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GAS FRAMEWORK CHANGES TO ENABLE HYDROGEN DEBLENDING

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CONTENTS

FOREWORD FROM NATIONAL GRID GAS TRANSMISSION

National Grid Gas Transmission (NGGT) sits at the heart of Great Britain's energy system, connecting millions of people and businesses to the energy they use every day. We understand our responsibilities to the environment and future generations, so we are working to develop solutions that enable the transition to a clean economy, in which nobody is left behind.

The role gas currently plays in energy security of supply and the benefits of gas decarbonisation have become front and centre for energy policy direction. Against the backdrop of rapidly evolving (technological and political) developments, it is more important than ever to focus on innovation activities that continue to support our business in delivering gas safely and reliably to our customers, as well as focusing on innovation activities to help achieve the Government's Net Zero carbon emissions target by 2050.

We launched this Network Innovation Allowance (NIA) funded Hydrogen Deblending Feasibility Phase 2 project to further industry understanding and research relating to gas separation (i.e. deblending technology) on GB's gas networks. This project was developed through two workstreams: 1) Technical workstream 2) Market workstream. We launched this project to build on the positive outcome of the 2020 Hydrogen Deblending in the GB gas network[1] study we undertook with all five of GB's gas networks to explore the concept of implementing deblending technology on the gas networks.

The findings from this latest deblending project will help to inform market participants on whether deblending technology should be considered as part of future-proofing considerations for the hydrogen transition. In addition, the outputs from this project will inform a potential physical trial of deblending technology in the second phase of NGGT's FutureGrid[2] project.

We welcome you to the following report: 'Gas Framework Changes to enable Hydrogen Deblending'. This report relates to the market workstream, where NGGT collaborated with Frontier Economics, Dentons, and an expert industry working group to explore how existing market frameworks may need to evolve to accommodate deblending technology on the gas networks. We selected Frontier Economics as our supplier considering their long record of advising on high profile projects on market design, as well as the added benefit of building on their previous learnings and collaborative approach to the project Hydrogen blending and the gas commercial framework[3], a 2020 NIA project that has clear parallels to the development of deblending.

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[1] NIA project page

[2] FutureGrid web page

[3] Frontier Economics (2020) 'Hydrogen Blending and the Gas Commercial Framework: Report on conclusions of NIA study', accessible here

We hope you find this document useful. Please share your views with us to help shape the future of the gas National Transmission System and how market frameworks may need to change across potential energy futures. You can find details of how to contact us on our website[4].

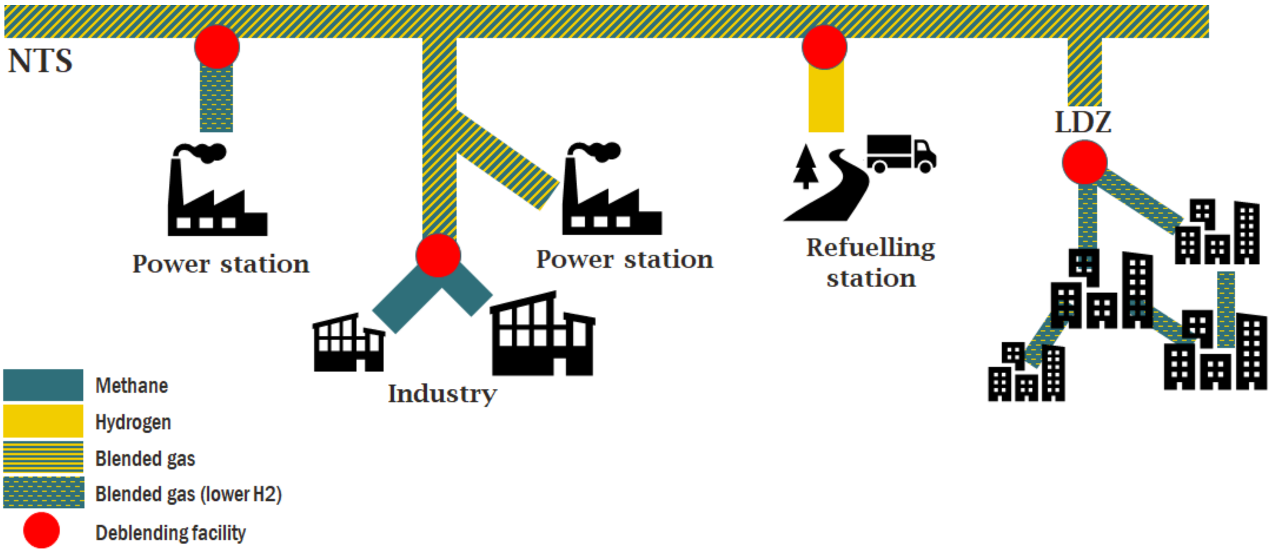
[4] https://www.nationalgrid.com/gas-transmission/future-of-gas

1 EXECUTIVE SUMMARY

To meet the target of net zero emissions in the UK by 2050, it is likely that low-carbon hydrogen will need to play a role in the UK's energy mix. As a transitional step, hydrogen can be blended into the existing methane grid, potentially up to 20% by volume, without any need for change to most domestic gas appliances.

However, **some existing non-domestic gas customers may be sensitive** to receiving hydrogen blends, or variability in the blend level. And some customers may want to consume (close to) pure hydrogen from the gas system. Deblending technologies that can separate hydrogen from natural gas could play a role in helping to manage these needs during the transition to a fully net-zero compliant system (e.g. a 100% hydrogen gas system).

FIGURE 1 ILLUSTRATION: DEBLENDING COULD HELP MEET DIFFERENT CUSTOMER NEEDS



Source: Frontier Economics

National Grid Gas Transmission (NGGT) has asked Frontier Economics to explore how the gas sector commercial and regulatory frameworks may need to evolve to accommodate deblending on the UK gas networks, across both the NTS and distribution networks. We **build on earlier work** that has considered the changes required to enable injections of hydrogen into the methane grid.[5]

[5] For example, see Frontier Economics (2020) 'Hydrogen Blending and the Gas Commercial Framework: Report on conclusions of NIA study', accessible here, and ENA (2021) 'Gas Goes Green: Britain's Hydrogen Blending Delivery Plan', accessible here.

1.1 ISSUES IN THE CURRENT FRAMEWORK AND RECOMMENDATIONS

Through our work with stakeholders, we identified the following **key groups of issues** which would need to be resolved to enable the use of deblending technologies:

- **Network planning and customer needs:** If customers have certain gas quality needs, networks could deliver this either through deblending, alternative solutions such as managing upstream hydrogen and methane injections, or customers could take action themselves (for example, adapting their equipment). Deblending is also one of the tools available for system operators to manage network blend levels. The key issue in this regard is how to ensure that **decisions to invest in deblending** to meet customer needs or network needs **are least cost** from a wider system perspective.

- **Managing system impacts:** In some cases, deblending may require reinjection of unwanted gas back into the network. If this reinjected gas is hydrogen, or a hydrogen-rich blend, this can cause issues around downstream blend levels coming close to the blend cap. New processes will be required to ensure the impacts of the use of deblending on **hydrogen blend levels downstream of deblending facilities are appropriately managed.**

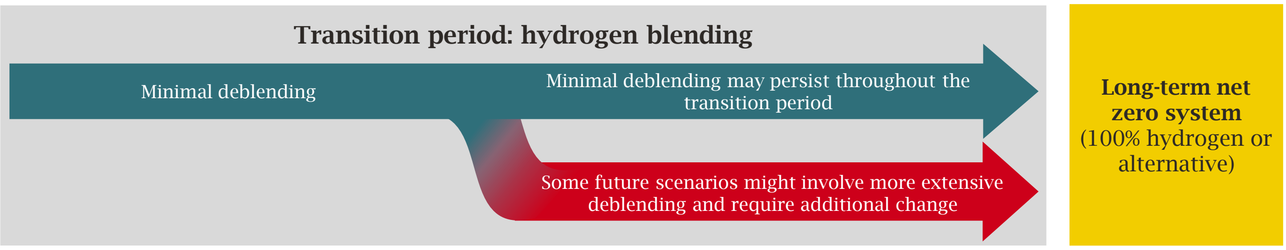
- **Network charging:** Decisions will need to be taken regarding how to **recover the costs incurred by network companies**, if they build and operate deblending facilities. In addition, changes to charging methodologies will be needed to ensure that **customers owning and operating deblending do not face 'double charging'**[6] of gases that are not consumed, but simply withdrawn and reinjected into the grid.

We have considered a range of solutions to these issues with stakeholders, and have selected those likely to deliver reasonably **efficient outcomes** in the near term, while involving **proportionate and low-regrets** changes to existing frameworks. This focus on pragmatic solutions is important, given the uncertainty regarding how extensive future hydrogen blending (and deblending) might be before the transition to a fully net zero system.

The different likely pathways for blending (and deblending) are illustrated below. The need for deblending is likely to be minimal in the near term, and it is possible that deblending will only have minimal usage throughout the transition to net zero. We have therefore focussed on solutions suitable for the near-term period. While these conditions may well persist through the transition, we have also sought to ensure that the proposed solutions avoid creating barriers to alternative solutions that could be needed to deal with potentially more complex circumstances, should they arise in future.

[6] Customers owning and operating deblending could pay network charges twice for the deblended gases not consumed and reinjected, an 'exit' charge when withdrawing gases from the system and an 'entry' charge when reinjecting gases to the system.

FIGURE 2 POSSIBLE PATHWAYS FOR HYDROGEN DEBLENDING



Source: Frontier Economics

We summarise our **recommended solutions** in Figure 3 below, and provide more detail below that.

FIGURE 3 RECOMMENDED CHANGES TO GAS COMMERCIAL FRAMEWORKS

Network planning	Implement an application process for customers to request a specific gas quality from network operators, including supporting evidence to justify the need.
	If costs of deblending are socialised, networks required to consider alternative options for meeting the gas quality need and justify expenditure on deblending using a cost-benefit analysis (CBA). If costs are targeted at the relevant customer, no changes needed.
	Rely on existing totex incentives to minimise network costs in the case of network deblending investments to meet a purely network-driven need (e.g. to manage blend levels).
Managing system impacts	Deblending reinjection points from customer-owned facilities connected to grid subject to a pre-connection Impact Assessment by the network operator. Connection agreement to enable the network operator to constrain reinjection if required for blend management purposes.
	An administrative approach* for network operators' choices between different tools (including deblending) for managing blend levels and for constraining any network owned deblending facilities that are being operated for customer needs.
	Enhanced co-ordination between transmission and distribution networks when applying system operation solutions.
Network charging	Networks that provide a deblending use-case to their customers recover the associated equipment and operating costs from the specific customers receiving the use-case.
	Customer-owned deblending facilities only pay network charges on the basis of 'net exit', with no entry charges on reinjections.

Source: Frontier Economics

*Note: * We refer to an "administrative approach" as any approach where decisions are not the outcomes of a market mechanism. Administrative approaches will usually specify permissible actions or provide guides for actions under certain circumstances.*

NETWORK PLANNING AND CUSTOMER NEEDS

As part of the policy decision in relation to blending, Government may decide, in certain circumstances, that all or part of the costs associated with the transition to blending (which could potentially include the costs of deblending to meet customer needs) should be socialised (that is, spread across all network users, or energy customers more broadly).

We recommend that:

- Gas **customers with a specific gas quality need** communicate their need through an **application to the relevant network operator**, including **supporting evidence to justify their need.** If the need is approved (potentially based on any policy criteria set out by Government), it would be left up to the network to assess the whole system costs of alternative options for meeting the gas quality need.

- If Government decides to socialise deblending costs through network charges, we recommend that **networks be required to justify any expenditure on deblending using a cost-benefit analysis (CBA).**[7] This CBA would need to be approved by Ofgem, who could then trigger the release of the necessary funding through an uncertainty mechanism. Such a CBA would ensure that **the most efficient solution** to the customer's gas quality needs is selected, including the option for the customer to adapt their equipment.

- If Government decides to target deblending costs such that they are recovered from the customer requiring deblended gas, we recommend **no changes to existing frameworks**. This is because customers will face the costs of their own deblending needs, and will therefore internalise the costs of different options for meeting their gas quality need and select the one that is most efficient.

- In the case where **deblending is used for networks' own needs** (e.g. to manage blend levels or billing impacts), we recommend continuing to **rely on existing totex incentives**[8], which will encourage the network operator to minimise the costs of managing their network's needs.

MANAGING SYSTEM IMPACTS

We recommend that **reinjection points are connected to the grid subject to an enhanced pre-connection Impact Assessment** (IA) by the relevant network operator. This pre-connection IA would seek to answer questions including how much blending capacity is available downstream of the connection location and the expected impact of reinjections on any other hydrogen-sensitive customers downstream. Based on this assessment, the network operator can decide whether the system impacts of the reinjection can be safely and efficiently managed, and therefore if the connection application should be accepted. If it is accepted, we recommend including **conditions in the Network Entry Agreement (NEA) such that reinjection can be constrained by the network**

[7] If costs are socialised, the customer may therefore not have a strong incentive to select the lowest cost solution for meeting the customer's gas quality need. Hence, safeguards are required to ensure efficient decisions in line with the interests of consumers more generally.

[8] The totex incentive mechanism is a regulatory incentive which allows network operators to retain a proportion of any underspend against regulatory allowances through a 'sharing mechanism', incentivising companies to cut costs over time. We assume that the totex incentive would apply to blend management costs. If and when blending becomes a material activity, some regulated funding will need to be provided for network operators to manage blend levels, either through the price control, or through an uncertainty mechanism such as a reopener.

operator if needed for blend management purposes. This could be achieved through conditions setting out that the gas injected must not cause the downstream gas blend to exceed the blend cap.[9]

It is possible that hydrogen injection and reinjection points could jointly contribute to a blend issue, meaning that there would need to be a decision over which injection/reinjection point to constrain. However, given that reinjection connections would have to be approved through the pre-connection IA discussed above, and we are focusing on the early period of 'minimal deblending', this should only happen on rare occasions.

If reinjection points do cause blend issues, we recommend that the choice of who to constrain be left to the network operator's discretion to select the most efficiency solution in this early period. To avoid any unfair outcomes for customers, Ofgem could carry out regular reviews or consultations on network operator constraint management decisions, or alternatively play a role in resolving any disputes between the network operator and customers if a customer considers ex post that a decision was unfair.

Once blending starts, blend management will be a part of day-to-day operation of the grid, more broadly than just managing blend issues associated with reinjection points. Network operators will need to manage blend issues as they arise, choosing between different available tools, including deblending but also constraining hydrogen injections or managing methane flows. We **recommend that, in the early stages of 'minimal deblending', an administrative approach[10] is used to enable operators to choose between different tools**. The specific approach will ultimately need to be decided by Ofgem, but could involve either one of the following:

- The network operator could be given responsibility to select the most efficient tool to manage blend; or

- A process or methodology could be agreed for selecting tools. This could range from a set of guidelines on which tools to prioritise, to a set of proxy costs that the network operator could use to compare different options in different circumstances. Proxy costs in particular could be helpful in encouraging network operators to take into account the costs to customers of having their (re)injection points constrained, when making choices between different blend management tools.

We recommend that this administrative approach is also extended to the management of network-owned deblending facilities, where the unwanted gas remains in the network.

Finally, we also recommend that where reinjections on the transmission network cause constraints on downstream networks (and vice versa), the **relevant networks should coordinate** to apply the chosen solutions described above in a 'whole system' manner. For operational purposes, this will

[9] In practice, deblending reinjection points may be interrupted only as a last resort, since customers using deblending are likely to be large industrial users who may face significant costs as a result of interruptions. This could be reflected in the 'administrative approach' to blend management discussed in the following paragraphs.

[10] We refer to an "administrative approach" as any approach where decisions are not the outcomes of a market mechanism. Administrative approaches will usually specify permissible actions or provide guides for actions under certain circumstances.

require timely sharing and joint management of gas blend information between NGGT and Gas Distribution Networks (GDNs).

NETWORK CHARGING

Absent any government policy decision to the contrary, we recommend that where networks secure funding allowances for investment in deblending facilities (i.e. via allowed revenues) to serve a customer need, the **costs of building and running such deblending facilities should be recovered through targeted charges**. In other words, the charging framework would need to change to allow networks to pass on deblending costs to the specific customer (or group of customers) to which they are attributable.[11]

We recognise that such a choice could raise competitiveness concerns for the customers concerned. Under certain circumstances (for example, where it considers that customers have a 'right' to current GS(M)R standards[12]) Government may decide to socialise[13] the costs of deblending. However, this is likely to result in less efficient outcomes than targeting deblending costs, as it relies on NGGT/GDNs to judge (through our suggested CBA, discussed above) whether deblending is most efficient solution.

As an alternative, it would be possible for **Government to separately compensate selected customers (e.g. via grants) for the additional costs they may face as a result of blending,** while retaining a targeted approach to charging. This would ensure an incentive for customers to consider whether alternative ways of managing hydrogen blends (for example, adapting their own equipment) might be cheaper than deblending, while addressing any affordability concerns.

We recommend that only direct equipment costs of deblending (i.e., capital, maintenance and operating costs) are targeted**, whilst the costs of any wider system impacts attributable to deblending** (e.g. impacts on blend management costs) **are socialised as part of allowed revenue.**[14] We do not expect it will be proportionate (at least with minimal deblending) for the network to measure and attribute these costs to specific customers through targeted charges.

Finally, we also recommend that, where customers own deblending facilities, the **network charges they face are levied on a 'net-exit' basis (i.e. the net amount that leaves the network less any amount that re-enters from the deblending facility) such that users do not face entry charges on reinjected gases.** This will help to avoid 'double-charging' that could lead to a disproportionate burden of network cost recovery falling on customers using deblending. It will therefore help to ensure better incentives for investment (and operation) of deblending facilities owned by customers.

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[11] We assume for the purposes of this assessment that the current commercial arrangements for access and use of the gas network remains unchanged, unless otherwise specified.

[12] We discuss this further in Section 5.3.

[13] There are a range of options for achieving this. For example, BEIS' (December 2021) consultation on recovering the costs of heat network regulation considered a range of socialisation models including spreading across: (a) heat network and gas consumer bills, (b) heat, gas and electricity consumer bills, and; (d) Government part-funding.

[14] We note that this approach draws parallels to the principles for recovering the costs of connection assets on the NTS.

1.2 ACTIONS REQUIRED AND ROADMAP

The **starting point** for the implementation of these changes will be **Government's decision** regarding whether blending should go ahead (a decision regarding blending at distribution level is expected in late 2023, subject to the outcome of ongoing work by BEIS on the economic and safety case for blending). Any **decision on blending will have to consider the costs of solutions for any hydrogen-sensitive customers.** These considerations will inform the pace, extent and location of any blending roll-out.

Once there is policy clarity, the substantive work of implementing the required changes can begin. Concretely, this will require changes to gas transporter[15] (GT) (and possibly also shipper) licences, industry codes, in particular, the Uniform Network Code (UNC), and to connection agreements such as the Network Entry and Exit Agreements (NE(x)As), as well as new ways of co-operation between NGGT and GDNs.

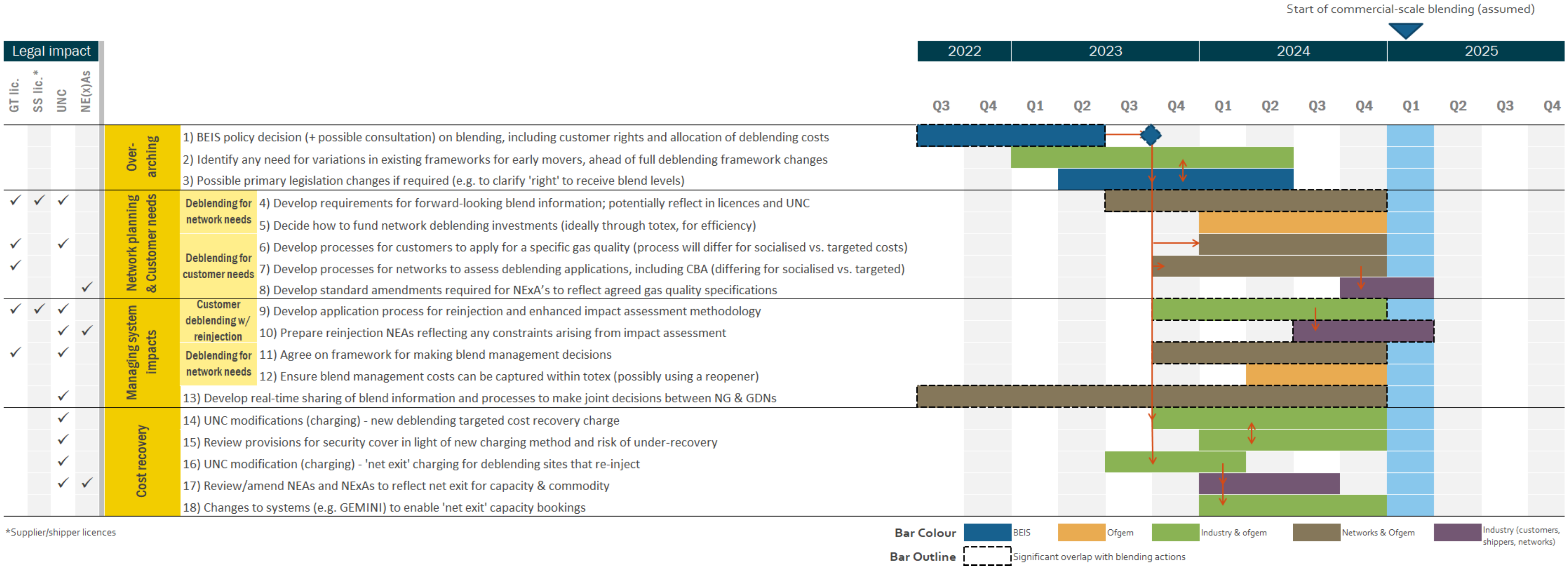
These **actions will need to be co-ordinated**: several actions will need to happen in parallel and certain actions will also need to be sequenced such that outcomes of one action can feed into another. It may take around 2 years following any Government policy decision on blending for the framework changes for deblending to be in place.

It is conceivable that some blending may take place ahead of all changes being made. If so, Government and Ofgem will need to consider how to give **early clarity** to customers on how their needs might be met, to **allow sufficient time to plan investments.** It may also be useful to have an **industry steering group** coordinating and driving forward the necessary further actions on both blending and deblending.

The full roadmap for enabling deblending is shown in Figure 4.

[15] I.e. network operator

FIGURE 4 ROADMAP FOR DEBLENDING



Source: Frontier Economics

Notes: The start of commercial scale deblending is indicative. Whilst it reflects current discussions there have, so far, been no commitments.

The expected BEIS policy decision in relation to blending in late 2023 relates to distribution networks only.

The sequencing of action (18) requires GTs to decide to undertake system development at-risk (as it would precede UNC Modification development) in order to meet timescales for blending.

2 INTRODUCTION

2.1 CONTEXT

Low-carbon hydrogen is anticipated to play a significant role in meeting the UK's net zero target by 2050.[16] In the medium term, Government has recently[17] announced a doubling of the UK ambition for hydrogen production to 10GW by 2030.

Ahead of a full transition to a net zero compliant gas system (for example, a 100% hydrogen system), hydrogen may be injected into the existing gas transmission and distribution system and blended with methane. Parts of the existing gas system may be able to accommodate blends of up to 20% hydrogen (by volume) without the need for replacement or significant upgrades of infrastructure or domestic appliances. The economic and safety case for allowing hydrogen blending in the existing gas networks is being considered separately by BEIS.

However, some existing non-domestic gas customers may be sensitive to receiving hydrogen blends (or to variability in the blend).[18] And some customers may want to consume (close to) pure hydrogen from the gas system. There may therefore be a role for deblending technologies, that can separate hydrogen from natural gas, in helping to manage customer needs as well as helping network operators to manage the impacts of blending on the gas system itself. Some deblending technologies are already well-established today in industrial applications, although they have not yet been deployed on GB gas networks.

Any decision on blending will have to consider the costs of solutions for existing hydrogen-sensitive customers. These considerations will inform the pace, extent and location of any blending roll-out. While there has been increasing focus on the actions and timelines required to enable blending, there has been limited work to date on actions required to manage customer needs (e.g. via deblending). It is therefore important that due thought is given to the actions required to enable deblending in parallel with any blending plan, to ensure that the transition is not unnecessarily held up.

2.2 PROJECT OBJECTIVES

NGGT has been carrying out a programme of work to understand the capability of the National Transmission System (NTS) to transport hydrogen. A previous Network Innovation Allowance (NIA)

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[16] See, for example, Climate Change Committee. December 2021. Sixth Carbon Budget: https://www.theccc.org.uk/publication/sixth-carbon-budget, which projects hydrogen demand in 2050 ranging between 150TWh and 350TWh depending on the scenario under consideration.

[17] UK Energy Security Strategy, April 2022

[18] For example, variability in the hydrogen blend may result in fluctuations in the Wobbe Index, which may in term affect flame temperature and shape, efficiency and emissions. See 'CEN SFGas GQS — Recommendations and considerations on Wobbe index aspects related to H-gas — Final report', Section A.3.

funded project,[19] together with the GDNs, evaluated, developed and demonstrated the concept of deblending at point-of-use. This work ('Phase 1') has now been completed.

NGGT has been taking forward Phase 2 of this work, supported by DNV, which aims to further understanding and research relating to gas separation on a gas network level by looking into:

- **UK network mapping:** Summarising the most likely locations for deblending technologies and fully understanding the challenges of installing gas separation technologies at gas offtake sites across the network;
- **High-level design:** Developing the high-level design of a demonstration deblending facility at FutureGrid, a hydrogen research facility funded in part by Ofgem's Network Innovation Competition (NIC) and managed by NGGT; and
- **Future technology work** (with the National Physical laboratory (NPL)): Carrying out a technology watch into future and emerging concepts that could disrupt the existing gas separation marketplace.

In addition, as part of Phase 2 of the deblending work, NGGT has asked Frontier Economics to explore how the gas sector commercial frameworks may need to evolve to accommodate deblending on the UK gas networks, across both the NTS and distribution networks. More specifically, the aims of our work are to:

- Consider future customer needs for deblending;
- Explore how the gas sector commercial frameworks may need to evolve to accommodate deblending technology;
- Identify the minimum changes required to enable deblending and develop a roadmap for industry, Ofgem and Government for the introduction of deblending; and
- Gain stakeholder input on the above deliverables.

We have in turn been supported in our work by Dentons, particularly in relation to identifying the changes required and in developing the roadmap.

Our scope is to consider the following components of the gas sector commercial frameworks:

- **Connections:** Network entry, exit and storage connection agreements;
- **Capacity:** Capacity booking regime for gas shippers;
- **Balancing:** Daily gas balancing regime;
- **Charging:** Recovering costs of deblending;

[19] See https://smarter.energynetworks.org/projects/nia_nggt0156

- **Gas Quality:** Ensuring hydrogen blending limits are met and allocating risks and liabilities;
- **Network planning:** Assessing network requirements, identifying solutions and planning investments; and
- **System Operation:** Managing the interaction of deblending with the wider gas system.

2.3 STRUCTURE OF REPORT

The rest of this report is structured as follows:

- Section 3 sets out our approach to developing recommendations.
- Section 4 explains the different ways in which deblending technologies might be used on the grid (each of which might raise different solutions and therefore require different solutions).
- Section 5 describes the issues with the current gas framework and our recommendations for addressing them.
- Section 6 sets out a roadmap for the changes initially required to enable deblending in the gas commercial framework.

This report contains two Annexes:

- Annex A - which sets out more detail on our assessment of the different options we assessed, before arriving at our recommendations; and
- Annex B - which explains how some of the more detailed issues identified during the course of our work have been addressed.

3 OUR APPROACH TO DEVELOPING SOLUTIONS AND THE ROADMAP

As discussed in section 2.2, the main objectives of this study are to identify how gas commercial and regulatory frameworks may need to evolve to accommodate deblending technology, and to set out a roadmap for the industry to take forward the associated changes. To do this, we:

- considered future models for the use of deblending technology on the grid;
- identified issues and challenges that would arise if deblending were used under the current gas frameworks, and developed recommended solutions to address these issues; and
- identified the actions associated with implementing our recommended solutions, and arranged them in a roadmap.

This work was carried out with the involvement of a group of stakeholders including representatives from Government, Ofgem, GDNs, NGGT, interconnectors, Energy UK, REA, shippers and suppliers, academics, Xoserve, hydrogen producers, major energy customers and EU stakeholders.

In the sub-sections that follow we set out in more detail our approach within each of these stages of work. Before doing so, we first set out some important assumptions that we have made in this work.

3.1 KEY UNDERLYING ASSUMPTIONS

We have made the following assumptions in undertaking this work.

- **Changes will be needed to gas quality regulations.** The Gas Safety (Management) Regulations (GS(M)R) will need to change to enable hydrogen blending, most critically to increase the allowed hydrogen content of gas in the network from 0.1% to 20%. We consider this to be a blending issue, and not to be investigated in more detail in this work on enabling deblending. We also assume that once the new GS(M)R are in place, responsibilities and liabilities will remain the same as they currently are in cases where gas quality regulations are breached.
- **Trading and balancing are unaffected by deblending.** We assume that National Balancing Point (NBP)[20] trading is unaffected by blending and deblending, i.e. gas trading will continue to be carried out on the basis of energy (therms), not gas type. Additionally, we have assumed the daily balancing regime and associated shipper incentives are unaffected. That said, we investigate the issues that blending and deblending can create for system operation (e.g. around managing hydrogen blend levels or physical congestion).

[20] The National Balancing Point is the "*…virtual point on the UK gas supply system through which all gas passes in accounting and balancing terms.*" See National Grid 'End-to-end balancing guide: An overview of the commercial elements of GB gas balancing activity' for further details.

- **Billing regime changes will be decided separately.** Changes to the billing regime have been considered by the Future Billing Methodology (FBM)[21] project, and are outside the scope of this work.

3.2 APPROACH TO THE ANALYSIS

DEBLENDING MODELS

We started this work by identifying different possible future models for the use of deblending technology on the grid. We explored different options within the following areas:

- **Use cases:** what might deblending technology be used for, and for whom?
- **Ownership and operation models:** who owns and operates the deblending equipment?
- **Funding: who pays for deblending?** Are the costs targeted at those with specific gas quality needs or socialised?

Following discussion with the stakeholder group, we then brought these different options together into a matrix of likely models (see section 4 for details).

DEVELOPING AND ASSESSING SOLUTION OPTIONS

We next engaged with the stakeholder group to identify a long list of potential issues, challenges and opportunities that could arise under each deblending model, across the following parts of the gas commercial and regulatory frameworks (see section 2.2).

We found that many of the most important issues cut across multiple framework areas (e.g. a single issue could create challenges across connections, capacity and system operation). We found that we could group most issues into three main topic areas. We list these topic areas below, and explain what they cover. The more detailed issues within each area are set out in later sections of this report.

- **Network planning and customer needs:** this covers issues related to planning the use of deblending (for example how gas customers should communicate their gas quality needs) and how networks should make efficient decisions when investing in deblending equipment. This area cuts across network planning and gas quality.
- **Managing system impacts:** this covers issues around (a) managing the impacts of deblending on network blend levels (if unwanted hydrogen or methane is reinjected back into the grid), and (b) how network operators can use deblending to manage blend levels. This area cuts across connections, capacity, system operation and balancing.

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[21] See xoserve.com/decarbonisation/decarbonising-gas/future-billing-methodology-project/

- **Recovering the costs of deblending:** this covers issues related to network charging, for example how the costs of deblending equipment (if owned by networks) should be recovered.

Having identified key issues to be resolved, we worked with the stakeholder group to develop a long list of potential solutions to those issues. We then evaluated the potential solutions against the set of criteria shown in Figure 5, and used the results to select a recommended solution to each issue (see section 5 for details).

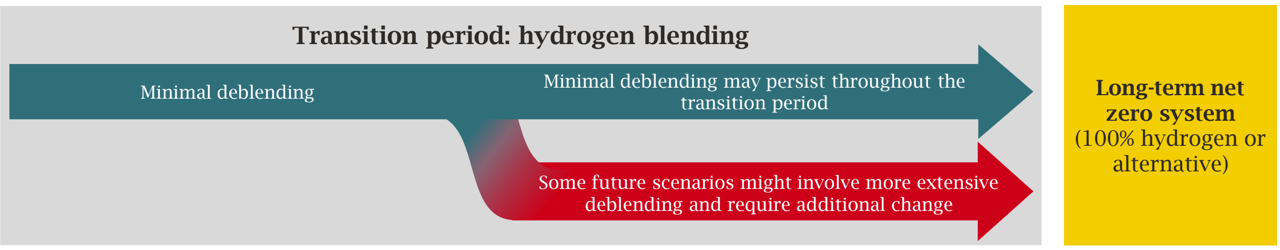
FIGURE 5 CRITERIA FOR ASSESSING DEBLENDING SOLUTIONS

EFFICIENCY (OPTIMISING WHOLE GAS SYSTEM COSTS)	EFFICIENT INVESTMENT	Decisions to invest in deblending should take into account alternatives such as adapting customer equipment or virtual H2 distribution, as well as stranding risks.
	EFFICIENT LOCATION	Decisions on where to install deblending should factor in locational impacts on H2 blend limits and network congestion.
	EFFICIENT OPERATION	Incentives should encourage selection of the most cost-effective approach to managing gas blend, whether that is deblending (with efficient decisions on when/where) or alternatives.
FEASIBILITY AND PRACTICALITY		Changes needed to enable the deblending approach are simple and quick to implement which limits administrative cost and complexity for networks.
ENABLING DECARBONISATION		Approach to deblending should enable a timely and effective transition to a net zero system.
FAIRNESS		Approach to deblending should promote a fair distribution of costs.
ADAPTABILITY		Approach to deblending in the near term should provide flexibility to adopt alternatives better suited to circumstances in the longer term.

Source: Frontier Economics

Selecting recommended solutions involved some **degree of judgement around the weighting of different criteria**, particularly in relation to feasibility and practicality versus efficiency. This is because there are different pathways for how hydrogen deblending could be used. Blending (and therefore deblending) is likely to be only a transitional phase on the path to a net zero compatible system (e.g. a 100% hydrogen grid), as illustrated in Figure 6 below.

FIGURE 6 POSSIBLE PATHWAYS FOR HYDROGEN DEBLENDING



Source: Frontier Economics

In the **early stages of hydrogen blending**, hydrogen blending itself is likely to be limited in volume (e.g. rarely reaching 20% by volume) and in only a limited number of grid locations, and therefore only a **small number of customers are likely to require deblending**. Under these 'minimal deblending' circumstances, **simpler solutions involving more limited change may be sufficient**.

The **'minimal deblending' phase could persist** all the way through the transition period, or it could evolve into a need for more extensive deblending at some stage, and potentially a need for more complex regulatory and commercial arrangements. We have therefore aimed to select solutions that require relatively limited change and can be implemented relatively quickly, yet also deliver sufficiently efficient outcomes under 'minimal deblending' circumstances (i.e. **proportionate and low regrets**). We have also **taken into account whether solutions can evolve to suit more complex future pathways** if needed.

DEVELOPING THE ROADMAP

Having identified a set of recommended solutions, we worked with the stakeholder group to identify the actions needed to implement those solutions. We also worked with Dentons to identify the likely changes needed to legal documents including the UNC and network licences. We then arranged these actions into a visual roadmap, reflecting:

- which industry parties should be responsible for each action;
- how long the actions are likely to take; and
- any dependencies between actions, and therefore the necessary sequencing.

The resulting roadmap (see section 6) provides a clear, sequenced action plan for the industry to enable deblending in time for the first hydrogen injections to enter the grid.

4 DEBLENDING MODELS

We explored different options for how deblending technologies might be used on the grid, within the following areas:

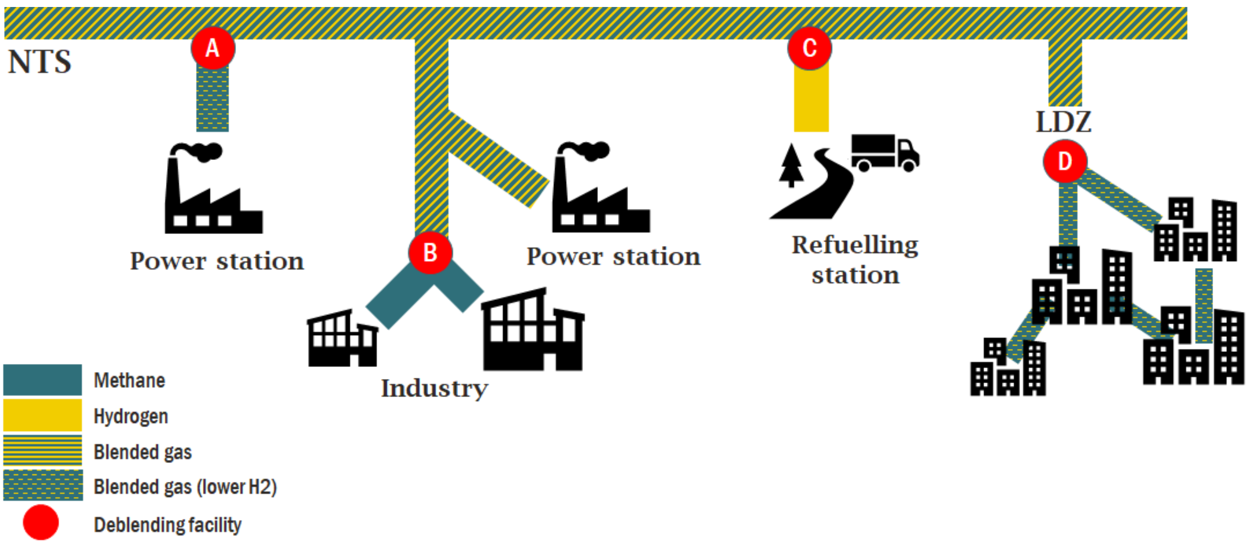
- **Use cases:** what might deblending technology be used for and for whom?
- **Ownership and operation models:** who owns and operates the deblending equipment?
- **Funding: who pays for deblending?** Are the costs targeted at those who have specific gas quality needs, or socialised?

4.1 USE CASES FOR DEBLENDING

Deblending technology on the grid could be used to meet various different gas composition needs that networks may not deliver to customers under amended GS(M)R. Figure 7 below illustrates some examples of this, although these examples are not comprehensive. In these examples, deblending is being used to:

- deliver a lower-hydrogen gas blend to a single customer (A);
- deliver a predominantly methane stream to a part of the grid serving multiple customers (B);
- deliver a high hydrogen stream to a single customer (C);
- deliver a specific gas blend to a part of the grid, different from the blend elsewhere in the network (D).

FIGURE 7 GAS CUSTOMER NEEDS



Source: Frontier Economics

Based on discussions with the stakeholder group, we identified a number of use cases for deblending technology on the grid (with a key distinction being between the use of deblending to meet the needs of customers versus use for system operation purposes, such as managing network blend levels). The use cases we identified were as follows:

- Deblending to meet customer needs, delivering:
  - close to 100% methane (in reality, this would simply be a high proportion of methane);
  - close to 100% hydrogen (of varying purity[22]); or
  - a specific and/or stable blend level (e.g. a constant 5% blend, or a blend no higher than 10%); and
- Deblending to meet network needs, delivering a specific and/or stable blend level (e.g. a blend no higher than 20%).

Note that, in relation to **customer needs**, for customers requesting a high (or stable) share of methane, alternatives to deblending may exist. For example, customers could adapt their equipment to accommodate a higher (or more variable) hydrogen blend. It is important that there are incentives for selecting the most cost-efficient solution, from a whole system perspective. We come back to this issue in the later sections of this report.

Within deblending for **network needs**, 'a specific and/or stable blend' is the only use case because the gas network does not have a specific need for hydrogen or methane, but it does need to remain within amended GS(M)R limits (e.g. less than 20% hydrogen by volume). Deblending could be used as a tool for managing network blend levels, by removing hydrogen from the system when blends are close to exceeding GS(M)R limits. The hydrogen could be stored and later reinjected when blend levels are lower (or reinjected at a different point in the grid). Deblending could also potentially be used to manage the impacts of hydrogen blending on billing, by helping to deliver a more homogenous blend to Local Distribution Zones (LDZs), and therefore reducing the effect of Flow Weighted Average Calorific Value (FWACV) capping.[23]

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[22] This use case captures both customers who require high but not pure concentrations of hydrogen (for example 99%), as well as those who require high levels of purity (for example 99.99999% hydrogen). There are technical distinctions between these two groups: for those customers who want a high level of purity (e.g. for use in hydrogen fuel cells), additional processes and equipment will be needed for purification. However, we do not need to distinguish between the two use cases for the purpose of considering impacts on commercial and regulatory frameworks.

[23] The introduction of low-carbon gases such as non-propanated biomethane and hydrogen into the grid leads to a challenge around billing due to the lower energy content ("calorific value", or "CV") of these gases. Under the current billing regime, the CV used for billing in a local distribution zone must be capped at 1MJ/m^3 above the lowest CV gas in the zone. Therefore even a small volume of biomethane or hydrogen can lower the billing CV and lead to under-recovery of energy, leading to shrinkage, which needs to be recovered by shippers who ultimately pass the cost on to consumers (resulting in the socialisation of the cost).

The Future Billing Methodology (FBM) project has been considering options for addressing this challenge, and has now published its final recommendations here: https://www.xoserve.com/media/43317/xos1434_xoserve-fbm-consultation-output-v7-final.pdf. One of the FBM findings is that current billing frameworks can be retained if hydrogen is blended at levels below 5% (at least initially, until the majority of the gas within a given LDZ is a broadly homogenous hydrogen blend).

Figure 8 below summarises the use cases identified.

FIGURE 8 USE CASES FOR DEBLENDING

CUSTOMER NEEDS			NETWORK NEEDS
100% METHANE	SPECIFIC /STABLE BLEND	100% HYDROGEN	SPECIFIC /STABLE BLEND

Source: Frontier Economics

4.2 OWNERSHIP AND OPERATION OF DEBLENDING EQUIPMENT

Regardless of the use case that deblending equipment is serving, there can be different ownership and operation models for that equipment. Specifically, it could be owned and operated by any of:

- the network;
- the customer; or
- a third party.

Based on our discussions with stakeholders, we established that it is likely to be most practical for the equipment to be owned and operated by the same party. Therefore from this point on we refer just to ownership of deblending equipment, assuming that this also captures operation of the equipment by that same party.

There will be different drivers of the different ownership models, as summarised below.

- **Customer ownership.** Certain customers may require a specific gas blend, and Government may make a policy decision that networks are not responsible for delivering that need. The customer may then decide to install its own deblending equipment behind-the-meter to obtain that blend.
- **Network ownership.** The network may decide to invest in deblending equipment for:
  - the 'network needs' use case, i.e. the network may need to use deblending to manage gas blends for safety or billing reasons; or
  - a 'customer needs' use case, i.e. certain customers may require a specific gas blend, and Government may decide that (under certain circumstances) they may request the network to deliver this.

Alternatively, the billing regime can be adapted using CV modelling to more accurately capture differences in CV across an LDZ. However this could be costly and take some time to implement.

We note that both networks and customers could contract out the construction and/or operation of deblending to third parties (in the case of customers, this could include contracting out to networks as an 'enhanced service'). This would be a private contractual matter between the relevant parties, and does not affect licensees' or customers' obligations.

We also note that because customer-owned deblending occurs behind-the-meter, it will only impact the wider gas system (and therefore have an impact on gas frameworks) if the customer reinjects their unwanted gas (hydrogen or methane) back into the network. For example, a customer who is receiving blended gas but who wants close to 100% methane could use deblending to separate the methane and hydrogen, and then reinject the unwanted hydrogen back into the network. If the customer does not reinject their unwanted gas (and instead finds another use for it, or sells it on), from a network perspective they will simply be taking blended gas from the network, and the fact that they are deblending the gas does not impact the system in any way. Therefore in later sections, we often specifically reference customer-owned deblending with reinjections.

4.3 FUNDING OF (NETWORK-OWNED) DEBLENDING

Under customer ownership, the costs of deblending will be borne, in the first instance, by the customer. It is possible – as we note below (section 5.3) – that Government could choose to compensate some customers for a proportion of these costs. However, such a decision would take place outside of the gas commercial framework, and so is not in the scope of this report.

Under network ownership, where deblending is carried out to meet a network need, the costs of deblending will be socialised (that is, costs will be recovered across all gas network customers). This does not require any change to the existing gas commercial framework. Where deblending is carried out to meet a customer need, there are different models for funding the costs of deblending. At the simplest level, the costs of deblending equipment can be:

- **Socialised:** recovered from energy consumers or taxpayers; or
- **Targeted:** recovered from the customers who have a specific gas composition need that is being addressed.

4.4 SUMMARY: DEBLENDING MODELS

Figure 9 below summarises the different options set out above in relation to:

- deblending use cases (red, header row);
- ownership models (teal, left column); and
- funding (blue, left column).

The resulting combinations of use cases, ownership and funding are different deblending models (labelled A to D in Figure 9) that could arise. We note that some combinations do not exist (the greyed-out boxes):

- deblending for network needs cannot sensibly be targeted to specific customers (since it is serving the general needs of the network, rather than customers); and
- it would not be practical for deblending for network needs to be customer-owned.

FIGURE 9 SUMMARY OF DEBLENDING MODELS

		CUSTOMER NEEDS			NETWORK NEEDS
		100% METHANE	SPECIFIC /STABLE BLEND	100% HYDROGEN	SPECIFIC /STABLE BLEND
Network owned	Cost socialised	A. The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs are socialised.			D. The network invests in deblending equipment to manage network blends. Costs are recovered from all network customers.
	Cost targeted	B. The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs recovered from the relevant customer(s).			*N/A - there are no specific customers to target costs at, since deblending is being used for network needs.*
Customer owned*		C. Customer owns and operates their own deblending equipment. Costs could be borne by the customer or reimbursed by Government (this is a policy decision that falls outside this work).			*N/A - deblending equipment for 'network needs' would not be owned by customers.*

*Note that customer-owned deblending only impacts the rest of the gas system if the customer reinjects their unwanted gas back into the system. If there is no reinjection, the customer simply makes their own arrangements behind the meter, and no changes are needed to gas frameworks.

Source: Frontier Economics

In the later sections of this report, we refer back to this set of deblending models to differentiate between issues that arise under different models, and associated solutions that are relevant to specific models. Since any of these models, or a mix of them, could materialise, it is important to consider each of them.

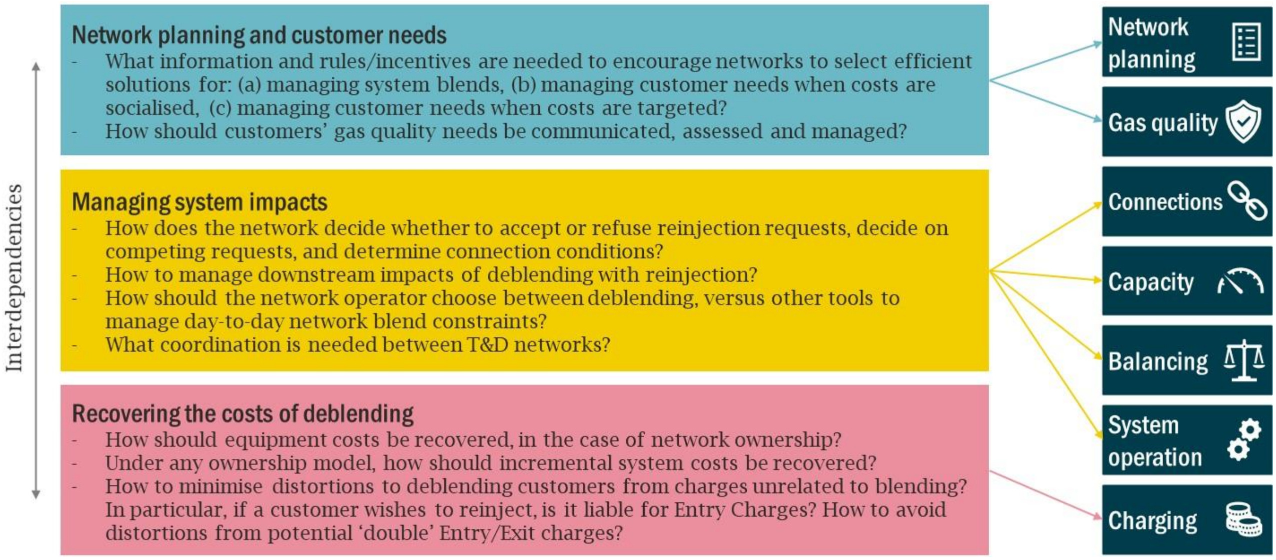
5 AREAS OF CHANGE TO ENABLE DEBLENDING (ISSUES AND RECOMMENDATIONS)

In this section, we set out the key issues and challenges associated with deblending and our recommended solutions for each of the three groupings of gas framework issues presented in section 0:

- Network planning;
- Managing system impacts; and
- Cost recovery.

The key issues are summarised in Figure 10 below.

FIGURE 10 KEY OVERARCHING ISSUES AND MAPPING TO COMPONENTS OF COMMERCIAL FRAMEWORK



Source: Frontier Economics

Within each sub-section we:

- explain the issues identified and under which of the deblending models they arise;
- summarise our recommended solution to each issue; and

- briefly outline the alternative solutions considered, explaining the grounds for the recommended option (referring to the assessment against criteria). More detail on this assessment is provided in Annex A.

5.1 NETWORK PLANNING AND CUSTOMER NEEDS

This section addresses issues and solutions around network planning and customer needs. In our work with stakeholders we identified the following issues, which we classify into the deblending models described in section 4 (corresponding to the yellow-highlighted boxes in Figure 11 below).

1. **How should customers' gas quality needs be communicated and assessed?** This issue arises when a customer is seeking to apply for network provision of a specific gas quality (close to 100% methane, 100% hydrogen or a specific/stable blend), i.e. under deblending models A and B.
2. **How should network operators be encouraged to select efficient solutions for meeting customer needs and network needs?** This issue arises when the network operator decides whether to approve customer applications for deblended gas or is making decisions on deblending investments to manage network needs, i.e. under deblending models A, B and D.
3. **Do networks have sufficient information to plan deblending investments?** This issue arises when the network operator is making decisions[24] on deblending investments to manage its own needs, i.e. under model D.

As Figure 11 shows, none of the issues in this area arise under customer-owned deblending (model C). If customers decide to install their deblending equipment behind-the-meter, then the only concern to networks (from a network planning perspective) relates to any blend issues caused by reinjections (which we cover in section 5.2 below).

FIGURE 11 MODELS FOR NETWORK PLANNING AND CUSTOMER NEEDS

		CUSTOMER NEEDS (100% METHANE / SPECIFIC /STABLE BLEND / 100% HYDROGEN)	NETWORK NEEDS (SPECIFIC /STABLE BLEND)
Network owned	Cost socialised	**A.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs are socialised.	**D.** The network invests in deblending equipment to manage network blends. Costs are recovered from all network customers.
Network owned	Cost targeted	**B.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs recovered from the relevant customer(s).	*N/A – there are no specific customers to target costs at, since deblending is being used for network needs.*
Customer owned		**C.** Customer owns and operates their own deblending equipment. Costs could be borne by the customer or reimbursed by government (this is a policy decision that falls outside this work).	*N/A – deblending equipment for 'network needs' would not be owned by customers.*

Source: Frontier Economics

[24] Or, indeed, not doing so due to lack of foresight on what investments are required to manage future blend issues.

A summary of these issues, and the recommended solution for each, is provided in Table 1 below. Note that some issues have different solutions dependent on the deblending model in question, which can be seen in the second column.

TABLE 1 NETWORK PLANNING AND CUSTOMER NEEDS - OVERVIEW OF ISSUES AND RECOMMENDED SOLUTIONS

ISSUE	MODEL	RECOMMENDED SOLUTION
How should customers' gas quality needs be communicated and assessed?	**(A)** Customer needs, costs socialised	Customers make applications for a deblending need, along with supporting evidence to justify their need.
	(B) Customer needs, costs targeted	Customers make applications for a deblending need but less supporting evidence is required.
How should network operators be encouraged to select efficient solutions for meeting customer needs and network needs?	**(A)** Customer needs, costs socialised	Funding for deblending investment must be justified by CBAs and approved by Ofgem.
	(B) Customer needs, costs targeted & **(D)** Network needs	No change needed. For (B), rely on existing totex incentives to encourage network operator to minimise costs of managing network needs.
Do networks have sufficient information to plan deblending investments?	**(D)** Network needs	The network operator gathers forward-looking information on hydrogen blends through surveys/studies.

Each of these issues and our recommended solutions are discussed in detail below.

HOW SHOULD CUSTOMERS' GAS QUALITY NEEDS BE COMMUNICATED AND ASSESSED?

Processes will need to be put into place for gas customers to apply to the relevant network operator for a specific gas quality need. If approved, the network could deliver this gas quality through deblending or alternative solutions such as managing upstream hydrogen and methane injections. The assessment of these applications, and their approval or rejection, will need to consider the cost of alternative options on the system and customer-based options (such as upgrading the customer's equipment to handle hydrogen blends) to ensure efficient outcomes.

If the customer's costs are socialised (model A), we recommend that the customer communicates their gas quality need through an application to the network, including supporting evidence to justify that need. A high evidential bar should apply since the customer will not face the full costs of deblending (or any alternative network solution) under the socialised model. It would be left up to the network (and eventually Ofgem) to establish the evaluation criteria and whether the application is the most efficient solution compared to any alternative investments which the customer could make.[25]

If the customer's costs are targeted (model B), we again recommend that the customer makes an application for a gas quality need. However, in this case, less supporting evidence is required, as the customer will be covering the costs of the deblending and the network operator providing a service in return. Customers who face the costs of meeting their gas quality needs should consider the costs of alternatives and choose the most efficient option. Even so, the customer may not consider the wider system costs associated with their choice of deblending (e.g. increased need for blend management services or their impact on downstream users), since they would only face the direct costs associated with installing and operating the deblending facility. The network will therefore need to consider these wider system costs when assessing the application.

HOW SHOULD NETWORK OPERATORS BE ENCOURAGED TO SELECT EFFICIENT SOLUTIONS FOR MEETING CUSTOMER NEEDS AND NETWORK NEEDS?

When networks make decisions about investing in deblending, whether to meet customer needs or network needs, they should be incentivised to do so efficiently. In both cases, the costs of alternative solutions to meeting customer/network needs (as we briefly mentioned in section 4.1) should be considered and weighed alongside the option of investing in deblending. For customer needs, alternative solutions to deblending could include:

- adapting customer equipment to enable operation using hydrogen blends;
- other system operation tools such as managing upstream gas injections, or changing gas flows;
- 'virtual' provision of specific gas needed, i.e. delivering the gas via road transport rather than via networks; or
- using existing deblending assets (i.e. those serving another customer) to serve a new customer, or coordinating multiple requests for deblending.

For network needs, alternative solutions to deblending could include:

- other system operation tools such as managing upstream gas injections, or changing gas flows; or
- adapting network equipment if the purpose is to protect non-hydrogen-ready network assets.

For situations in which customers face socialised costs, we recommend that networks be required to **justify any expenditure on deblending using a CBA,** which would be approved by Ofgem, who

[25] Beyond this, Ofgem will likely need to play a backstop role in resolving any disputes between the network operator and customers if a customer wishes to challenge an assessment outcome. Ofgem would be responsible for revisiting and confirming the assessment outcome.

could then release the necessary funding through an uncertainty mechanism.[26] Such a CBA would ensure that the network considers the costs of alternative solutions to delivering the customers' gas quality needs, and selects the most efficient solution. Without this, the network would not have incentives to minimise **overall** costs of managing customers' gas quality needs (i.e. considering solutions involving network costs as well as costs of non-network solutions such as upgrading a customer's equipment to handle hydrogen blends).

We note that information asymmetry between networks and customers (in particular, lack of transparency around the costs of upgrading a customer's equipment) may create a challenge in carrying out an accurate CBA. Nevertheless, we find this to be the **most proportionate approach in the initial stages of blending/deblending**, even if it is not fully accurate, should Government decide that customer costs be socialised in certain circumstances.

We also considered more complex solutions to encouraging efficient solutions, for example with a new regulatory incentive which would expose networks to a portion of the costs of alternative solutions (such as end customer equipment adaptation), creating an incentive to minimise these costs. While such approaches could deliver efficient outcomes, the complexity of such a regime and the issues around information asymmetry led us to rule it out as a suitable solution.

For situations in which customers face targeted costs, we recommend **no changes.** This is because under this mechanism, customers face the costs of their own deblending needs rather than these costs being borne by energy consumers or taxpayers. Customers will therefore internalise the costs of different options for meeting their gas quality need and select the one that is most efficient.

For network needs, we again recommend **no changes**, instead **relying on existing totex incentives** to encourage the network operator to minimise their costs of managing network needs. The totex regime should be able to capture the costs of:[27]

- Opex solutions – such as management of upstream hydrogen or methane injections; and
- Capex solutions – such as installing deblending equipment or adapting non hydrogen-ready network assets.

Accordingly, it can provide networks with incentives to select the most efficient options. As the totex regime is already in place, this is a low cost, low effort solution. However, it does **require Ofgem to consider how these costs will be captured within regulated totex allowances**. This may pose some challenges due to the absence of historical deblending costs on which to base forward-looking allowances. However, given the limited materiality of deblending in early stages, we do not believe this should not render this solution unworkable. If these costs do become material during a price

[26] Ofgem sets ex ante baseline totex allowances to recover 'sufficiently certain efficient network investments'. If there are uncertain areas of expenditure that may arise during the price control period, such as deblending investment, funding can be provided through an uncertainty mechanism such as a price control re-opener. These uncertainty mechanisms enable the regulator to increase allowed revenues within a price control period if the need arises, rather than providing funding upfront.

[27] We assume that the totex incentive would apply to blend management costs, because if and when blending becomes a material activity, some regulated funding will need to be provided for network operators to manage blend levels, either through the price control, or through an uncertainty mechanism such as a reopener. We assume that networks operators can fund deblending investments through these allowances, and that the totex sharing factor will apply to any underspend relative to these allowances.

control period, an uncertainty mechanism such as a price control reopener can be used to release required funding.

We considered alternative solutions, including using CBAs to justify investment in deblending for network needs and introducing additional incentives encouraging networks to select solutions providing most decarbonisation benefits (i.e. which maximise hydrogen volumes in the grid, subject to the blending cap). However, we concluded that these were unlikely to be proportionate as a first step. While a CBA could help capture the system wide costs of alternative options and incentivise coordination of requests, it adds an administrative burden, and is not likely to deliver much additional value over the existing totex incentive. Similarly, new incentive regimes would be burdensome and complex to implement. However, these options could be considered and implemented in future if the need arises.

DO NETWORKS HAVE SUFFICIENT INFORMATION TO PLAN INVESTMENTS?

For investment in deblending technology for network needs (in particular for the management of blend levels), the network will need to make assumptions on how blend levels will evolve. If there is likely to be significant hydrogen injection in the future in a given area, resulting in the frequent threat of breaches of the blending cap, the network operator will need to anticipate this and may decide that investment in deblending equipment is the most effective way to deal with it.

We recommend that the network operator gathers forward-looking information on hydrogen blends through surveys or studies. This will involve engagement with future hydrogen producers.

5.2 MANAGING SYSTEM IMPACTS

In this section, we address issues and solutions around managing the system impacts of deblending. In our work with stakeholders, the following key issues were identified. We have also highlighted the deblending models under which these issues arise.

1. **How does the network operator decide whether to accept or refuse customers' requests for a reinjection connection, and under what conditions will the connection be offered?** This issue arises under deblending model C (the customer owns the deblending equipment to serve their own needs), and where the customer is looking to reinject the unwanted deblended gas back into the network, specifically if that gas is hydrogen or a hydrogen-rich blend.[28]
2. **How should the network operator manage downstream impacts of deblending if a customer is reinjecting their unwanted gas back into the network?** This issue arises under deblending model C, once reinjection is approved and connected.
3. **How should the network operator choose between deblending versus other tools to manage day-to-day network blend constraints?** This issue arises under model D (where the network owns the deblending equipment to serve its own needs), and refers to the network's short-term

[28] Reinjection of close to 100% methane should not cause any issues, as the reinjection point would be similar to any methane injection point today.

decision-making on how to manage blend levels in the network. This is separate to the long-term deblending investment decisions that we discussed in the network planning section above.

4. **How should the network operator manage downstream impacts of deblending facilities they own and operate to meet customer needs?** This issue arises under models A and B where operation of deblending may cause hydrogen blend levels to increase downstream of the deblending facility.
5. **What coordination is needed between transmission and distribution networks to manage these issues?** This issue arises under all models where any blend management issues discussed above (either caused by customer reinjections, network-owned deblending or general blend issues which the system operator may address with deblending equipment) occur across the transmission and distribution networks.

FIGURE 12 MODELS FOR MANAGING SYSTEM IMPACTS

		CUSTOMER NEEDS			NETWORK NEEDS
		100% METHANE	SPECIFIC /STABLE BLEND	100% HYDROGEN	SPECIFIC /STABLE BLEND
Network owned	Cost socialised	**A.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs are socialised.			**D.** The network invests in deblending equipment to manage network blends. Costs are recovered from all network customers.
	Cost targeted	**B.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs recovered from the relevant customer(s).			*N/A – there are no specific customers to target costs at, since deblending is being used for network needs.*
Customer owned		**C.** Customer owns and operates their own deblending equipment. Costs could be borne by the customer or reimbursed by government (this is a policy decision that falls outside this work).			*N/A – deblending equipment for 'network needs' would not be owned by customers.*

Source: Frontier Economics

An overview of the recommended solutions to each of the issues identified above is provided in Table 2 below. We have grouped the first two questions as our recommended solution addresses both jointly. The following sub-sections discuss each of these recommendations in more detail.

TABLE 2 MANAGING SYSTEM IMPACTS - OVERVIEW OF ISSUES AND RECOMMENDED SOLUTIONS

ISSUE	RECOMMENDED SOLUTION
How does the network operator decide whether to accept or refuse reinjection requests and determine connection conditions? How should the network operator manage downstream impacts of reinjection?	Reinjection points are connected to the grid subject to an enhanced pre-connection Impact Assessment (IA). Reinjection points are connected subject to constraints on their ability to reinject if/when this causes downstream blend issues. The network operator can constrain customers to manage blend levels if needed.

ISSUE	RECOMMENDED SOLUTION
How should the network operator choose between deblending versus other tools to manage network blend constraints?	The network operator is given responsibility to select the most efficient tool to manage blends or does so according to a methodology specified by Ofgem. The existing totex regime incentivises minimisation of network costs.
How should the network operator manage blend levels downstream of deblending facilities they own and operate to meet customer needs (where the unwanted gas remains in the network)?	These blend management decisions should be made using the same approach described in the row above, for choosing tools to manage blend levels more generally.
What coordination is needed between Transmission and Distribution networks to manage these issues?	Develop processes for sharing and management of gas blend information between NGGT and GDNs.

Source: Frontier Economics

HOW DOES THE NETWORK OPERATOR DECIDE WHETHER TO ACCEPT OR REFUSE REINJECTION REQUESTS, AND DETERMINE CONNECTION CONDITIONS? IF ACCEPTED, HOW DOES IT MANAGE THE DOWNSTREAM IMPACTS OF REINJECTION CONNECTIONS?

Reinjection connections (for hydrogen or hydrogen-rich blends) are, from a framework perspective, very similar to any hydrogen injection connection,[29] in that they that could cause issues downstream such as:

- exceeding the blend cap;
- constraining other injection or reinjection points by utilising the system's capacity to accept hydrogen within the cap; or
- causing undesirable variations in blend for downstream customers.

To manage these issues (noting that the final issue may or may not be network operators' responsibility to manage, depending on Government policy), network operators will need to have a process for making decisions on whether to accept reinjection connection applications, determine the conditions under which accepted connections are allowed to operate, and manage downstream blend impacts if they do occur. Since reinjections are very similar to hydrogen injection connections, we note that the processes developed to manage reinjection impacts are likely to be part of enabling hydrogen blending more generally.

[29] However, we note that hydrogen reinjections are not identical to hydrogen injections from an incentives perspective, as hydrogen injections will likely be driven by incentives delivered by support mechanisms for the production of hydrogen.

Our **recommended solution is that reinjection points are connected to the grid subject to an enhanced pre-connection Impact Assessment (IA)** evaluation by NGGT (for NTS connections)[30] or the relevant GDN (for distribution network connections). This pre-connection IA would cover the following questions:

- How much blend capacity is available in the network, downstream of the connection location? I.e. is there sufficient headroom to the blend cap to inject the expected volumes of hydrogen without frequent risk of breaches?
- If blending capacity is limited, are there alternative investments (e.g. upgrading a plant to be hydrogen ready) or locations that would be better suited? (However, we note that alternative locations may not be an option for existing gas customers who are already established in a fixed location.)
- What is the expected impact on any hydrogen-sensitive customers downstream?

Based on this assessment, the network operator can decide whether the system impacts of the reinjection can be safely and efficiently managed, and therefore if the connection application should be accepted. If it is accepted, we recommend including **conditions in the NEA and potentially the UNC such that reinjection can be constrained by the network operator** if needed for blend management purposes.[31] This could be achieved through conditions setting out that the gas injected must not cause the downstream gas blend to exceed the blending cap. As to whether the network operator compensates the customer for interrupting their reinjection, this is a question which will need to be addressed in relation to blending more generally, and it is likely to make sense to follow a consistent approach for deblending. There may also need to be further conditions to limit the impact of reinjections on any sensitive customers, such as specific flow rates and injection profiles.

It is possible that hydrogen injection and reinjection points jointly contribute to a blend issue, meaning that there would need to be a decision over which injection/reinjection points to constrain. Given that reinjection connections would have to be approved through the pre-connection IA discussed above, and we are focusing on the early period of 'minimal deblending', this should only happen on rare occasions. Therefore if injection and reinjection points do, infrequently, cause blend issues, we recommend that the network operator be given discretion to select the most appropriate connection to constrain in this early period.

We considered a number of alternative solutions for managing reinjection impacts, ranging from highly constrained (reinjection is not allowed at all) to more sophisticated approaches (reinjections are connected without any restrictions, and the system operator uses a market mechanism of abatement bids to constrain customers when the blend cap is reached).

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[30] This would be additional to the existing Planning and Advanced Reservation of Capacity Agreement (PARCA) process. PARCA is a bilateral contract that allows entry and/or exit capacity to be reserved for the customer while they develop their own projects which focuses on determining whether sufficient capacity is available for the connection. For more information: https://www.nationalgrid.com/gas-transmission/reserving-capacity-parca-and-cam

[31] This would mean that, once reinjection begins, the customer should not be injecting gas that causes network blend caps to be breached. If they are, the network operators would play a backstop role, constraining the reinjections if they do cause blend issues downstream, or breach any other conditions in the NEA.

Preventing reinjection altogether would increase costs of deblending by limiting customer choices (for example, reinjection may be cheaper from an overall system perspective than forcing customers to purchase and find another buyer or use for gas they do not require).

A market-based approach to curtailment would avoid the risk of inefficient operational outcomes resulting from the network operator's inability to know the cost to customers of being constrained. However, because the impact should be limited in the early phase of blending and deblending, introducing a more sophisticated approach to constraints would be disproportionate at this stage. As an interim solution to avoid unfair outcomes for customers,[32] Ofgem could carry out regular reviews or consultations on network operator constraint management decisions, or alternatively play a backstop role in resolving any disputes between the network operator and customers if a customer considers that a decision was unfair ex post.

Overall, we found that an enhanced impact assessment with administrative constraints on reinjection connections would strike the right balance between efficiency and practicality in the early stages of minimal deblending. It should deliver reasonably efficient investment and location outcomes, and the inefficiency in operational outcomes should be limited. This approach can also evolve into a more sophisticated constraint management approach in future if needed.

HOW SHOULD THE NETWORK OPERATOR CHOOSE BETWEEN DEBLENDING AND OTHER TOOLS TO MANAGE NETWORK BLEND CONSTRAINTS?

Once blending starts, irrespective of whether there is reinjection from deblending, blend management will be a part of day-to-day operation of the grid. Operators will need to manage blend issues as they arise, choosing between different tools they have available to them, including:

- Constraining hydrogen injections and reinjections (from customer-owned deblending facilities);
- Constraining network-owned deblending facilities operated to meet customer needs where the unwanted gas remains in the network;
- Requesting increased injections of methane; and
- Operating any network-owned deblending equipment to remove excess hydrogen (and re-introduce it into the grid when/where blend levels are lower).

We **recommend that, in the early stages, an administrative approach is used to enable operators to choose between different tools**. The specific approach will ultimately need to be decided by Ofgem, but could involve either one of the following.

- The network operator could be given responsibility to select the most efficient tools to manage blend; or

[32] For instance, two customers could have the same costs but one may end up being chosen more frequently to be constrained by the operator.

- A process or methodology could be agreed between Ofgem and network operators for selecting tools. This could range from a set of guidelines or decision tree specifying which tools to prioritise, to a set of proxy costs that the network operator could use to compare different options in different circumstances.[33]

The **existing totex regime** (where regulatory allowances are set in advance at the start of a price control, and network operators are incentivised to spend those allowances efficiently though a 'sharing mechanism' where they retain a share of any savings they make) will **encourage network operators to minimise their own costs** under either of these approaches.

However, it will **not capture the costs to customers** of having their (re)injection points constrained. This could mean that the network operator optimises its own costs but in doing so does not choose an overall efficient solution. The approach of **assigning proxy costs to different tools** would help address this (noting that actual day-to-day costs will differ from these proxy costs), while requiring limited changes to implement.

We considered a range of alternative solutions that could deliver greater efficiency gains by implementing new incentives that capture and expose network operators to customer costs of constraint (and any other system costs not captured by the totex incentive scheme), encouraging the operator to minimise wider system costs. However, we concluded that the additional complexity of setting up new incentives, and the challenge of obtaining accurate estimates of customer costs, were likely to outweigh the benefits of such incentive schemes, particularly in the early stages of deblending. Such an incentive can be introduced at a later stage if/when the need is clear. We also considered market-based approaches to pricing curtailment versus alternative tools to manage blends, but ruled these out for the same reasons as described in the previous section.

We note that the solutions recommended above for choosing between network operator tools, and managing the downstream impacts of reinjections, do not incentivise network operators to take account of decarbonisation outcomes (e.g. maximising hydrogen levels in the grid by redirecting gas flows rather than constraining hydrogen injections when the blend cap is reached). Whilst achieving this would be disproportionately complex in the initial stages of deblending, decarbonisation objectives could be addressed later by implementing an incentive rewarding networks who avoid constraining hydrogen volumes, within the blend cap.

HOW SHOULD THE NETWORK OPERATOR MANAGE BLEND LEVELS DOWNSTREAM OF DEBLENDING FACILITIES THEY OWN AND OPERATE TO MEET CUSTOMER NEEDS (WHERE THE UNWANTED GAS REMAINS IN THE NETWORK)?

So far, we have discussed managing reinjections from customer-owned deblending, and the various tools that networks have to manage blend issues arising from those reinjections. We have not yet considered the network counterpart to customer-owned reinjections, that is, when networks invest

[33] We note that both of these options can involve guidance or proxy costs that result in deblending reinjection points being interrupted only as a last resort (after interrupting hydrogen producers for example), since examples of customers using deblending technology could include large industrial users who may face significant costs as a result of interruptions..

in and operate deblending to meet customer needs, and the unwanted gas flows downstream in the network, impacting downstream blend levels.

Similar issues may arise to those in customer-owned deblending with reinjection. Keeping the unwanted gas in the network could cause issues downstream such as risk of exceeding the blend cap, constraining downstream (re)injection points and causing volatility in downstream blends. An added complication is that decisions on which deblending sites to constrain to manage downstream blends may cut across customer-owned and network-owned facilities. How these two types of facilities are treated and how this is implemented will need to be addressed.

We recommend that, **in the early stages of 'minimal deblending', these blend management decisions are incorporated into the administrative approach used for the network operator's choice of tools to manage blends more generally (above).**

It is possible that multiple deblending sites could jointly contribute to a blend issue, meaning that there would need to be a decision over which site to constrain and this could cut across customer owned and network owned facilities. However, this should only happen on rare occasions in the early period of 'minimal deblending', especially given that sites would have had to pass the pre-connection Impact Assessment (for customer owned reinjections) or the gas quality application approval process (for network-owned deblending for customer needs). Therefore if multiple injection points do, infrequently, cause blend issues, we recommend that the choice of who to constrain is left to the operator's discretion to select the most efficient option in this early period. This is in line with our recommendation on the approach to choosing a reinjection site to constrain, but generalising it to include network-owned deblending sites.

WHAT COORDINATION IS NEEDED BETWEEN TRANSMISSION AND DISTRIBUTION NETWORKS TO MANAGE THESE ISSUES?

In the discussion above, we have simply talked of 'network operators' making operational decisions to address blend issues. However, blend issues can occur across different networks that make independent decisions with differing sets of information. The exact way in which the responsibilities for managing blends will fall across network boundaries will depend on how amended GS(M)R is specified. For example, new reinjection connections on the transmission network could raise hydrogen levels to just below the blend cap and, in so doing, constrain injection or reinjection points on the distribution network. Or reinjection connections low down the pressure tiers on the distribution network could quickly use up available hydrogen capacity (because methane volumes are low at these pressure levels), and prevent the connection of much larger hydrogen injections on the transmission network where there is far more blending capacity.

We recommend that, where reinjections on the transmission network cause constraints downstream, and vice versa, the **relevant networks should co-ordinate** to apply the solutions recommended in the sections above in a 'whole system' manner, rather than simply defaulting to the network who ends up facing the GS(M)R constraint. In the longer term, ensuring this co-ordination may be a potential role for the Future System Operator. In the shorter term, this will require timely sharing of gas blend information, and management of these blends, between NGGT and GDNs.

While one way of achieving this would be through a regulatory cost-sharing mechanism between networks, such that networks are incentivised to minimise the whole system costs of managing blends, such a mechanism may be complex to introduce in the near term. Therefore we recommend that this whole system approach is instead achieved through networks regularly reporting on steps they are taking to achieve a whole system approach, and regulatory oversight of this by Ofgem.

5.3 COST RECOVERY

In this section we address issues and solutions regarding network charges and the recovery of network costs in a system with deblending.[34] These issues are relevant only to models under which deblending serves a customer need (i.e. A, B and C).

In our work with stakeholders, the following key issues were identified:

1. Under network-owned deblending models (models A and B), **how does the network recover the direct costs of deblending** (both capital and operating) in a way that promotes efficient investment in, and use of, deblending relative to alternative solutions (e.g. adaptation of customer equipment)?
2. **How does the network recover the indirect costs of deblending** (i.e. wider system impacts, such as the impacts of the use of deblending on hydrogen blend levels or on the need for network reinforcements)**?** The issues relating to *indirect* costs cuts across all deblending models that serve a customer need (i.e. A, B and C).
3. Where customers own deblending facilities, **how should the capacity and commodity charging framework adapt to minimise distortions** from the recovery of network costs unrelated to deblending (e.g. sunk network costs)? In particular, how should 'double charging' of exit and (re-)entry be avoided? This issue relates to deblending model C only, where gas is taken off the network, deblended behind-the-meter, and unwanted gas is reinjected back onto the network.

The relevant deblending models in which these issues arise are highlighted in yellow below.

[34] We consider issues related to funding (i.e., how to reflect costs of deblending in allowed revenues) within Section 6.2.4.3

FIGURE 13 RELEVANT SCENARIOS FOR COST RECOVERY

		CUSTOMER NEEDS			NETWORK NEEDS
		100% METHANE	SPECIFIC /STABLE BLEND	100% HYDROGEN	SPECIFIC /STABLE BLEND
Network owned	Cost socialised	**A.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs are socialised.			**D.** The network invests in deblending equipment to manage network blends. Costs are recovered from all network customers.
	Cost targeted	**B.** The network invests in and operates deblending equipment to deliver a specific customer need. The associated costs recovered from the relevant customer(s).			*N/A - there are no specific customers to target costs at, since deblending is being used for network needs.*
Customer owned		**C.** Customer owns and operates their own deblending equipment. Costs could be borne by the customer or reimbursed by government (this is a policy decision that falls outside this work).			*N/A - deblending equipment for 'network needs' would not be owned by customers.*

Source: Frontier Economics

As illustrated above, we do not consider there to be any issues related to cost recovery under deblending model D. In this model, deblending is owned and operated by the network for system operation purposes and, therefore we expect these costs to be recovered as part of the network's allowed revenues and recovered across the network user base, under minimal blending and deblending circumstances.[35]

An overview of the relevant issues and recommendations is provided in Table 3 below.

TABLE 3 COST RECOVERY - OVERVIEW OF ISSUES AND SOLUTIONS

ISSUES	MODEL	RECOMMENDED SOLUTIONS
How to recover the direct costs of deblending?	**(A + B)** Network-owned, customer needs	Implement a new, dedicated cost-reflective charging methodology to recover direct capital costs of the deblending equipment and ongoing operating costs.
How to recover the indirect costs of deblending?	**(A + B)** Network-owned, customer needs **(C)** Customer owned	Costs of managing wider system impacts (e.g. monitoring and mitigating localised concentrations of hydrogen) are socialised under existing network charging methodologies.

[35] If a future decision were made that users seeking to inject hydrogen would pay for any resulting additional system operation costs and/or costs incurred by other network users, then the costs of deblending to serve a network need might not be socialised, but instead targeted towards blending (and reinjections). However, we do not consider such an approach would be appropriate under circumstances of minimal blending and deblending.

How to minimise distortions from standard network charges?	**(C)** Customer owned	Implement a 'net-exit' based charging approach for capacity and commodity charges levied on exit connections.

The recommendation in the first row of Table 3 proposes a targeted charge for deblending *in addition to* existing charges of the network designed to recover other allowed revenues (e.g. capacity and commodity charges). If a deblending customer also reinjects unused gas back onto the network, we recommend (third row of Table 3) that the standard capacity and commodity charges are levied on a 'net-exit' basis.

In the following sections we discuss these issues in turn, with reference to the relevant deblending models in which they arise and our recommended solutions.

HOW TO RECOVER THE DIRECT COSTS OF DEBLENDING?

As part of the policy decision in relation to blending, Government may decide that all or part of the costs associated with the transition (which could include the costs of deblending equipment) should be socialised. Absent such a decision, **our recommendation is that the direct costs of deblending should be recovered through targeted charges.**

Under models A and B, the network invests in deblending equipment to serve a customer (or group of customers) and must recover these direct costs. Our recommended approach is to pass on the incremental costs of deblending to the specific customers using deblending to provide an incentive for these customers to consider whether alternative ways of managing hydrogen blends (for example, adapting their own equipment) might be cheaper than deblending. In other words, the charging framework would need to change to allow networks to pass on deblending costs to the specific customer (or group of customers) to which they are attributable.

If these costs were not targeted but instead socialised, the efficiency of these choices depends entirely on the strength of TO/GDN incentives and the solutions discussed in section 5.1 above.[36]

A targeted charge could be implemented in different ways, depending on the extent to which Ofgem determines it is appropriate to include any deblending costs within Allowed Revenues (as opposed being incurred at the TO/GDN's own risk).[37]

- The cost of deblending could be funded entirely outside of Allowed Revenues (e.g. as a Directly Remunerated Service (DRS)).[38] Implementing a DRS may be relatively straightforward, and not need a change to GT charging frameworks. However, it would require customers to agree commercial terms with GTs (for example, regarding the allocation of stranding risk associated

[36] In particular, we recommend that networks be required to justify any expenditure on deblending using a CBA to be approved by Ofgem.

[37] This decision is likely in part to be driven by any considerations around 'rights' customers may have to a given gas composition.

[38] Under this approach, the costs of deblending would be recovered by GTs from customers through bilateral commercial arrangements.

with deblending facilities), which may be challenging (for example, if the number of users of a deblending facility may change over time).

- We therefore also consider the possibility that at least part of the costs of deblending could be included within Allowed Revenues through a dedicated charging methodology that ensures customers of deblending bear the charge. In this situation, to ensure that incentives for customers to use deblending are effective, and to minimise the risk that deblending costs are picked up by the wider network user base, it will be important that such targeted charges are accompanied by appropriate collateral arrangements. This could work similarly to the arrangements currently in place for connection charges (a similar case of networks carrying out investments to meet the needs of a specific user or group of users, and then recovering the costs of those investments from the same users).

We note that even with a targeted charge, it would still be possible for Government (should it wish) to separately compensate deblending customers ex ante (e.g. via grants) for some share of the additional costs they may face as a result of a decision to allow hydrogen blending. As will be the case for any possible decision to socialise costs, any decision to compensate costs will in turn depend on various considerations including whether Government considers that existing gas customers have 'rights' for specific gas quality needs.

HOW TO RECOVER THE INDIRECT COSTS OF DEBLENDING?

We recommend that only direct costs are targeted, whilst the costs of any wider system impacts attributable to deblending are socialised as part of allowed revenues.

Irrespective of whether the network or the customer owns and operates the deblending equipment (i.e., model A, B or C) we expect there to be incremental costs associated with the impacts that deblending has on other customers and the network. However, we do not expect it will be proportionate (at least with minimal deblending) for network operators to attempt to measure and attribute these costs to specific customers through targeted charges. We therefore do not recommend further changes to existing charges or their methodologies to deal with this issue.

This is based on our assumption that any additional wider system costs associated with deblending are likely to be limited initially (see section 0). This means that any potential efficiency gains from ensuring customers internalise such costs are likely to be limited, while it may be quite complex to accurately measure and apportion marginal impacts to specific customers.

HOW TO RECOVER OTHER NETWORK ALLOWED REVENUES

We recommend that exit capacity and commodity charges are levied on a 'net-exit' basis (i.e. based on the net amount of gas that leaves the network less any amount that re-enters) so users do not face entry charges on reinjected gases.

Under model C, deblending takes place behind the customer's meter. The customer may seek to reinject any unused separated gases back onto the network.[39] In the absence of any changes to current charging methodologies, the customer may require both an exit and an entry connection with associated network charges incurred on both the gross amount of (blended) gas off-taken at the exit point as well as any separated gas reinjected at the entry point.

However, this risks artificially distorting the cost of deblending to the customer. This is because network charges recover not only the incremental costs of exit and entry of gases, but also the sunk (i.e. historical) network costs that are unaffected by customers' decisions. Such charges do not aim to create particular incentives for network customers (indeed, the recovery of sunk costs may actually distort customer incentives). However, these costs do need to be recovered across all customers of the network, in the least distortive way.

Under the current framework, deblending model C would result in a disproportionate cost-recovery burden falling on customers using deblending compared to the net amount of energy they actually take from the network. As a result, customers may be disincentivised from investing in deblending even when it is optimal (from an efficiency perspective) to do so. Similarly, doubling of charges may also artificially distort the customer's decisions regarding when to operate deblending.

We therefore recommend that capacity charges and commodity charges levied on £/kWh or £/peak kWh/day basis on *both* the exit and entry points are replaced with a single set of exit charges calculated on the basis of the net-exit quantity of gas, i.e. the amount of gas used by the deblending facility less the amount of any reinjected gas.[40,41] This approach leads to network charges levied only on gas that is consumed on-site, in effect ensuring similar charges are paid compared to customers with the same demand attributes that do not use deblending. This will remove any incremental distortion from doubling the cost-recovery component of network charges whilst also retaining the positive efficiency properties of cost-reflective components (since it is the net-withdrawal of gas which impacts network costs).

[39] We note that, under existing Gas Transporter licence conditions, we would not expect networks to operate equipment behind the customer's meter.

[40] In particular, for the NTS, we recommend that the following charges move to a net-exit approach: 'NTS TO entry capacity', 'NTS TO exit capacity', 'NTS TO exit revenue recovery', 'NTS TO entry recovery' and 'General non-Transmission Services'. For the LDZ, this should apply to the following charges: 'LDZ customer capacity charge', 'LDZ capacity system charge', 'LDZ commodity system charge'.

[41] As part of this work we don't seek to prescribe how networks should implement this net-exit principle and, indeed, there may be a variety of different options for doing so (e.g. defining new types of connection point, or re-calculating charges across existing connection points etc.). Further work, as part of the UNC Modification process, will also be required to address issues affecting the capacity booking regime (on the NTS) and prescribing conditions under which customers would be eligible for 'net-exit' charges.

6 ROADMAP TO ENABLE DEBLENDING

The industry has taken forward work to map out the steps required to enable blending of hydrogen in the gas networks. For example, building on earlier NIA-funded work by Frontier,[42] the Energy Networks Association (ENA)[43] has set out a possible series of actions (starting in H2 2021) that could enable blending by end-2024/early 2025.[44]

BEIS is currently reviewing blending timelines with stakeholders. As noted in the introduction to this report, the steps to enable blending cannot be considered independently of the steps required to ensure that customer needs are met in different blending scenarios.

As part of BEIS' review of blending timelines, it will be important to consider the urgency of addressing possible issues faced by gas customers from any move to allow hydrogen blending. For example, blending may start at such low levels or in locations sufficiently far away from sensitive customers that deblending (or alternative solutions) would not be immediately required. If deblending is urgently needed, it may be enabled temporarily (ahead of full implementation of the various steps described later in this section) through variations in the existing commercial framework.

Figure 14 below sets out the full set of actions, based on our assessment in section 5 above, required to enable our recommended changes to the gas frameworks for deblending:

- It sets out the actions that will need to be taken, their approximate duration and sequencing, which parties are responsibility for undertaking them, and the legal impact of each action (i.e. which legal documents may be affected).
- As explained above, there is some uncertainty around the timeline for blending. We have for now assumed that commercial-scale blending will start at the beginning of 2025.[45]

In the rest of this section, we explain the incremental changes required to enable deblending in further detail, by area:

- Overarching changes;
- Network planning and customer needs;

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[42] Frontier Economics (2020) 'Hydrogen Blending and the Gas Commercial Framework: Report on conclusions of NIA study'

[43] ENA (2021) 'Gas Goes Green: Britain's Hydrogen Blending Delivery Plan'

[44] The ENA report also considered an alternative, 'target-driven' timeline that could enable blending by Winter 2023/24, assuming significant preparatory work/consultation.

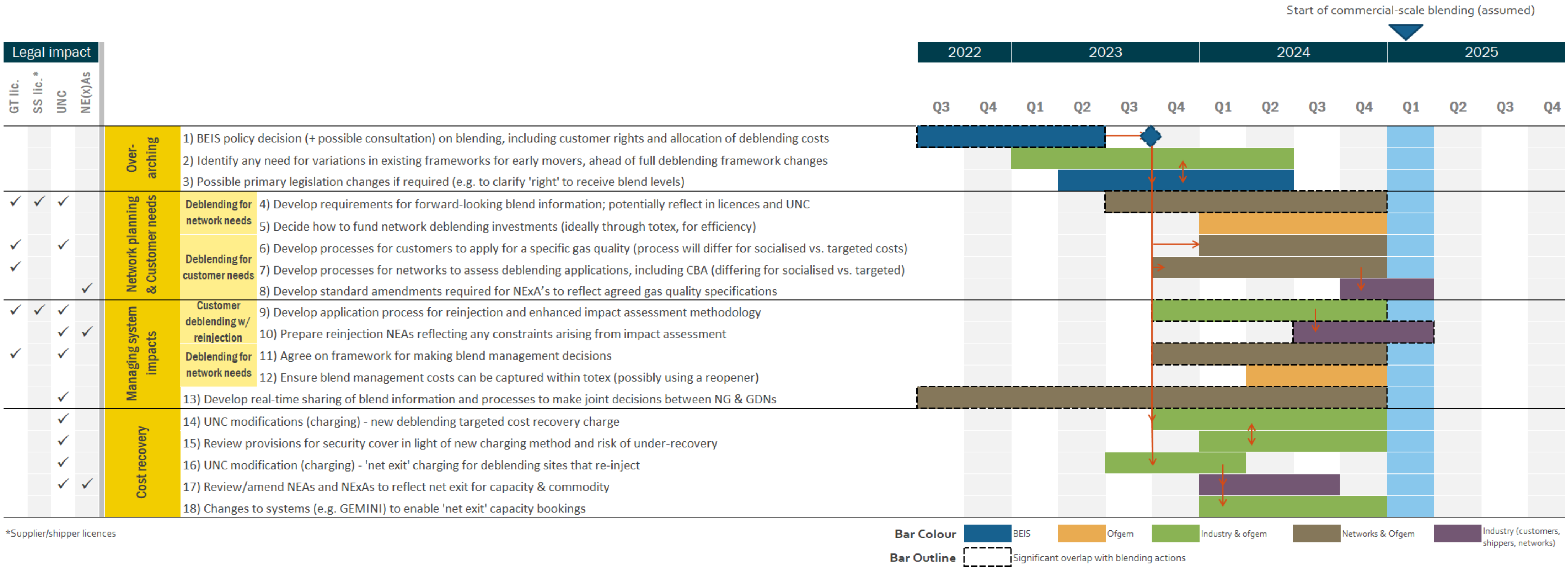
[45] As noted above, BEIS is currently reviewing the timescales for blending. The UK Hydrogen Strategy indicates that blending could start in the mid-2020s, subject to policy decisions. We further assume (for simplicity) that blending timelines are aligned at both LDZ and NTS level. We understand, however, that BEIS has only announced an intention to decide on blending at LDZ level (in the second half of 2023).

- Managing system impacts; and
- Network charging.

Given the number of actions that will have to take place in parallel to enable deblending, it may be useful to have an industry steering group coordinating and driving forward the necessary further actions on both blending and deblending, to help ensure that the transition is not unnecessarily held up.

Finally, we present a table summarising the likely changes required to the UNC across the various areas set out above.

FIGURE 14 ROADMAP FOR DEBLENDING



Source: Frontier Economics

Notes: The start of commercial scale deblending is indicative. Whilst it reflects current discussions there have, so far, been no commitments.

The expected BEIS policy decision in relation to blending in late 2023 relates to distribution networks only.

The sequencing of action (18) requires GTs to decide to undertake system development at-risk (as it would precede UNC Modification development) in order to meet timescales for blending.

6.1 OVERARCHING CHANGES REQUIRED

A number of overarching steps (some related more generally to blending) will need to be taken as part of any move to enable deblending:

- Government needs to consult and decide on blending and deblending policy;
- Government and Ofgem need to identify steps required to facilitate early investment decisions ahead of implementing the full deblending framework; and
- Government needs to consider the need for changes to primary legislation.

1) CONSULT AND DECIDE ON BLENDING AND DEBLENDING POLICY

The starting point for all further work will be Government's decision regarding blending. BEIS is currently considering the safety and value for money case associated with blending (as indicated in the introduction to this section, at distribution network level initially). This work will lay the ground for an eventual policy decision on blending and deblending, including market arrangements.

The following questions about deblending will be important for Government to consider as part of this work:

- Whether, and if so under what circumstances, **the costs to customers of adapting to hydrogen blends (including possible deblending costs) should be socialised**, or otherwise compensated (see section 4.3).
- **The case for derogations from GS(M)R** so that commercial arrangements downstream of deblending activity are not in breach of GS(M)R.

We assume that BEIS will consult with stakeholders on some of these policy issues ahead of any decision on blending (which we have assumed takes place in late 2023 as per Government publications[46]).

2) IDENTIFY STEPS REQUIRED TO FACILITATE EARLY INVESTMENT DECISIONS AHEAD OF FULL DEBLENDING FRAMEWORK BEING IMPLEMENTED

The full implementation of changes to the gas commercial framework may stretch beyond early 2025. However, it may be possible to provide certainty for early investments in deblending (and blending) ahead of full implementation, if required, through variations in the existing commercial framework, for example, to:

- allow GTs to build, own and operate deblending facilities in time for the start of blending;

[46] BEIS (2021) UK hydrogen strategy, p.70. Accessible here.

- allow reinjections from customer-owned deblending facilities.

We assume the work associated with identifying these steps could start prior to the blending policy decision, provided there is at least some emerging visibility of key policy objectives regarding blending and deblending. However, it can only be completed following the BEIS policy decision (we assume 9 months subsequently).

3) CONSIDER THE NEED FOR CHANGES TO PRIMARY LEGISLATION

It will also be important for BEIS to consider (as part of this process) whether any changes are required to primary legislation to enable deblending – in particular to establish a 'right' for a particular gas specification other than the GS(M)R standard. Neither existing legislation, licences nor the UNC establish such a 'right'.[47] We describe below (section 6.2) a process whereby this could be achieved through changes to the UNC and to GT licences.

6.2 NETWORK PLANNING AND CUSTOMER NEEDS

Our key recommendations in this area, set out in section 5.1, were:

- The network operator should gather forward-looking information on hydrogen blends through surveys/studies.

- There needs to be a process in place for customers to make applications for a deblending need, along with supporting evidence to justify their need (with a evidential bar required for customers with socialised costs).

- For meeting the needs of customers with socialised costs, funding for deblending investment must be justified by CBAs and approved by Ofgem.

- For meeting the needs of customers with targeted costs or for network needs, no changes are needed and existing totex incentives can be relied upon.

In order to implement these recommendations, we have identified the following actions (note that the numbering follows the roadmap description in Figure 14).

4) DEVELOP INFORMATION REQUIREMENTS FOR FORWARD-LOOKING BLEND INFORMATION

Networks, with input from Ofgem, will need to confirm what forward-looking information they need in order to enable them to plan any deblending investments for network needs (model D). This

[47] Under the UNC, the GTs commit to making gas available which conforms with the specification in GS(M)R. There is a possibility a customer could challenge or claim compensation for a change to GS(M)R. Such a claim (against the authority making the change rather than the GTs) might be based on legitimate expectation (for example, if the customer believed procedural rights, such as consultation, would be available and these were denied or if the customer is denied a substantive right which it was entitled to expect due to the actions of the authority). A claim might also be made on the basis a change to GS(M)R interferes with the customer rights under the ECHR (e.g. peaceful enjoyment of property in the context of physical plant or contractual rights). At this stage the likelihood of such a claim and/or its merits is not known.

information will need to come from engagement with potential future hydrogen producers and will need to include the likely location of future hydrogen injections, hydrogen injection volumes and profiles and any information on future user needs (such as downstream customer ability to accept hydrogen). Once networks have identified their information requirements, they will need to plan and carry out surveys or other engagement activities to collect this information. This process should be integrated into any network planning that networks will carry out for blending in general.

This work could be done informally, or existing gas transporter licence conditions could be expanded to reflect the need for further information gathering (e.g. building on the requirement for the system operator to prepare a Gas Ten Year Statement (GTYS)). Similarly, other than limited requirements on shippers in the UNC, there is currently no compulsory basis for parties to provide planning information to networks, but Ofgem and networks could consider whether provision of planning data requirements should be reflected in shipper licences and the UNC (TPD Section L – Maintenance and Planning, OAD Section H – NTS Long Term Demand Forecasting).

We expect this work could take up to 18 months if licences and the UNC are amended to reflect the need for forward-looking information gathering and provision. This timeframe is fairly long due to the time required for networks to establish what their information needs are, to make any licence and UNC modifications, and to start collecting the relevant information. This action is not dependent on any others and therefore can be completed in parallel to the items that follow.

5) DECIDE HOW TO FUND NETWORK DEBLENDING INVESTMENTS

Under deblending for network needs (model D), our recommended solution was to fund deblending investment through regulated totex allowances, and therefore rely on the totex incentive mechanism to ensure that decisions to invest in deblending are made efficiently. However, this approach may pose some challenges for Ofgem in setting ex ante deblending allowances within totex, such as the lack of historical data on deblending costs and the uncertainty around the amount of deblending that may be needed. Further, the next price control for gas networks will not start until 2026, so a reopener may need to be triggered if there are material costs prior to that date. Ofgem will need to consider these factors, and it could ultimately decide to take a different approach to funding deblending investments, such as through an uncertainty mechanism (although the timing issue of the next price control would still exist here).

We expect that it could take approximately 12 months for Ofgem to consider this question, engage with networks and make a decision as to its approach.

6) DEVELOP PROCESSES FOR CUSTOMERS TO APPLY FOR A SPECIFIC GAS QUALITY

Networks and Ofgem will need to develop a process for gas customers to apply to their network operator for a specific gas composition need (in the case of network-owned deblending for customer needs, i.e. models A and B).

An important question is whether the customer's request to the GT should be routed through the supplier/shipper or come directly to the GT. This will affect the extent to which the supplier/shipper needs to be involved in the process (and whether new licence conditions would be needed in shipper / supplier licences and GT licences). In any case, some recognition of the arrangements between the

GTs and shippers will be required in the UNC (for example, regarding curtailment of injections) as these will have a commercial impact on shippers and the supply arrangements between suppliers and customers.[48]

This action is dependent on the outcome of action 1 above, i.e. BEIS making a decision on the circumstances under which deblending costs should be socialised versus targeted. In both cases, the customer's application will need to set out details of their gas need. However, if their costs are socialised (and therefore borne by others), significant supporting evidence will be required to ensure deblending is genuinely needed and the need meets BEIS criteria for socialising costs.

The agreed process will need to be reflected in network licence conditions and the UNC (TPD Section J – Exit Requirements), and possibly shipper/supplier licences if requests were routed via the shipper/supplier, by amending these documents to set out the conditions under which networks have an obligation to deliver a specific gas quality (and as a result, these conditions would need to be met through the application process).

We expect work to agree on the detail of the application process and to amend licence conditions and the UNC would take approximately 12 months.

7) DEVELOP PROCESSES FOR NETWORKS TO ASSESS DEBLENDING APPLICATIONS, INCLUDING CBA

Together with developing the process for customers to apply for a specific gas quality (action 6 above), networks and Ofgem will also need to develop a process for networks to assess those applications and a framework to make decisions on whether or not to invest in deblending to meet the customer's requirements. This process will likely include an assessment of:

- Whether deblending can deliver the required need;
- The technical impacts of deblending on the grid (e.g. due to reinjection);
- The cost of the investment; and
- Alternative options for delivering the required gas composition (e.g. managing hydrogen injections or adapting the customer's equipment).

We have recommended that a CBA framework is developed for networks to assess the case for using deblending versus alternative options, especially when the costs of managing the customer need are socialised. This CBA tool could be adapted from the tool developed by the Energy Networks Association for carrying out whole system cost-benefit analyses.

The resulting process for making decisions on whether and how to meet a gas quality request should be reflected in the GT licence. We expect that this action could take approximately 15 months.

[48] If the arrangements do not involve the shipper / supplier then consideration would need to be given to whether a bilateral arrangement between the GT and the customer might constitute 'transportation arrangements' and therefore require the customer to hold a shippers licence.

8) DEVELOP STANDARD AMENDMENTS REQUIRED FOR NEXA'S TO REFLECT AGREED GAS QUALITY SPECIFICATIONS

Following the completion of actions 1 and 7 above, if a network receives an application for a gas quality need and finds that this need can and should be delivered by deblending, the relevant customer's NExA should be amended to reflect the agreed gas quality specification.

We expect that development and consultation on the standard amendments required (carried out by the relevant network and gas customer) could take approximately 6 months.

6.3 MANAGING SYSTEM IMPACTS

Our key recommendations in this area, set out in section 5.2, were:

- Network operators to use an enhanced pre-connection Impact Assessment to decide if reinjection points can connect to the grid.
- If a reinjection point is connected, it is subject to constraints on its ability to reinject if/when this causes downstream blend issues. The network operator can constrain reinjections to manage blend levels if needed.
- Network operators are given responsibility to select the most efficient tool to manage blend or do so according to a methodology specified by Ofgem. This includes the management of any downstream impacts of network-owned deblending for customer needs.
- Develop timely sharing / management of gas blend between NGGT and GDNs.

In order to implement these recommendations, we have identified the following actions. We note that most of these actions have significant overlap with blending actions. (Again, note that the numbering follows the roadmap in Figure 14.)

9) DEVELOP APPLICATION PROCESS FOR REINJECTION AND ENHANCED IMPACT ASSESSMENT METHODOLOGY

This action relates to customer-owned deblending (model C), particularly where the customer wishes to reinject their unwanted gas. Reinjections will generally require a new entry connection (even when there is an existing exit connection). In the case of the reinjected gas being methane, existing connection processes can be used. However, in the case of hydrogen (or hydrogen blend) reinjections, a new connection application process will need to be developed, which will include the customer providing more information about the blend of the gas they will be reinjecting and the likely profile of injections. This process can be the same as the process that is developed for hydrogen injection connections for blending more generally.

An enhanced pre-connection Impact Assessment methodology will also be needed to enable the network to gauge the impact of the reinjection connection on network blend levels (e.g. through modelling), on other customers, and the need for any constraints on the connection point and any additional blend monitoring equipment. Again, this can be the same as the approach used for blending connections more generally.

Ultimately, hydrogen reinjections are the same (from a framework perspective) as general hydrogen injections into the network, which is why these processes will be developed as part of enabling hydrogen blending more generally. However, we have included them here for completeness as they are also required for deblending.

Conditions on reinjection connection will need to be reflected in GT/supplier/shipper licenses and the UNC (TPD Section B – System Use and Capacity, TPD Section I – Entry Requirements, TPD Section J – Exit Requirements). This action will need to be carried out by Ofgem and networks, along with input from gas customers (who may be sensitive to hydrogen reinjections) and shippers. We expect this could take approximately 15 months.

10) PREPARE REINJECTION NEA'S REFLECTING ANY CONSTRAINTS ARISING FROM IMPACT ASSESSMENT

Having completed action 9 above, if a network receives an application for reinjection of hydrogen (or a hydrogen blend) and, having gone through the enhanced Impact Assessment, accepts the connection, any constraints around the reinjections will need to be reflected in the NEA for that reinjection connection along with any agreed compensation for interruption. These constraints may include flow limits needed to ensure network blend levels do not exceed the cap, and the ability for the network to interrupt reinjections if needed for blend management. They are likely to be very similar to constraints required for blending connections more generally.

The development of standard clauses to be inserted into NEAs will need to be carried out by networks and gas customers (who are deblending and reinjecting) and reflected in the UNC (sections B, I and J). We expect this could take approximately 9 months.

11) AGREE ON FRAMEWORK FOR MAKING BLEND MANAGEMENT DECISIONS

In the case of deblending for network needs, we have recommended an administrative or discretionary process for networks to select the most efficient tool to manage blend levels and decide between the use of deblending versus alternative blend management tools. Ofgem and networks will need to work together to agree on a process, whether that is:

- Giving networks responsibility to select the most efficient solution, or
- Providing a set of guidelines or a methodology (as well as developing any associated proxy costs for comparing different options) for deciding which tools to use under which scenarios.

In the case of network-owned deblending for user needs, where the unwanted gas stays in the network, we have recommended their management be incorporated into the same administrative approach. The related UNC modifications will mirror those for managing reinjections above (sections B, I and J), and can happen in parallel. We expect this action could take approximately 15 months.

12) DECIDE HOW TO FUND BLEND MANAGEMENT COSTS

The ongoing costs of networks managing blend levels using deblending should be provided for within totex allowances, which will encourage networks to minimise blend management costs. Ofgem will need to ensure therefore that blend management operating costs are captured within totex allowances (possibly through a reopener, given that the next price control for gas networks will not start until 2026).

We expect that Ofgem's review of how blend management costs should be funded and potentially implementing adjustments to totex allowances through a reopener could take 9 months.

13) DEVELOP SHARING OF GAS BLEND INFORMATION AND PROCESSES TO MAKE JOINT BLEND MANAGEMENT DECISIONS BETWEEN NGGT AND GDNS

In order to enable blend issues (resulting from hydrogen reinjections, but this equally applies to general blend issues if they affect both the transmission and distribution networks) to be managed effectively across the grid, NGGT and the GDNs will need to be able to rapidly share information on gas blends (either measured or modelled[49]) and will need to be able to communicate rapidly in order to ensure that their decisions are coordinated. This will require networks to develop infrastructure and processes to enable joint management of blend issues. This requirement could be reflected in a code modification, which would need to be agreed with Ofgem. Specifically, the Offtake Arrangements Document (OAD) sections of the UNC code relating to operational flows between NTS and LDZs (OAD Section F – Determination of Calorific Value, OAD Section I – NTS Operational Flows).

We note that code changes may be quite complex, requiring several changes such as:

- addressing CV-related issues at NTS/LDZ Offtakes;
- new information flows between NTS and DNOs; and
- reflecting changes to GS(M)R.

We expect that this action will take some time to implement, potentially from now until the assumed start of commercial scale blending, i.e. approximately 30 months.

6.4 NETWORK CHARGING

Our key recommendations in this area, set out in section 5.3, were:

- New targeted charges at both NTS and LDZ for customers making use of (network-owned) deblending; and
- Changes to NTS and LDZ exit charging methodologies to enable customers owning deblending facilities (and reinjecting gases into the network) to be charged on the basis of their net-exit.

Below we set out the actions we have identified to implement these recommendations (note that the numbering follows the roadmap in Figure 14). Section 5.3 included one further recommendation – namely that any wider system costs (or benefits) of deblending should be socialised via existing charging methodologies. This would not require any further actions to implement.

[49] For clarity, the gas blend information being shared may be either measured or modelled (or both).

This will require new charging methodologies[50] to be developed by the industry and approved by Ofgem, requiring modifications to the UNC (principally TPD Section Y – Charging Methodologies). We have assumed a timeline of 15 months for this work, though given the additional complexity involved in developing targeted charging methodologies, some preparatory work may need to start ahead of this (potentially also ahead of BEIS' policy decision on blending in Q2 2023).

15) REVIEW PROVISIONS FOR SECURITY COVER IN LIGHT OF NEW TARGETED CHARGES

In parallel, it will be important (as described in section 5.3 above) for GTs to review provisions for security cover in light of the new charging methodology to mitigate the risk of under-recovery of the targeted charge. Reviewing security cover may involve changes to the UNC (TPD Section V – General), and could take 12 months.

16) AMEND UNC TO CREATE NET-EXIT CHARGES FOR CUSTOMERS USING DEBLENDING

A change to the UNC (likely to be TPD Section B – System Use and Capacity) would be required to allow capacity and commodity charges to be levied on a net-exit basis at reinjection sites, at both NTS and LDZ levels. Given the existing precedent for charging on a net basis,[51] we expect the modifications required to ensure net-exit charging to be less complex (compared to the modifications required for targeted charging). It might be possible to complete this process in 9 months.

17) REVIEW/AMEND NEA'S AND NEXA'S TO REFLECT NET-EXIT FOR CAPACITY & COMMODITY

In order to implement the net-exit approach, it may be necessary that the same shipper handles both the offtakes and reinjections of the customer, and there may also need to be some form of combined NEA/NExA. This issue should be considered further from a legal perspective, and a combined NEA/NExA should be developed if required.

We expect this action could take approximately 9 months, following the UNC modification to create net-exit charges.

18) CHANGES TO SYSTEMS TO ENABLE NET-EXIT CAPACITY BOOKINGS

Charging on a net basis would also require changes to existing systems, such as GEMINI, used for managing entry and exit capacity management and trading. Such changes could take up to 12 months and it would only be possible to start this following approval of the UNC modifications. As a result, some work on the UNC modifications may need to start ahead of the BEIS policy decision on blending to allow systems changes to take place ahead of the start of 2025.

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[50] At both NTS and LDZ level.

[51] In particular, UNC Modification 0363V 'Commercial Arrangements for Commingling Facilities' reflects a net-entry charging principle for commingling facilities that take gas off the NTS, blend in lower-quality gas that does not meet GS(M)R specifications, and reinject the mixture which does meet GS(M)R. We note however that, whilst approved, this approach is yet to be operationalised.

6.5 SUMMARY OF CHANGES REQUIRED TO UNC

Table 4 below provides a summary of the various changes to the UNC that have been discussed in the sections above.

TABLE 4 SCOPE OF POTENTIAL CHANGES TO UNC

UNC SECTION	SCOPE OF POTENTIAL CHANGES
TPD Section B – System Use and Capacity	To allow capacity and commodity charges to be levied on a net-exit basis at reinjection sites. To introduce new constraint management processes at reinjection sites. And at exit points where a special composition is agreed based on deblending.
TPD Section I – Entry Requirements	Network Entry Provisions (to be included in a Network Entry Agreement) may include rules around reinjection, e.g. when a GT can constrain reinjection in given circumstances and charging basis. TPD Section I may need to reflect the potential for inclusions of Network Entry Agreement constraint rules in a reinjection context. Potentially to dovetail with constraint management in TPD Section B2.
TPD Section J – Exit Requirements	To reflect changes to GS(M)R e.g. in definition of Standard Offtake Requirements. Network Exit Provisions (to be included in a Network Exit Agreement) may include rules regarding specific gas composition requirements at an offtake site and charging basis. Reduction in flexibility of offtake rates and/or rules for constraining offtake at an offtake site where deblending occurs. To dovetail with constraint management in TPD Section B3. Rules to complement changes in licences to support User/customer application for specific gas composition at an offtake site.
TPD Section L – Maintenance and Planning	New information flows from Users to GTs on future requirements for deblending at offtake sites to facilitate system planning requirements.
TPD Section V – General	New credit cover rules to mitigate risk of under-recovery of targeted cost recovery charges.
TPD Section Y - Charging Methodologies	To allow for targeted cost recovery charges.
OAD Section F – Determination of Calorific Value	To deal with any CV-related issues at NTS/LDZ Offtakes.

UNC SECTION	SCOPE OF POTENTIAL CHANGES
OAD Section H – NTS Long Term Demand Forecasting	Any changes in demand forecasting relating to blend/deblending.
OAD Section I – NTS Operational Flows	▪ New information flows (e.g. gas composition) between NTS and DNOs to support gas flows at NTS/LDZ Offtakes and to manage blend. ▪ Possible changes depending on nature of changes to GS(M)R. ▪ Possibly other commercial arrangements (or options for such arrangements) where deblending could occur upstream or downstream of an offtake.

Source: Dentons

ANNEX A - DEVELOPMENT OF RECOMMENDATIONS

As discussed in Section 3.2, we identified three key topic areas that issues around deblending could be grouped into:

- Network planning and customer needs;
- Managing system impacts; and
- Recovering the costs of deblending.

We then worked with the stakeholder group to develop a long list of potential solutions to address the issues within these topic areas.

In this Annex, we:

- Set out the different solution options we considered;
- Explain how we assessed the different options; and
- Summarise the conclusions of our assessment.

APPLICATION OF THE ASSESSMENT CRITERIA TO COMMERCIAL FRAMEWORK AREAS

Once we had identified a list of potential solutions to each set of issues, we evaluated these solutions against the criteria set out in Table 1Figure 5. To do so, for each issue, we constructed a matrix of solution options versus each evaluation criteria. An example of this assessment process can be seen in Figure 15. Here we consider the issue of managing reinjections from customer-owned deblending facilities (within the topic of "managing system impacts"). As illustrated, each potential solution option is shown in the grey boxes along the top and evaluated against each criterion using a rating indicating whether the criteria is met (green), partly met (yellow) or not met (red). We also include next to each rating a shorthand explanation of our reasoning.

FIGURE 15 AN EXAMPLE APPLICATION OF THE ASSESSMENT FRAMEWORK ('MANAGING CUSTOMER-OWNED REINJECTIONS')

Key
- Meets criterion
- Partly meets criterion
- Does not meet criterion

		Option 1 User reinjection is not permitted. User can either sell on the unwanted gas (off-grid) or use it in a local process	Option 2 Reinjection points are connected subject to constraints. NO can constrain users to manage blends	Option 3 Option 2 + an enhanced pre-connection IA to determine the suitability of the solution and location.	Option 4 Option 3 + user agrees to NO constraining their production based on a pre-agreed admin approach, takes into account system costs.	Option 5 Reinjection points connected without restrictions. Production constraints based on a market mechanism of abatement bids.
EFFICIENCY	INVESTMENT	Cost of deblending is inflated due to no reinjection option	Only the user considers alternative solutions	Alternatives taken into account in impact assessment	As per opt. 3	Efficient outcome (given adequate information)
	LOCATION	Incentive to locate near demand source for unwanted gas	Incentivised by chance of constr., not system cost	Alternatives assessed according to system cost	As per opt. 3	Efficient outcome (given adequate information)
	OPERATION	No change to system operation (no reinjections)	Network discretion in prod. constraint vs alternatives	As per opt. 2	Guidance on constr. manage. considers whole system costs	Efficient blend management on a system wide basis
FEASIBILITY & PRACTICALITY		Simplifies/removes several challenges	Changes to conn. conditions and monitoring of blend	Additional cost of specifying and assessing IAs	Costs and admin of designing and operating scheme	Requires extensive design of new regimes
ENABLE DECARBONISATION		Costs for deblended methane **and** H2 consumption incr.	NO accommodates H2 per network ability	As per opt. 2	As per opt. 2	As per opt. 2
FAIRNESS		Users can be locationally disadvantaged	NO discretion on constr., new conn. limits downstr. conn	IA takes account of impact on existing users	Constr. approach makes NO choose who to constr. fairly	Allows cost impacts on all parties to be considered
ADAPTABILITY		No reinjection learnings but also no mistakes made	No path dependencies	No path dependencies	Risks of creating rights/expectations and wasted effort	Most complex and complete option before 100% H2

Source: Frontier Economics

Note: NO is Network Operator

Using the above assessment, we then identified each solution's key strengths and weaknesses across the evaluation criteria and used this to select a recommended solution. To identify practical and low-regrets solutions under a scenario of "minimal deblending", we often placed more weight on feasibility and practicality considerations, rather than solutions that deliver highly efficient outcomes. We also focused on ensuring that solutions should be sufficiently flexible to adapt to alternatives that are suited to a more complex deblending world in future if needed. In the following sections of this annex we provide an overview of this evaluation for each set of issues within our three topic areas.

NETWORK PLANNING AND CUSTOMER NEEDS

In Section 5.1 we discussed our recommended solutions to issues regarding network planning and customer needs. The specific issues were:

1. How should customers' gas quality needs be communicated and assessed?
2. How should network operators be encouraged to select efficient solutions for meeting customer needs and network needs?
3. Do networks have sufficient information to plan deblending investments?

For issues 1 and 3, around communication of gas quality needs and the sufficiency of information to plan investments, we identified one clear solution for each (which we have covered in the main body of our report). Therefore we only considered multiple potential solutions for the question of "How should network operators be encouraged to select efficient solutions for meeting customer needs and network needs?".

We considered three potential solutions to this issue:

- Existing totex incentives are relied upon to encourage network operators to minimise the costs of managing blends;
- CBAs, approved by Ofgem, are additionally required to justify investments; or
- New incentives are introduced to minimise costs and maximise benefits.

We then evaluated these options under the three different deblending models under which this issue arises (because different solutions may be best suited under different models – see section 4.4 of the main body of this report):

- Network deblending for network needs (Model C);
- Network deblending for customer needs with socialised costs (Model A); and
- Network deblending for customer needs with targeted costs (Model B).

The evaluation summary under each model can be seen in the figures below. In each case, we have identified our recommended solution with a green highlighted option number. In cases where we found that it could be worth transitioning to a different option in a more complex deblending world, then we have highlighted that option in orange.

NETWORK DEBLENDING FOR NETWORK NEEDS

Figure 16 below shows our evaluation of solutions for how network operators should be encouraged to select efficient solutions for meeting network needs. We concluded that Option 1 (no changes to existing frameworks, and relying on existing totex incentives) is the best solution to accommodate deblending initially, under a 'minimal deblending' world.

FIGURE 16 HOW SHOULD NETWORK OPERATORS BE ENCOURAGED TO SELECT EFFICIENT SOLUTIONS FOR MEETING NETWORK NEEDS? OPTIONS ASSESSMENT

Option		DESCRIPTION	SUMMARY OF ASSESSMENT
No changes	1	Relies on existing totex incentives to encourage TSO/DSO to minimise costs of managing blends	+ Lowest cost and effort to implement. + Networks are incentivised to minimise their own costs, which helps deliver broadly efficient outcomes when network is investing for its own needs. - Incentives to consider the impacts of investment location or wider decarbonisation are limited. However, these considerations are less of an issue with minimal deblending.
Admin approach	2	Network discretion in planning deblending investments. However, funding must be justified, e.g. with an enhanced CBA (with non-network options), and approved by Ofgem.	+ CBA requires network to consider alternatives to deblending, stranding risks, locational and decarb. impacts. - It may be difficult to quantify some elements of the CBA. - Some ongoing resource costs.
Changes to incentives	3	New output incentives to maximise benefits (e.g. H2 volumes).	+ Provides incentives to consider the impacts of location or wider decarbonisation. These impacts are likely to be more material under more complex future scenarios, so this might be a more suitable solution under those scenarios. - Complex to implement.

Source: Frontier Economics

Relying on existing totex incentives (Option 1) presents a low cost, minimal effort solution with broadly efficient outcomes. Networks will be incentivised to minimise their own costs, trading off between deblending and alternatives to manage blend levels, without additional intervention needed. The costs of opex solutions (such as management of upstream hydrogen or methane injections) and capex solutions (such as installing deblending equipment or adapting non hydrogen-ready network assets) should all be captured within the totex incentive regime.

However, under Option 1 (existing totex incentives), there remain limited incentives to consider locational efficiency, i.e. the impact on other upstream/downstream networks will not be considered directly when deciding whether and where to locate a deblending site. There are also limited incentives for network operators to consider decarbonisation impacts, i.e. there is a risk that network operators may find it is cheapest to manage blend levels by simply constraining hydrogen injections, rather than attempting to maximise the amount of hydrogen in the networks. However, given the limited materiality of deblending in early stages, we believe these considerations are not highly material.

If deblending becomes more complex over time, there may be benefits in transitioning to Option 3 (changes to incentives). Adding new incentives to encourage accommodation of hydrogen and to capture the costs to other networks when choosing deblending sites may help deliver more efficient outcomes in a world with more extensive deblending. We also considered the use of an enhanced CBA for planning deblending investments (Option 2). However, we did not consider that this would drive significant additional efficiency, as the use of the totex incentive should already encourage networks to weigh up different solutions in order to minimise their costs.

NETWORK DEBLENDING FOR CUSTOMER NEEDS WITH SOCIALISED COSTS

Figure 17 below shows our evaluation of solutions for how network operators should be encouraged to select efficient solutions for meeting customer needs when costs are socialised. We concluded that Option 2 (using enhanced CBAs to justify investments) delivers the best solution under this deblending model.

FIGURE 17 HOW SHOULD NETWORK OPERATORS BE ENCOURAGED TO SELECT EFFICIENT SOLUTIONS FOR MEETING CUSTOMER NEEDS WITH SOCIALISED COSTS? OPTIONS ASSESSMENT

		DESCRIPTION	SUMMARY OF ASSESSMENT
No changes	1	No changes to existing frameworks.	+ Lowest cost and effort to implement. - Networks have limited incentives to minimise overall costs (because costs are socialised), delivering poor efficiency outcomes. - Incentives to consider the impacts of investment location or wider decarbonisation are limited. However, these considerations are less of an issue with minimal deblending.
Admin approach	2	Network discretion in planning deblending investments. However, funding must be justified, e.g. with an enhanced CBA (with non-network options), and approved by Ofgem.	+ CBA requires network to consider alternatives to deblending, stranding risks, locational and decarb. impacts. This helps improve efficiency outcomes, but… - Information asymmetry between networks and customers makes it difficult to carry out an accurate CBA. - Some ongoing implementation costs.
Changes to incentives	3	New output incentives to maximise benefits (e.g. H2 volumes). **And** a regulatory incentive such that networks are required to share customer costs if a non-network solution is chosen to meet customer needs.	+ Efficient outcomes because network faces wider costs of deblending investment decisions. - Extremely complex to implement, due to the difficulty of obtaining accurate information on customer costs.

Source: Frontier Economics

Using enhanced CBAs to justify any deblending investment is a proportionate way of mitigating the risk of inefficient outcomes in dealing with customer requests, where the costs of deblending are socialised. Such inefficient outcomes could arise because network operators are not incentivised to minimise overall costs when deciding how to address customer needs, e.g. potentially carrying out expensive deblending investment when customer-based solutions such as upgrading equipment might be more efficient. The enhanced CBA will require the network to consider alternatives to deblending to meet customer needs along with facing locational costs (e.g. impact on other networks or customers) and decarbonisation objectives. While an enhanced CBA could be more complex to carry out, due to information asymmetry between networks and customers (in particular, a potential lack of transparency around the costs of upgrading a customer's equipment), it strikes a good balance between practicality and delivering efficient outcomes.

Even if deblending becomes significantly more complex, our view is that Option 2 (an administrative approach) would likely continue to deliver the best outcomes. This is largely due to the complexity of implementing new incentive schemes (Option 3), where the network operator would face or share the customer's costs of any alternative investment solution to the customer's gas quality need.

NETWORK DEBLENDING FOR CUSTOMER NEEDS WITH TARGETED COSTS

Figure 18 below shows our evaluation of solutions for how network operators should be encouraged to select efficient solutions for meeting customer needs when costs are targeted at customers. We concluded that Option 1 (no changes to existing frameworks) delivers the best solution under this deblending model.

FIGURE 18 HOW SHOULD NETWORK OPERATORS BE ENCOURAGED TO SELECT EFFICIENT SOLUTIONS FOR MEETING CUSTOMER NEEDS WITH TARGETED COSTS? OPTIONS ASSESSMENT

		DESCRIPTION	SUMMARY OF ASSESSMENT
No changes	1	No changes to existing frameworks.	+ Lowest cost and effort to implement. + Networks have limited incentives to minimise overall costs, but this is not an issue because customers face the costs of their own deblending needs, so will only request deblending where this is an efficient solution. - Incentives to consider wider system impacts, looking for opportunities to coordinate requests, and considering wider decarbonisation costs are limited. However, these considerations are less of an issue with minimal deblending.
Admin approach	2	Network discretion in planning deblending investments. However, funding must be justified, e.g. with an enhanced CBA (with non-network options), and approved by Ofgem.	+ CBA requires network to consider alternatives to deblending, stranding risks, locational and decarb. impacts. Offers a slight benefit over option 1 by encouraging networks to coordinate deblending requests. - It may be difficult to quantify some elements of the CBA. - Some ongoing implementation costs.
Changes to incentives	3	New output incentives to maximise benefits (e.g. H2 volumes). And incentives to coordinate across customer requests.	+ Provides incentives to consider the impacts of location or wider decarbonisation. These impacts are likely to be more material under more complex future scenarios, so this might be a more suitable solution under those scenarios. - Complex to implement.

Source: Frontier Economics

The 'no change' approach (Option 1) presents a low cost, minimal effort solution with broadly efficient outcomes. This is because under targeted costs customers face the costs of their own deblending needs, rather than these costs being borne by energy consumers or taxpayers. Customers will therefore internalise the costs of different options for meeting their gas quality need, and select the one that is most efficient.

However, similar to "deblending for network needs", there are limited incentives for network operators to consider locational efficiency, decarbonisation impacts and system-wide costs (since the decision to deblend is now made from the customer's perspective, which does not include system costs).

There is also an additional issue that multiple applications for gas quality needs could be most efficiently served with a single deblending facility, requiring network operators to coordinate across customers' gas quality requests. To deliver highly efficient outcomes, there would need to be incentives in place to drive this coordination. However, given the limited materiality of deblending in early stages, we believe this is unlikely to be a material issue and introducing complex incentives would involve disproportionate resource.

If deblending becomes significantly more complex, we concluded that there could be benefits in transitioning to Option 3 (changes to incentives). Introducing additional incentives could help encourage accommodation of hydrogen, capture whole gas system costs, and incentivise coordination of requests when making decisions to invest in deblending. In theory, Option 3 could deliver more efficient outcomes than Option 2 (administrative approach).

MANAGING SYSTEM IMPACTS

In Section 5.2 5.1we discussed our recommended solutions to issues regarding the management of system impacts of deblending. The specific issues were:

1. How does the network operator decide whether to accept or refuse customers' requests for a reinjection connection and under what conditions will the connection be offered?
2. How should the network operator manage downstream impacts of deblending, if a customer is reinjecting their unwanted gas back into the network?
3. How should the network operator choose between deblending, versus other tools to manage day-to-day network blend constraints?
4. How should the network operator manage the impacts of deblending facilities they own and operate to meet customer needs on downstream blends?
5. What coordination is needed between transmission and distribution networks to manage these issues?

For issue 5, around coordination between transmission and distribution networks, we identified one clear solution (which we have covered in the main body of our report). Therefore we only considered multiple potential solutions for issues 1 to 4 above.

To do so, we grouped these issues into two categories:

- Managing customer-owned reinjections, which concerns how network operators decide to approve requests for reinjection and under what conditions (issues 1 and 2, corresponding to deblending model C); and

- Choosing between network operator tools, which concerns how network operators choose between tools to manage blends (issue 3, corresponding to Model D), and how they manage the downstream impacts of deblending that they are providing for customer needs (issue 4, corresponding to Models A and B).

We considered five potential solutions to managing customer-owned reinjections and two potential solutions to choosing between network operator tools:

- Managing customer-owned reinjections:

    1. Customer reinjections are not permitted;
    2. Customer reinjections are permitted but subject to constraints such that the network operator can interrupt reinjections to manage blend levels;

3. Same as Option 2, with the addition of an enhanced pre-connection Impact Assessment (IA) to approve reinjections;
4. Same as Option 3, with the addition of a pre-agreed approach to selecting deblending sites for constraint; or
5. Reinjection points are connected without restrictions, and constraints are based on a market mechanism of abatement bids.

- Choosing between network operator tools:

1. The network operator is given the responsibility to select the most efficient solution to manage blend levels, potentially according to an Ofgem specified methodology. Existing totex incentives are relied upon to minimise network costs; or
2. New incentives are introduced to capture system costs not currently captured by the totex regime and to maximise benefits such as incentivising accommodation of hydrogen in the system.

We also considered market-based solutions for "Choosing between network operator tools", but eliminated these options once we ruled out market-based solutions for "Managing customer-owned reinjections".

Our evaluations of each are explained below.

MANAGING CUSTOMER OWNED REINJECTIONS

Figure 19 below shows our evaluation of solutions addressing management of customer-owned reinjections. We concluded that Option 3 (an administrative approach with a pre-connection Impact Assessment) delivers the best solution.

FIGURE 19 OPTIONS ASSESSMENT FOR MANAGING USER OWNED REINJECTIONS

		DESCRIPTION	SUMMARY OF ASSESSMENT
Preven-tion	1	customer reinjection is not permitted. customer can either sell on the unwanted gas (off-grid) or use it in a local process.	+ Easy to implement, simplifies blend management. - Potentially cuts off efficient outcomes for investment, location, decarbonisation and fairness as well as discriminating against customer owned deblending (network owned is not prevented from reinjection).
Admin	2	Reinjection points are connected subject to constraints. NO can constrain customers to manage blends.	+ Improves outcomes by allowing reinjections, while still relatively easy to implement. - customers and NO face own costs only, so likely suboptimal efficiency. Poor fairness outcomes: who is constrained is up to NO discretion and new connections will impact existing downstream customers.
	3	Option 2 + an enhanced pre-connection impact assessment (IA) to determine the suitability of the solution and location.	+ IA helps improve investment and location efficiency and ensures new connections cannot connect where they will detrimentally impact existing customers (or that they face constraints to limit their impact). - Production constraint decisions still only consider NO costs, which could lead to inefficient operational outcomes.
	4	Option 3 + customer agrees to NO constraining their production based on a pre-agreed admin. approach which takes into account system costs.	+ Some consideration of system costs for operation decisions. - Complexity (specifying /maintaining an agreed procedure) and path dependency risks (may create rights or expectations).
Market-based	5	Reinjection points connected without restrictions. Production constraints based on a market mechanism of abatement bids.	+ Delivers the most efficient outcomes under the right conditions. - Not proportionate as a first step.

Source: Frontier Economics

We found that an administrative approach where reinjection points are connected to the grid subject to an enhanced pre-connection IA (along with conditions that reinjection can be constrained by the network operator) is a proportional solution in the period of “minimal deblending”, which delivers broadly efficient outcomes. Simply preventing reinjections (Option 1) would increase investment costs of deblending (if it was cheaper to dispose of unwanted gas by reinjection) and could create unfair outcomes for some customers (e.g. those facing a longer distance to a point of demand for the unwanted gas).

Allowing reinjection connections and giving the network operator discretion to constrain reinjections to manage blend levels (Option 2) is fairer and more efficient but could result in connections being accepted in locations where they could cause significant impacts on downstream customers or other injection points, or where the connection will need to be interrupted regularly to manage blends.

Adding the pre-connection IA (Option 3) helps to identify these impacts and encourages consideration of alternative investments (e.g. upgrading a plant to be hydrogen ready) or connection locations to limit these impacts. However, we do note that alternative locations may not be an option for existing gas customers who are already established in a fixed location.

Once a reinjection point is connected, there remains a question as to how the network operator selects which injection/reinjection points to constrain when there are multiple hydrogen injection and reinjection points contributing to a blend issue. If the network operator arbitrarily chooses sites to constrain, then this could lead to inefficient operational outcomes as the network does not know the cost to different customers of being constrained. However, because the instances of blend issues driven by multiple connection points should be infrequent in the early phase of blending and deblending, introducing a more sophisticated approach to managing constraints (such as Option 4, where a pre-agreed administrative methodology is applied) would be disproportionate at this stage.

If deblending becomes significantly more complex, transitioning to Option 4 (an administrative methodological approach) could help deliver more efficient outcomes. It may also be beneficial to introduce incentives to encourage the accommodation of hydrogen in the system. Moving to a complete market-based approach (Option 5), on the other hand, will be complex and costly and therefore disproportionate, given that blending is only a transitional stage.

CHOOSING BETWEEN NETWORK OPERATOR TOOLS

Figure 20 below shows our evaluation of solutions addressing the choice of network operator tools for blend management. We considered four potential solutions, two based on administrative approaches, and two market-based approaches. We concluded that Option 1 of the administrative approaches (where the network is given responsibility to select the most efficient tool to manage blend or does so according to an agreed methodology) delivers the best solution. Given that we ruled out the market-based approach in the previous section (managing customer-owned reinjections), we have also ruled out market-based approaches here for the same reasons of practicality, and for consistency across the recommended frameworks.

FIGURE 20 OPTIONS ASSESSMENT FOR MANAGING CUSTOMER OWNED REINJECTIONS

Approach chosen			DESCRIPTION	SUMMARY OF ASSESSMENT
Admin	No new incentive	1	NO given responsibility to select most efficient solution to manage blend, potentially according to a methodology specified by Ofgem. The existing totex regime incentivises minimisation of network costs.	+ Minimal changes required. - Without incentives to minimise wider system costs this could be unfair to customers and cut off more efficient system wide outcomes.
Admin	New incentive	2	**Option 1** + new incentives encourage the NO to minimise wider system costs, and maximise benefits.	+ Delivers more efficient outcomes whilst addressing fairness through new incentives. - Complexity of designing and implementing new incentives. However, comparable NO incentives do exist, e.g. shrinkage, residual balancing.
OR				
Market	No new incentive	1	Blend managed by taking bids for production abatement / methane injection (with network deblending integrated). Existing totex regime incentivises minimisation of network costs.	+ Delivers efficient approach to managing blend. - Without incentives to capture any potential externalities or maximise the benefits of hydrogen this could lead to inefficiencies and may not enable decarbonisation.
Market	New incentive	2	**Option 1** + new incentives encourage the NO to minimise wider system costs, and maximise benefits (such as accommodating H2 volumes).	+ Delivers efficient outcomes (captures potential externalities) and enables decarbonisation through new incentives. - Complexity of setting up new incentives.

Source: Frontier Economics

Note: We have ruled-out market-based approaches following practicality considerations and consistency across issues.

Concentrating on the administrative approaches, relying on existing totex incentives and giving the network operator responsibility (or use an Ofgem agreed methodology) to select the most efficient solution for managing blend, presents a low cost, minimal effort solution with broadly efficient outcomes. In the existing totex incentive scheme regulatory allowances are set in advance at the start of a price control, and network operators are incentivised to spend those allowances efficiently through a 'sharing mechanism' where they retain a share of any savings they make. This encourages network operators to minimise their own costs.

However, relying on the totex incentive scheme (Option 1) will not capture the costs to customers of having their reinjection points constrained, meaning there may be an incentive to constrain customers when possible as these costs do not feed into the totex incentive scheme. This could be addressed to a degree by assigning proxy costs to different tools as a part of the Ofgem agreed methodology.

If deblending becomes significantly more complex, we concluded that Option 2 would deliver the best outcomes. Efficiency can be improved by implementing new incentives that capture and expose network operators to customer costs of constraint (and any other wider-system costs not captured by the totex incentive scheme). These would encourage the operator to minimise those wider-system costs when making day-to-day system operation decisions. However, the additional complexity of setting up these new incentives, and the challenge of obtaining accurate estimates of customer costs, make this only appropriate when the need for such schemes becomes clear in a more complex deblending world where constraints are occurring more frequently.

We considered that managing the downstream impacts of deblending that a network provides for customer needs was another form of day-to-day blend management, where the constraint of that deblending site is one of the tools the network operator has to manage blend. Therefore, we concluded that the management of these sites should be incorporated into the administrative approach we arrived at above (Option 1). In the world of "minimal deblending", and with the use of an Ofgem agreed methodology, further conditions could be specified to limit the impact of deblending on any sensitive downstream customers, such as specific flow rates or operation profiles. If deblending becomes significantly more complex, and Option 2 is taken, then new incentives could capture these costs (to downstream users) and any other system-wide costs caused by these deblending sites that are not captured within the totex incentive regime.

Decarbonisation outcomes could also be improved with additional incentives (Option 2), such as incentivising increased hydrogen levels in the grid. There is a risk that it would be least cost for the network operator to simply constrain (re)injections rather than, say, redirecting gas flows when the blend cap is reached. However, these risks are also less likely to be material in the "minimal deblending" world and should only be considered when deblending becomes significantly more complex.

COST RECOVERY

As discussed in Section 5.3, in the cost recovery topic area, we evaluated potential options to address issues regarding network tariffs and the recovery of network costs in a system with deblending. In particular, we identified two sets of issues;

1. Under network-owned deblending models (models A and B), **how does the network recover the direct costs of deblending** (both capital and operating) in a way that promotes efficient investment in, and use of, deblending relative to alternative solutions (e.g. adaptation of customer equipment)? **And how does the network recover the indirect costs of deblending** (i.e. wider-system impacts, such as the impacts of the use of deblending on hydrogen blend levels or on the need for network reinforcements)**?** The issues relating to *indirect* costs cuts across all deblending models serving a customer's need (i.e., A, B and C).
2. Where customers own deblending facilities, **how should the capacity and commodity charging framework adapt to minimise distortions** from the recovery of network costs unrelated to deblending (e.g. sunk network costs)? In particular, how should double charging of exit and (re-)entry be avoided? This issue relates to deblending model C only, where gas is taken off the network, deblended behind-the-meter, and reinjected back onto the network.

HOW TO RECOVER THE COSTS OF DEBLENDING

We considered three potential solutions for recovering costs of deblending. Figure 21 describes each of the three solutions and summarises our assessment.

FIGURE 21 OPTIONS ASSESSMENT FOR RECOVERING THE COSTS OF DEBLENDING

		DESCRIPTION	SUMMARY OF ASSESSMENT
All costs socialised via allowed revenues	1	Equipment and incremental system impacts recovered via Allowed Revenue and socialised through Entry/Exit charges.	- Under full socialisation, the efficiency of outcomes (e.g., investment, operation etc.) relies on the options for 'Network Planning' and 'Managing System Impacts'. - At LDZ-level, socialisation may create uneven allocation of costs across GDNs (and their users) which may distort location decisions of larger I&C customers.
Target equipment costs	2	As Option 1, but equipment (capital and operating) costs targeted towards users of deblending, recovered via annual charges for capital costs and ongoing charges for operating costs.	+ Customers are exposed directly to deblending costs, which should lead to more efficient outcomes (though the effectiveness of the incentive does depend on networks' ability to effectively measure deblending costs, target them through charges, and for users to be able to respond to these signals effectively). - Broader network or social costs/benefits (e.g., impact on decarbonisation objectives) would not be reflected in price signals.
Target all costs	3	As Option 2, but also targeting incremental system costs/benefits (either those on gas system only or wider) on users of deblending	+ Customers are directly exposed to all costs and benefits (including wider impacts), so their incentives are perfectly aligned with those of society. - As per Option 2, benefits rely on effectiveness of signals. However, under Option 3, achieving this in practice (e.g. attributing downstream impacts to individual customers) is extremely complex

Source: Frontier Economics

We concluded that Option 2 (i.e. 'Target equipment costs') delivers the optimal balance of efficiency and proportionality under minimal deblending circumstances. Targeting the costs of deblending means that customers have incentives to consider alternatives to deblending (including customer adaptation). These incentives should be effective as long as:

- the network operator is able to accurately measure and apportion these costs to the right customers (which seems plausible, as the network operator will know the costs of deblending it has incurred, and the relevant customers will need to identify themselves through an application process); and

- those customers are able to effectively respond to these price signals through their private investment and operating decisions. For incentives to be effective, it is important that suitable collateral arrangements are in place (as discussed in section 5.3).

Under Option 1 (cost socialisation), since customers do not face incentives directly, it is the role of administrative solutions (e.g. enhanced CBA carried out by the networks) to ensure efficient decisions in investing in deblending. The ideal CBA would consider alternative options customers may have to deblending (including adaptation of end-user equipment). However, as discussed earlier in this Annex (see "Network planning and customer needs"), given the information asymmetry between customers and networks, it will be difficult for networks to ensure that they have accurate information on the costs of alternative measures. As such, the CBA is likely to result in less efficient decisions compared to the case where customers are directly exposed to the costs of deblending.

Socialisation of deblending costs could be one way of dealing with potential negative financial consequences for individual customers of any move to blending (for example, where Government deems that certain customers have rights to receive a specific gas quality. However, it would also be possible (for Government) to address such issues by compensating customers separately (e.g. via grants) while retaining a targeted approach to charging that would expose customers to incentives to consider alternatives to deblending.

Option 3 (targeted costs) may be more efficient in theory. However, the information requirements for targeting costs of downstream wider-system impacts are likely to be far greater and the efficiency benefits of these signals lower (at least under minimal deblending circumstances). Our assessment therefore concludes that these wider-system impacts should be socialised across all users of the network.

To the extent that deblending becomes more widespread, networks may need to consider whether socialising wider-system impacts remains proportionate relative to the potential efficiency benefits of targeting these costs.

HOW TO MINIMISE DISTORTIONS FROM STANDARD NETWORK CHARGES

We considered three potential solutions for reforming network charges faced by customer-owned deblending with reinjection. Figure 22 describes each of the three solutions and summarises our assessment.

FIGURE 22 OPTIONS ASSESSMENT FOR RECOVERING OTHER ALLOWED REVENUES FROM DEBLENDING CUSTOMERS

		DESCRIPTION	SUMMARY OF ASSESSMENT
Baseline approach	1	Exit charges payable on full offtake volume (incl. volumes later re-injected). Re-injected gasses from a non-network deblending user also incurs full entry charge on re-injected volume.	- Deblending is artificially expensive for users, which leads to underinvestment in equipment and inefficient operating decisions.
Storage approach	2	Approach from gas storage: 80% discount applied to both (re)entry/exit charges for deblending facilities. At LDZ-level, discounts only applied on exit charges.	- Lowers the distortion of non cost-reflective (re)entry charges compared to Option 1, but discount on exit creates differences in exit charges faced by customers (deblending users vs. other customers)
Net exit approach	3	Deblending facility only pays Exit charges on the basis of 'net exit' (i.e., difference between off-take and reinjection).	+ Deblenders face the same cost of using the network as regular network users on both (net) quantity of gas consumed and gas (re-) injected, removing any distortions to decision of whether to invest/operate deblending.

Source: Frontier Economics

We concluded that Option 3 (i.e. 'Net exit approach') best minimises the distortions from network charging without disproportionate administration costs.

If customers face capacity and commodity charges on both exit and (in the case of reinjection) entry connections (i.e. Option 1), then this is likely to artificially inflate the cost of deblending relative to alternative options. This problem exists today with respect to other storage connections and, in principle, would also apply to potential future ‘commingling’ sites on the NTS. We therefore evaluated the existing solutions associated with storage (i.e., 80% discount on entry and exit charges) and co-mingling (e.g., net-exit charges) for suitability in the context of deblending.

Our assessment found that, both Options 2 (storage approach) and 3 (net-exit approach) would reduce distortions, compared to Option 1, by reducing the burden of charges faced by deblending facilities, and that both would be relatively straightforward to implement. However, Option 3 is more efficient, since it ensures that customers using deblending face the same charges on the gas they actually consume as customers not using deblending.[52]

[52] Under our recommended approach, under minimal deblending circumstances, to socialise the wider costs of deblending, this would mean that customers would face only a charge on (net) exit with no separate charge for reinjections. However, under more complex circumstances, if the wider costs of deblending were to be targeted towards individual users, customers may face separate reinjection charges in addition to our proposed net exit charges.

ANNEX B - MORE DETAILED ISSUES AND CHALLENGES

As part of our work with stakeholders to identify issues in the current framework that might need addressing with the introduction of deblending, we identified a number of specific issues not captured in the three high-level groups of issues set out in section 3.2 (and considered in more detail in section 5).

These more specific issues are summarised in Figure 23 below.

FIGURE 23 OTHER SPECIFIC ISSUES TO ADDRESS IN THE CURRENT GAS FRAMEWORK

		Cross-cutting
Network planning	▪ No additional issues	Should deblending equipment be licenced, and if so, how?
Gas quality	▪ Who bears risks & liabilities if a network-operated deblending facility fails to deliver the gas quality required by specific users, in cases where these requirements go beyond GSMR? ▪ How do network codes need to change to specify a process for users to express a demand for a deblended product, with optional reinjection, and for networks to evaluate and deliver this?	
Connections	▪ What agreements need to be in place for users to connect deblending with reinjection? ▪ What information should users provide to networks to enable them to evaluate whether to connect their deblending equipment and how to optimise it?	
Capacity	▪ Is a new entry capacity product needed for reinjections? ▪ If so, how should it be allocated?	
Balancing	▪ How to account for gas that is used as part of the deblending process (e.g. as shrinkage)? ▪ How to account for gas that is reinjected? Should it be netted off? What metering is needed?	
System op.	▪ What new monitoring equipment is needed when deblending plants are installed, to detect downstream blend issues?	
Charging	▪ No additional issues	

Source: Frontier Economics

In this Annex, we explain how we have addressed these issues in our work.

SHOULD DEBLENDING EQUIPMENT BE LICENCED, AND IF SO, HOW?

Where deblending is carried out by (or for) a GT (i.e. a network), any requirements can be addressed through modifications to existing GT licences. As explained in section 6.2, some changes to GT licences may indeed be required – in particular, to set out the process for making decisions on whether and how to meet a gas quality request.

Where deblending is carried out by a customer, just as there is no need to licence consumption, there would be no requirement for licensing. Any reinjection of gases would be licensable activity, but the customer could contract this activity to a shipper.

WHO BEARS RISKS AND LIABILITIES IF A NETWORK-OPERATED DEBLENDING FACILITY FAILS TO DELIVER THE GAS QUALITY REQUIRED BY SPECIFIC CUSTOMERS, IN CASES WHERE THESE REQUIREMENTS GO BEYOND GS(M)R

Following any amendment to GS(M)R, we might expect three cases of customer gas quality ‘right’:

- The majority of customers will only have a legal right to receive gas quality corresponding to the amended GS(M)R, which may allow greater variation in gas quality than current GS(M)R. In principle, the current system of liabilities could apply in case the network fails to deliver the gas quality stipulated under any amended GS(M)R.

- Some customers might be given 'rights' to request (and receive) a specific gas quality (e.g. current GS(M)R). Again, in principle, the current system of liabilities could apply in such cases.

- GTs may also agree contractually with other customers to deliver a more specific gas composition/quality than these customers would be legally entitled to following amendments to GS(M)R. GTs and customers may negotiate 'firm' gas quality delivery by GTs within the range requested by customers, or they may agree it is sufficient for GTs to make 'best/reasonable endeavours' to deliver the requested gas quality. The form of the contractual obligation will also affect the penalty regime that applies.

In addition, in the third case, a number of wider issues will need to be addressed (by Ofgem):

- Whether any revenues earned by GTs from providing such services would fall within their price control;

- If so, how the costs of monopoly network assets should be priced when providing such services; and

- How to ensure, bearing in mind their monopoly position, that GTs accept reasonable liabilities in their contract, which also recognise the relatively low risk (and return) of their business, and which do not unduly discriminate or cross-subsidise between network users.

HOW DO NETWORK CODES NEED TO CHANGE TO SPECIFY A PROCESS FOR CUSTOMERS TO EXPRESS A DEMAND FOR A DEBLENDED PRODUCT, WITH OPTIONAL REINJECTION, AND FOR NETWORKS TO EVALUATE AND DELIVER THIS?

We have described the changes required for customers to request deblending from networks in section 6.2. We have set out the changes required for customers to request permission to reinject gases (from deblending facilities they operate) in section 6.3.

WHAT AGREEMENTS NEED TO BE IN PLACE FOR CUSTOMERS TO CONNECT DEBLENDING WITH REINJECTION? WHAT INFORMATION SHOULD USERS PROVIDE TO NETWORKS TO ENABLE THEM TO EVALUATE WHETHER TO CONNECT THEIR DEBLENDING EQUIPMENT AND HOW TO OPTIMISE IT?

We have set out the changes required for customers to request permission to reinject gases (from deblending facilities they operate) in section 6.3, including the pre-connection Impact Assessment that would be required, which may result in requests being rejected or accepted (in the latter case, possibly subject to constraints on entry).

IS A NEW ENTRY CAPACITY PRODUCT NEEDED FOR REINJECTIONS? IF SO, HOW SHOULD IT BE ALLOCATED?

A new entry capacity product for reinjections would not be needed. However, a net-exit concept would need to be created, as described in section 6.4.

HOW TO ACCOUNT FOR GAS THAT IS USED AS PART OF THE DEBLENDING PROCESS?

If deblending is network owned/operated, then this constitutes an “own use” component of shrinkage.

If deblending is occurring customer-owned/operated (i.e. incurs behind-the-meter) then the customer will face the cost of needing to purchase additional gas.

HOW TO ACCOUNT FOR GAS THAT IS REINJECTED (FOR BALANCING AND BILLING PURPOSES)? SHOULD IT BE NETTED OFF? WHAT METERING IS NEEDED?

Given the different calorific content of gas reinjected (compared to the blended gas withdrawn by the deblending facility), netting is likely to be complicated. Instead, two separate sets of metering equipment at Exit and Entry, with calorific and volumetric telemetry, are likely to be required.

WHAT NEW MONITORING EQUIPMENT IS NEEDED WHEN DEBLENDING PLANTS ARE INSTALLED TO DETECT DOWNSTREAM BLEND ISSUES?

There will be a more general rollout of blend monitoring equipment required to enable hydrogen blending. This is not specific to deblending. As set out in section 6.3, at points of reinjection, an assessment should be undertaken to see if additional equipment is required to manage the blend downstream of the reinjection point.