands will be considered when the routing is selected. We see project union having the benefit of connecting the midlands to clusters and having access to hydrogen from large production centres near the coast</p>
<p>There is too little discussion of H2 storage, de-blending, compressor limitations, competition and market liquidity in the wild-eyed idea of a 'H2 network.'</p>	<p>National Grid is undertaking trials and demonstrations, such as FutureGrid, working closely with wider industry and the supply chain to demonstrate the impact of hydrogen on transmission assets. The FutureGrid programme will explore options such as deblending and assess the impact of hydrogen on compressors. We are also collaborating with other European Transmission System Operators in technical groups, such as H2GAR (Hydrogen Gas Asset Readiness), to share knowledge and learning across a range of themes, including storage. Short, medium and long-term storage requirements are also being investigated through modelling studies within the gas networks.</p>

What do you see the potential of hydrogen import from other regions (e.g., north Africa or middle east) through hydrogen energy carriers (e.g., Ammonia)?	Hydrogen imports from other regions could provide access to cost-competitive hydrogen. Shipping hydrogen through energy carriers are options that are being investigated.
Project Union has to look at CO2 transportation and storage, otherwise it will reach the wrong conclusions	Blue hydrogen will largely be on the coast where our in-land pipelines will not be needed for CO2 transport and NG are not responsible for offshore CCS infrastructure. However, we are assessing our ability to repurpose one feeder for CO2 in Scotland as part of project acorn.
What are the constraints in transitioning more of UKs network to Hydrogen/Hy Blending (25% forecast currently) Is there potential for more than 25%	There are many areas that require work and evidence to allow blending. The technical aspect, regulation, customer needs, market framework, system operation, funding...some of these will be solved through trials that provide evidence and some will be solved through engagement across industry and with BEIS/Ofgem to define a suitable transition pathway.
Will the blend required to be fixed or can it vary within a range? If fixed, then it presents real challenges for H2 producers or large storage	This is one of the aspects that the work through the ENA, Gas Goes Green programme will seek to address.

5. Managing methane emissions

Do we know of the GHG potential of Hydrogen? Is leakage of Hydrogen a problem?	BEIS conducted a literature review - Hydrogen Heating: Atmospheric Impacts, BEIS Research Paper Number 2018: no. 21. Although it is not a pollutant in its own right, hydrogen can take part in atmospheric chemical reactions in the lower and upper atmospheres and these chemical reactions may lead to environmental damage. Current research suggestions that hydrogen has a Global Warming Potential of 1.4-4 times of CO2, but this is currently yet to be tested on a real-world environment.
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6. Supporting regional hydrogen transitions

Is there a risk of duplication and double counting of all these projects as they seem to overlap what we hear from Zero carbon Humber, Teesside etc. plans?	There are several projects within the same regions, but these usually cover different aspects of the value chain or different industries. However, we must engage with projects such as Zero Carbon Humber, Teesside etc to ensure alignment and to mitigate any risks of duplication.
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Assume East Coast Hydrogen is 100% hydrogen network not blending?	The end goal is 100% hydrogen, but blending could be used as a transitional tool
How does industry dense areas, such as the Black Country, fit into regional deployment of hydrogen?	The exact routing of the backbone is to be determined and connecting the midlands will be considered when the routing is selected. We see project union having the benefit of connecting the midlands to clusters and having access to hydrogen from large production centres near the coast
Please could repeat the details about the h105 project? Scottish gas networks?	SGN H100 Fife project will bring renewable hydrogen into homes in 2023. In the project's first phase, the network will heat around 300 local homes using clean gas produced by a dedicated electrolysis plant, powered by a nearby offshore wind turbine. More can be found here https://www.sgn.co.uk/H100Fife
Is there sufficient water resources in the East Coast area for 7GWs of hydrogen production? Is this being looked at?	The majority of the 7 GW is blue hydrogen, which presents less of a water resource challenge than green. As green scales up though, the water requirements will need to be assessed. This was not a detail considered in the feasibility study.

7. Understanding the skills needed for a net zero world – to be updated

8. Digital strategy and information provision – to be updated

9. Operating the network	
What would be the operating implications of moving above 20% H2?	The implications on physical assets are currently being looked at under FutureGrid of differing levels of Hydrogen. The HSE research report referenced in the presentation looked at the safe limits of existing downstream appliances and concluded 20% would not increase risk. This considered effects on flame properties etc. (https://www.hse.gov.uk/research/rrhtm/rr1047.htm)

<p>What happens if you inject a higher percentage of hydrogen than the 20%? I think there is a goal to get to a 100% injection in the longer run, correct?</p>	<p>We plan to trial 2, 20 and 100% hydrogen as part of the FutureGrid offline test facility. 2% is expected to have minimal impact on our assets. As we move up to 20% this is currently considered to be the limit for some of our asset types. When we move to 100% hydrogen testing, we will be able to see how the assets react to hydrogen and whether they are capable of operating with higher concentrations of hydrogen. The results of the testing may show where further work is required or where we may need to take remedial action to ensure the assets are suitable for higher concentrations. More information can be found here: FutureGrid hydrogen test facility</p>
<p>With lower domestic heating requirements and higher pressures due to hydrogen or H2 blending will the gas network become very inefficient in terms of cost?</p>	<p>The future market models and frameworks have not been looked at in any detail. The cost per energy throughput will increase with increasing hydrogen but is likely to impact compression (fuel) as a marginal cost rather than the pipelines and will of course need to be set against overall demand reduction and decarbonisation pathway. Gas Transmission efficiency increases with higher pressure due to reduced mass flow velocity and hence friction which is one of the reasons we operate with a higher linepack in the winter.</p>

10. Gas incident and emergency overview – to be updated

<h3 style="background-color: #000080; color: white; padding: 5px;">11. FutureGrid 2021 – progress report launch</h3>	
<p>Are there any synergies with other national test centres in other countries that could advance the programme?</p>	<p>National Grid are actively collaborating with European TSOs (Transmission System Operators) to align our research programmes and share data. This is being coordinated through the H2GAR (Hydrogen Gas Asset Readiness) group and National Grid are supporting a hydrogen materials project at the RICE research centre in Paris.</p>
<p>Are there any plans to expand to test industrial processes and equipment?</p>	<p>Phase 1 testing includes pressure reduction equipment and also a boiler house. As part of planned future expansion of the FutureGrid facility we will be testing assets required for compression on the NTS. This will include a rotating turbine, so some learning from this phase will be applicable to industrial processes.</p>
<p>With the digital first approach, will you be exploring new sensors / data collectors that work with older assets that could be deployed out on the NTS?</p>	<p>Yes, the FutureGrid project is testing innovative methods to capture data on older NTS assets</p>

How will you assess the risk of repurposed and reinstalled assets having different performance capabilities and impacting conclusions of test bed?

Any maintenance carried out upon assets will only be carried out as if the asset was still in service on the NTS to ensure the data obtained is a fair reflection and the site fulfils its purpose of being representative.

12. Annual network capability assessment report – to be updated